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A Vulnerability Analysis and Strategic Framework for the Sustainability of Sarawak Lowland Endangered Orchids Established through an Urban Orchid Botanic Garden

by

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DEDICATION

Praise be to God

"For Pablo and fellow Sarawakians"

My dear Mother/Bonda Tengku Salma; Husband - H. Ikhwan; Children – Ir Wan Ashraff & Ir Sunna, Dr Wan Idoracaera & Dr Ashraf, Chichi, Pasha, Peaches, Coco, Picasso, Paolo and Creampuff, you have tolerated and sacrificed a ton especially during the Covid-19 pandemic, the 2 years which were the most painful and crucial part of the journey so that I can achieve my dreams. I cannot express enough appreciation to all of you in this lifetime for your contribution to my life.

"To My Ever-Loving Father who never saw the end of this adventure"

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Abstract

Historically, Sarawak forests have been internationally well-known to support the richness and endemism of extraordinary mega-diversified species orchid (SO). However, despite the drastic dawning of Anthropocene activities threatening valuable orchidaceae habitat, Sarawak does not have a Botanic Garden to lead scientific study, research and conservation addressing and educating the community on major gaps in awareness, knowledge, and the importance of SO as key bio-indicators of ecosystem health in changing circumstances. A proposed Sustainable Urban Orchid Botanic Garden (SUOBG) in an excellent location in Kuching the capital city is predestined to be an effective role model institution for the above while protecting endangered species and restoring threatened populations through establishing a living collection of lowland endangered orchids. Conceptually, the proposed SUOBG drives impact through its unique garden structure integrating relatable first-hand nature-based learning, latest interactive technology and building upon successful ongoing novel ex situ orchid conservation programs involving the younger generation and core industries such as in vitro orchid micropropogation programs in secondary schools and the reintroduction of rescued endangered lowland orchidaceae into monoculture estates. These programs focus on sustainability through producing keikes, a self-sustaining pool of capital human resource, a botanic garden network throughout the country and improving the biodiversity of ecosystems of Sarawak's increasing 12% altered land areas. Combating illegal activities through improved legislations and creating sustainable economic benefits revolving around emergent orchid properties within the pharmaceutical, gastronomic and tourism industries appear to be best achieved by concerted conservation actions of orchidologists, non-government organisations, administrative stakeholders including direct engagement of communities. Racing against time, the proposed SUOBG can become a hub of engaging futuristic integrated conservation strategies creating a holistic insight into long term dynamics whilst understanding the need to create sustainable infrastructure for a healthy, beneficial, and harmonious living landscape for people and organisms mitigating the continuing orchid extinction crisis.

Acronyms

AG	*Arundina graminifolia*
BBG	Bangkok Botanic Garden
BGCI	Botanic Garden Conservation International
BGs	Botanic Gardens
CBD	Convention on Biological Diversity
CITES	Convention on International Trade Endangered Species
CPG	Chelsea Physic Garden
CS	Citizen Science
CUBG	Cambridge University Botanic Garden
Da	*Dendrobium anosmum*
DBOG	DBKU Orchid Garden
Dc	*Dendrobium crumenatum*
Eg	*Elaeis guineensis*
FDSG	Sarawak Governments' Forest Department
FIOCC	First International Orchid Conservation Congress
GBB	Gardens By the Bay
GDP	Gross Domestic product
GJBG	Gunung Jerai Botanical Garden, Peninsular Malaysia
GNOS	Global Network of Orchid Seedbanks
GSPC	Global Strategy for Plant Conservation
HOB	Heritage Orchid Bridgeway
HOW	Historical Orchid Walk
HS2	High Speed Rail, London Birmingham

IOSOP	Introduction of Orchid Species into Oil Palm
IUCN	International Union for Conservation of Nature’s
IVOM	In Vitro Orchid Micropropagation
MP	Monoculture Plantations Estate Project
MRSM	Mara Junior Science College
MSOP	Monoculture Plantations
NBGs	MRSM/SARORSO orchid project
OBGA	Non-Botanical Gardens
OC	Orchid Conservation
OCE	Orchid Conservation Economic
OE	Orchid Extinction
OEC	Orchid Extinction Crisis
OP	Observation Period
OPE	Oil Palm Estate
OPF	Oil Palm Foliage
OPT	Oil Palm Trees
OPTr	Oil Palm Trunk
OS	Orchid Species
OBGA	Oxford Botanic Garden and Arboretum
OSOPP	Introduction of Orchid Species into Oil Palm Estate Project
PP	Pilot Project
QR	Quick Response
QSBG	Queen Sirikit Botanic Garden, Choieng Mai, Thailand
RBGK	Royal Botanic Garden, Kew
RCP	Rail Corridor Project, Kranji Woodland, Singapore

RRP	Royal Park Rajapruek, Bangkok, Thailand
SARORSO	Sarawak Orchid Society
SBG	Singapore Botanic Garden
SC	School Children
SDG	Sustainable Development Goals
SLEO	Sarawak Lowland Endangered Orchid
SO	Species Orchids
SS	Secondary School
SSCOSG	Species Survival Commission’s Orchid Specialist Group
SUOBG	Sustainable Urban Orchid Botanic Garden
SZ	Citizen Science
UBBG	University of Bristol Botanic Garden
UBG	Urban Botanic Garden
UN	United Nations
UOBG	Urban Orchid Botanic Garden
USP	Unique Selling Points
WG	Water Gardens
WSBE	Writhlington School Orchid Project
YG	Younger Generation

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CHAPTER 1

1 Introduction

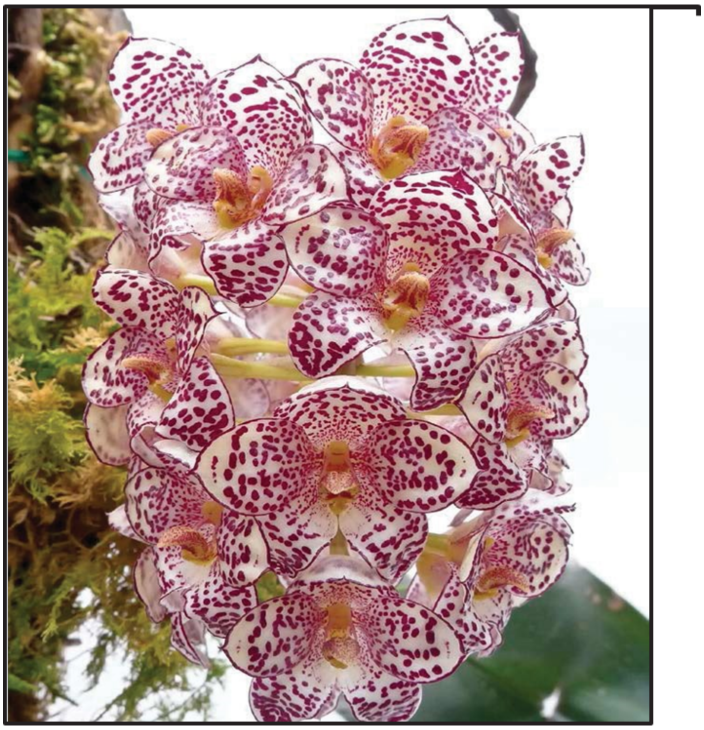
Over the preceding five centuries, the perception of botanic gardens (BGs) has predominantly characterised them as outdoor educational environments affiliated with universities, underscoring the imperative for human involvement in plant and habitat conservation and, consequently, augmenting social willingness to contribute to environmental protection (Bean, 1903; Desmond, 1998; BGCI, 2019). In the last, fifty years, the role of BG has undergone a notable evolution, gravitating significantly towards a conservation-oriented paradigm (Ballantyne, et al., 2007; Chen, et al., 2018). In the contemporary landscape, BGs stand at the forefront of ex-situ conservation initiatives incorporating on-site research facilities like seed banks, laboratories, herbariums, nurseries, and conservatories to address the diverse habitat requirements of plants from global origins (Bean, 1903; Dhanda, et al., 2019).

However, within the context of this research, the primary focus centers on orchid species (OS), recognised for their inherent value and acknowledged as being at considerable risk according to the International Union of Nature Conservation (IUCN) Global Red List (IUCN, 2019). OSs are additionally listed in Appendix 1 of the Convention on International trade in Endangered Species of Wild Fauna and Flora (CITES). With an impressive count of 35,000 species and 800 genera, orchids represent the largest angiosperm family (Chase, et al., 2017; Stuppy, 2020). Crucially, OS are deemed flagship species intergral to gauging the overall health of ecosystems and environment (Shahidhar, 2012; Basu & Cetzal- Ix, 2016; Gale, et al., 2018).

This study is to investigate the efficacy of integrating BGs and OS with the dual objectives of safeguarding endangered OS and concurrently educating the public on pertinent issues such as functions of OS, biodiversity loss, habitat degradation, and climate change (Cowan, 2019). This collaborative initiative also indirectly examines the barriers hindering orchid conservation (OC) (Koopowitz, 2001; Fay, 2018) and identifies factors conducive to successful in favour of successful practices and collaborations through the analysis of case studies and experiments conducted in chapters 4,5 and 6. Furthermore, the research delves into how collaborations among stakeholders, are connected as explored in chapters 5 and 6, may shape the knowledge, skills, attitudes, commitments, connection and interest of the local community and the younger generation concerning OS and OC when visiting BGs (Chen, et al., 2018; Fay, 2018; Fay, et al., 2018).

Moreover, the study delves into landscape architecture considerations that embody the characteristics of various OS habitats, emphasizing relatability, functionality, aesthetic, safety, educational value, and uniqueness (Gratzfeld, 2016) representative of Sarawak. The concept of integrating BGs and OS within their 'actual local natural' setting, tailored to resonate with local visitors, rather than an unnecessary highly technical setup that may not effectively convey the significance OC, aims to achieve outcomes not attained when treating these aspects independently by scientists and conventionists (Wraith, et al., 2020). Simultaneously, integrating these aspects could enhance citizen science (Turrini & Bonn, 2018). The primary objective of this partnership is to heighten public awareness and engagement regarding the orchid extinction crisis (OEC) and the impact experienced by the visitors to the UOBG (Ballantyne, et al., 2008; Chen & Sun, 2018) . This is crucial because the OE is not due to a lack of knowledge among scientists or specialist audiences, but rather stems from the insufficient communication between specialists and the general public. The author and her educated friends who were not orchidologists or conservationist, were unaware of the importance of OS beyond their aesthetic value and unfamiliar with cases such as that of of *Bulbophylum kubahense* (plate 1.1)as stated by , which mysteriously appeared in the Singapore Botanic Garden only to be classified as endangered immediately after being discovered as reported by Vermeulen, 2016 (Vermeulen & Lamb, 2011; Schuiteman, 2016). This lack of awareness could be prevented if the public understood the value of OS. Notably, the individuals for clearing the OS from its habitat were locals well acquainted with the rainforest in Sarawak, acting upon demand from illegal traders who paid them meagre amount. The overarching aim is not only to prevent cases like *Bulb kubahenese* from recurring but also to elucidate necessary action taken by BGs and potential improvement that visitors can adopt in their homes and communities. These endeavours aligned with the unmet objectives and targets of the updated Global Strategy for Plant Conservation (GSPC) in addressing OSE (CBD.int, 2020; KewSN, 2020).

Plate 1-1



The famous and beautiful Bulbophyllum kubahense – endangered before formally described due to being extracted illegally by orchidhunters. One living specimen was found in Singapore Botanic Garden. How did it get there? Source: Tengku, 2019

Plate 1-2

Bulbophyllum kuibahense – Bud. Source: Tengku 2019

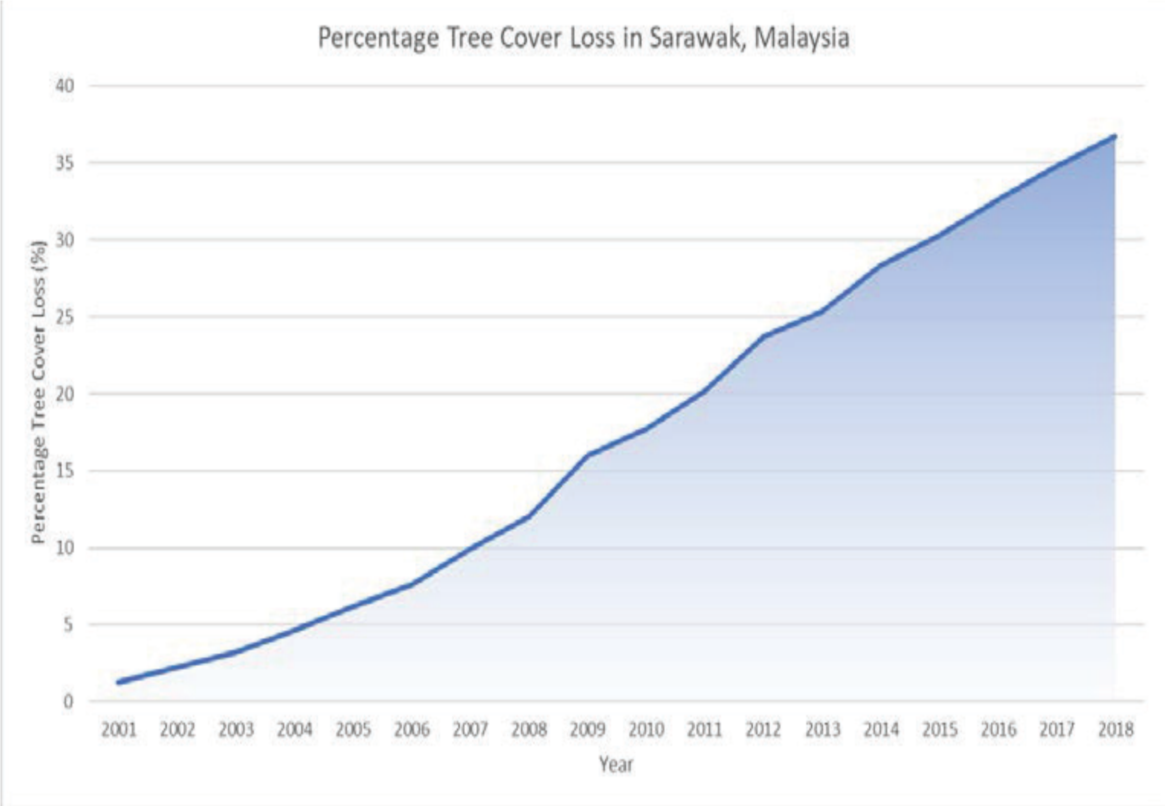
Plate 1-3

Bulbophyllum kubahense flowers bloomed after 12days. Source: Tengku, 2019

1.1 Research Overview

As the world is facing the 'sixth mass extinction' (Wilson, 2001; Ceballos, et al., 2015), constituting one of the highest commercially traded (FloraHolland, 2015; Hinsley, et al., 2017), most diverse and largest families of angiosperms (Chase, et al., 2017) is facing extinction (Schuiteman, 2016). 10% of the world's known OS are found in Malaysia (Go & Pungga, 2018), one of the 12 megadiverse countries (Holtum, 1953; ForestSwk, 2019) in the world, with the numbers arising each year (Schuiteman, 2017). Sarawak, the largest state of Malaysia, comprises the north-western part of the island ofBorneo, has a unique flora that includes rich, highly endemic orchids. Sarawak holds 72% of OS of Malaysia (Chan, et al., 1994). 75.9% of these orchids are epiphytic whereas the remaining are terrestrial, lithophyte and saprophytic orchids (Beaman, et al., 2001; SBFM; FRIM; SARFDM, 2000). However, for Sarawak, many orchid habitats have been destroyed since the 18th century (Schuiteman, 2017) due to reckless collection by orchid hunters (Myoberg, 1930; Low, 2002) and deforestation for economic development (Sarawak Forest Corporation, 2019). As a result, approximately 1500-2500 known Sarawak OS (Beaman, et al., 2001) are threatened or in some cases extinct in the wild (Vermeulen & Lamb, 2011; Schuiteman, 2016). Although technological efforts to conserve endangered OS have been forthcoming within the Sarawak Higher Education Institution (UNIMAS, 2019), the Sarawak Forest Corporation (Sarawak Forest Corporation, 2019) and the newly founded Sarawak Orchid Society - SARORSO (Dayak Daily, 2019; Tribune, 2019), more research is required to further these efforts targeting the public to arrest the crisis of extinction that OS are facing. Any efforts made will need be impactful at over and above the unprecedented rate of disappearance of forest (Figure 1-1).

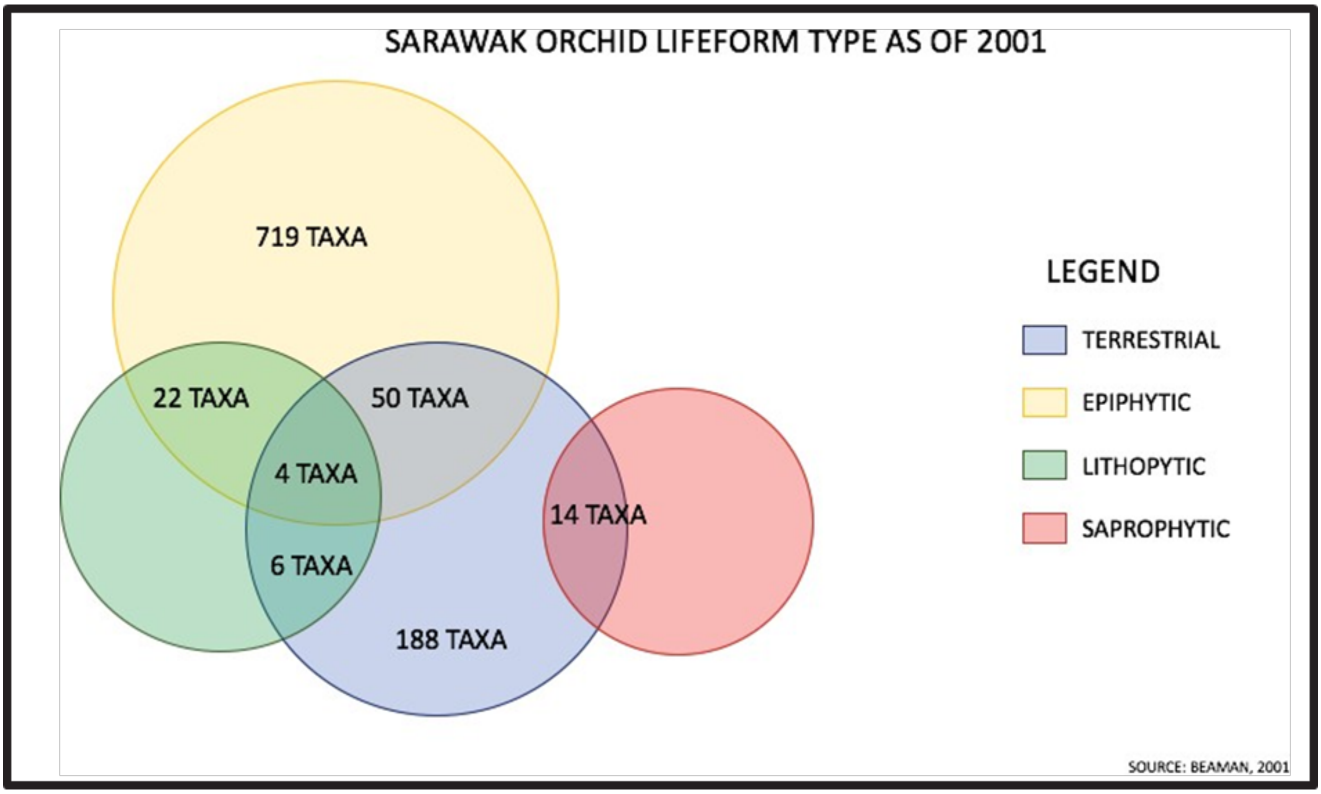
Figure 1-1



Cumulative Tree Cover Loss (%) in Sarawak since 2001. (Source: globalforestwatch.org, 2020)

Based on the history of traditional BGs (BGCI, 2019), historical BGs such as Kew Royal Botanic Garden (RBGK) have been regarded as living museums as well ashorticulture and economic research centres Garden (Pritchard, 1989; Parker, et al., 2013). As such, the thesis outlines key studies exploring the evolution of an Urban Botanic Garden (UBG)into a functional educational Urban Orchid Botanic Garden (UOBG) promoting and focusing on Sarawak lowland endangered orchids (SLEO) conservation (Figure 1-2). It also investigates whether the UOBG would be able to create widespread public awareness of the threats pertaining to SLEO and their effective conservation as well promoting the SLEO aesthetic values and education to promote tourism (Kolanowska, 2019). The study also challenges the notion of what a successful 21st century UOBG (BGCI, 2019) is today and what it can be in the future. Situated in the heart of the city, Kuching, the proposed UOBG design incorporatesSarawak's orchid rich history (Myoberg, 1930; Holtum, 1953; Low, 1968; Beaman, et al., 2001), natural and alternative habitats, scientific research, interactive education, and conservation programmes which also aims to generate educational and learning appeal (Maunder, et al., 2001; Zelenika, et al., 2018) not only to local and foreign researchers, entrepreneurs but also inspiring and delightful to the younger generation (Zoe, 2013) .

Figure 1-2



Sarawak Orchid Lifeform Type as of 2001. Now the figure has changed. However, the latest numbers of Taxa of Sarawak orchid species have not been finalised by the Sarawak forest. Source: Beaman, 2001

The study also includes an ongoing trial of introducing SLEO orchids (in this study epiphyte *Dendrobium anosmum (Da), Dendrobium crumenatum (Dc)* and terrestrial *Arundina graminifolia (Ag)* were used into monoculture plantations (MP). Without the need to carry out expensive trials (Figure 1-2 the trial examines whether available SLEO ex situ conservation technology (Koopowitz, 2001; Darani, 2019) is effective in optimising the monoculture oil palm (*Elaeis guineensis*) tree and plantations, as hosts and alternative habitats to effectively conserve this highly diverse family of orchidaceae. A creation of an arboretum as one of the features of the UOBG representing Sarawak's current agricultural landscape (Potter, 2015), actsas a model representing sustainable SLEO scientific technology available in Sarawak, such asthat is used in the trial above. The creation of other landscapes in the UOBG such as in RBGK(Plate 1-5), depicting the various natural orchid habitats found in Sarawak, links the ex-situ conservation of living collections in the UOBG with effective in situ programmes in Sarawak. Arboretums with introduced orchids mounted on the trees as hosts, as in SLEO natural habitats, are an essential component in the design of the UOBG, not only to establish an identity (through its rich history) for the UOBG of Sarawak, but also to promote the available scientific research programmes to visitors globally. Could these functional UOBG features also lead to opportunities to improve orchid conservation management, as well as the reintroduction and long-term orchid ecological restoration outcomes, and promote interest in commercially developing SLEO at monoculture plantations?

Finally, the study examines the effectiveness of the first In Vitro Orchid Propagationfrom seeds project involving a public school (MRSM – Mara Junior Science College; Choo, 2019). The purpose of the project is not only to instil awareness regarding orchid conservation among the younger generation, but also to create a sustainable orchid seedlings bank (Jones-Pugh, 2019) for SLEO conservation projects using affordable basic scientific equipment (Seaton & Ramsay, 2005; Utami, et al., 2017). This first educational programme on ex situ conservation is a joint collaboration between the SARORSO (Cowan, 2019) and Writhlington School, United Kingdom (UK), which has up to 30 years of experience in orchid conservation (WSBE, 2019) – referred to as the MRSM/SARORSO orchid project (MSOP), which was funded by the Sarawak Government. *Da*, an edible (Teoh, 1980; Bodos & Sang, 2019) and endangered lowland epiphytic orchid (Beaman, et al., 2001; IUCN, 2019); *Dc,* a city orchid with medicinal value (Teoh, 1980; Pant & Raskoti, 2013); and *Ag,* a common terrestrial orchid with medicinal value(Beaman, et al., 2001; 0'Bryne, 2011; Pant & Raskoti, 2013) were used to establishinitial techniques (Seaton & Ramsay, 2005) and protocols for in vitro micropropagationthrough fresh seeds (due to readily available seeds). The only challenge foreseen was that the Writhlington School Orchid Project has been, for the past 30 years, within a controlled environment, both in the laboratory and greenhouses, whereas the project in MRSM was not. Inthe event of the success of the MSOP, the project could be copied by others and implemented in the UOBG itself as an important component of sustainable orchid conservation. Could it develop opportunities for younger generation who are potential keys to future awareness to be engaged in such scientific programmes thus attracting them to be activistin orchid science and conservations at an early age (WSBE, 2012; Kew, 2019)?

Therefore, this study attempts to establish the following three hypotheses: (1) What factors contribute to the successful collaboration between an urban botanic garden and SLEO orchid conservation with the intention to improve visitors' experiences in relation to awareness and interest acquirement about SLEO, its conservation and its importance to ecosystem and biodiversity while visiting the UBG. (2) Would an unexpected and unique experience while visiting in the proposed UOBG educate visitors (both local and foreign) to create awareness and update their knowledge, learning interest and commitment on SLEOs, its conservation technologies and actions which could lead to a positive impact on conservation efforts knowingthat today public EDUCATION is not the primary and initial objective of most existing BG visitors (Ballantyne, et al., 2007) (Plate 1-5). (3) Could the Monoculture Plantations be part of asuccessful ex situ conservation model in cultivation of orchids in living collections in a botanicgarden? Thus, a functional inspiring UOBG focusing on SLEO may also enhance visitors' satisfaction and encourage repeated visits (Williams, et al., 2015). These three hypotheses aretested using case studies analysis and experimental investigations in chapters 4, 5, 6 and 7.

Plate 1-4

Sarawak Orchid Lifeform Type as of 2001. Now the figure has changed. However, the latest number of Taxa of Sarawak orchid species has not been finalised by the Sarawak forest. Source: Beaman, 2001

1.2 Purpose of Study

The research stems from the researcher's awareness of the threats Sarawak orchids are facing (Schuiteman, 2016; Fay, 2018) and the disappearance of their habitat at an alarming rate (Holtum, 1953; Chan, et al., 1994; Nobuo, et al., 2018). Secondly, the absence of a botanic garden (Kew, 2019) in Sarawak inspired the researcher to proceed with the investigation as towhether the existence of a UOBG which focuses only on SLEOs could further mitigate orchidextinction and habitat degradation (Fay, 2018; Chen, et al., 2018). The decision to carry out the research in the United Kingdom (UK) despite having only

52 OS (Pritchard, 1989; Bersweden, 2017) in contrast to the 2500 known species (SBFM; FRIM; SARFDM, 2000) found in Sarawak, was because the UK through its oldest BGs: Oxford Botanic Gardenand Arboretum (OBGA, 2020) and RBGK has a wealth of valuable scientific studies on orchidsand orchid conservation dating as far back as the 17th century (Kittow, 2020). In addition to this, the UK has a long tradition of a passionate and profitable gardening industry for the last 350 years, with a value of £12.6 billion in 2018 (Floud, 2019). This fact is important as the landscape architecture and design of a UOBG will need to have a unique selling point (USP) in order to create a strategic advantage over other UBG (Harrison, 2007) by providing an experience not offered elsewhere to attract the type of visitor targeted and repeated visits (Landezine, 2019).

Based on the fact that globally, UBGs have become the most visited sites for both local and foreign tourists (BGCI, 2019) attracting more than 500 million visitors annually (William 2006(Smith, et al., 2018)), with the abovementioned orchid conservation plans coupled with a thematic landscape architecture design, could the functional UOBG be the most effective wayto enrich local community awareness and knowledge on critical threat to SLEO populations? Could it also educate the public on the importance of the ecological connections of SLEOs involving pollinators (Darwin, 1901; Mitchell, et al., 2009; Nouri, et al., 2018) and mycorrhizal fungi (Ferlian, et al., 2018; Chuan, et al., 2019) as well as the ongoing ex situ and in situ conservation programs (Braverman, 2014) which are still in need of additional support and participation in this part of the world.

Therefore, the purpose of the research is to investigate the possibilities of addressing the lack of public awareness, engagement and knowledge of SLEO and their conservation needs in

Sarawak (Chen & Sun, 2018; Gale, et al., 2018; Wraith, et al., 2020) to mitigate the extinction crisis through a functional UBG. Could the development of a functional UOBG initially focusing on SLEO be the answer to address this potential extinction? In addition, could a UOBG focusing on SLEO and ex situ conservation of SLEO create awareness, education, communication, interest and commitment among the locals and visitors to meet the challenge of preventing or mitigating the SLEO extinction crisis?

1.3 Research Needs and Aim

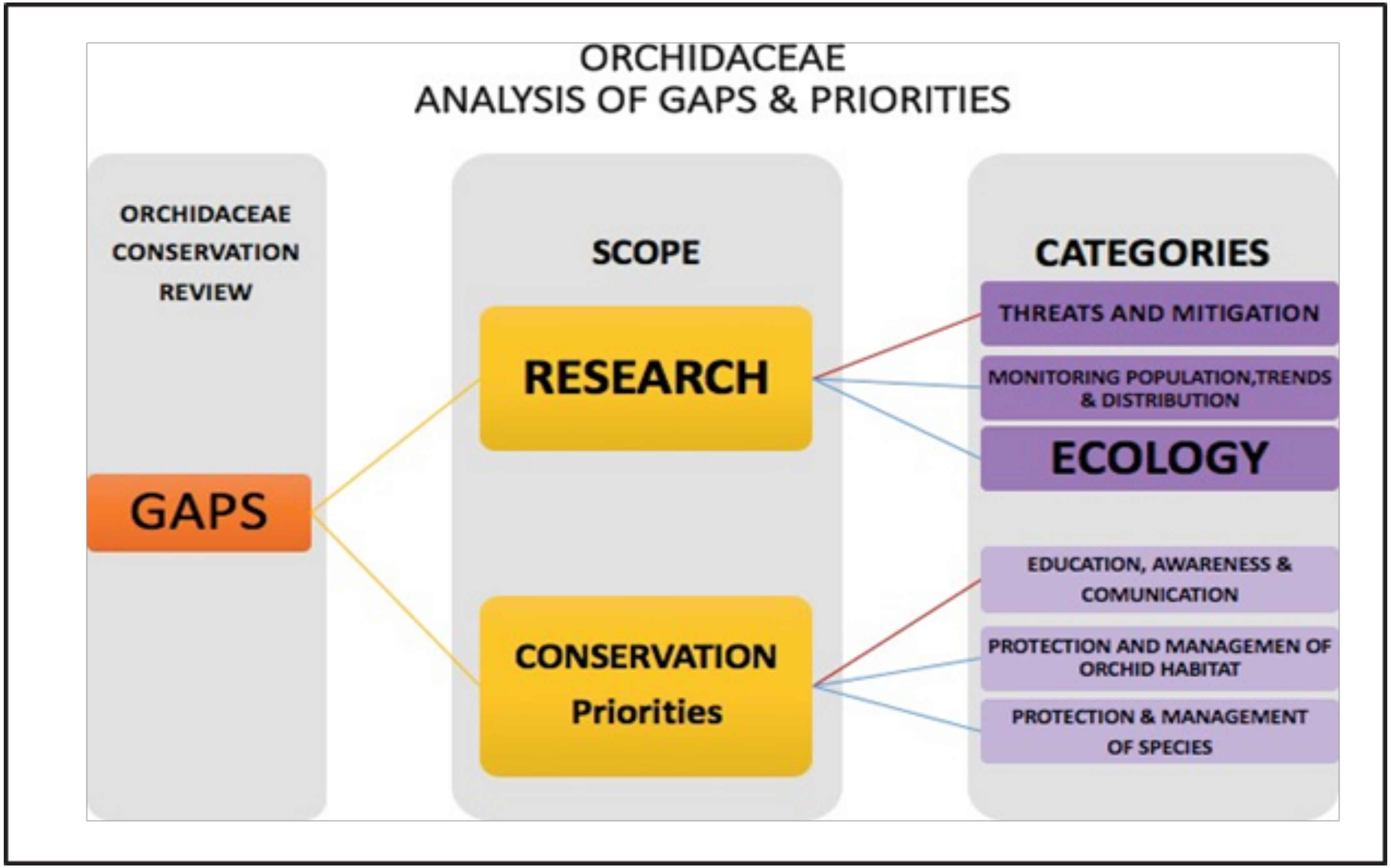
The primary forests of Sarawak, home to rare and important wildlife, for example Orangutans (Voight, et al., 2018), rare *Thismia neptunis* (Daley, 2018) and endemic orchids (of which theirsymbiotic relationship with mycorrhizal fungi (Ferlian, et al., 2018) and specific pollinators make orchids valuable and important for further scientific research, are as mentioned before among the world's top biodiverse ecosystems. However, from the records of the Sarawak Government's Forest Department (FDSG), over the last century (from 1919), Sarawak has losta significant portion of its forests (Figure 1-1) due to anthropogenic activities (FDSG, 2019) withoil palm plantations being one of the main drivers (MPOC, 2019). Only half of Sarawak's primary forest cover remains today, down by more than 35% since 2001 (GFW, 2019).

Basedon the review conducted by scientists on 20 countries which have the most threatened OS (Wraith, et al., 2019; IUCN, 2019), gaps in knowledge requires more **research** on three main categories, identified as: i) **threats and mitigation**, ii) **monitoring population** and iii) ecology (Figure 1-2). In addition, there are three major **categories of knowledge gaps** (IUCN, 2019) **regarding OC** that requires prioritising (Figure 1.3). The categories are i)

education, awareness and communication involving the public, government, scientists and other parties directly or indirectly involved in orchid conservation; ii) protection and management of OS which can involve physical efforts such as caging populations or developing management plans in collaboration with stakeholders and iii) protecting threatened orchid habitats (IUCN, 2019; Wraith, et al., 2019).

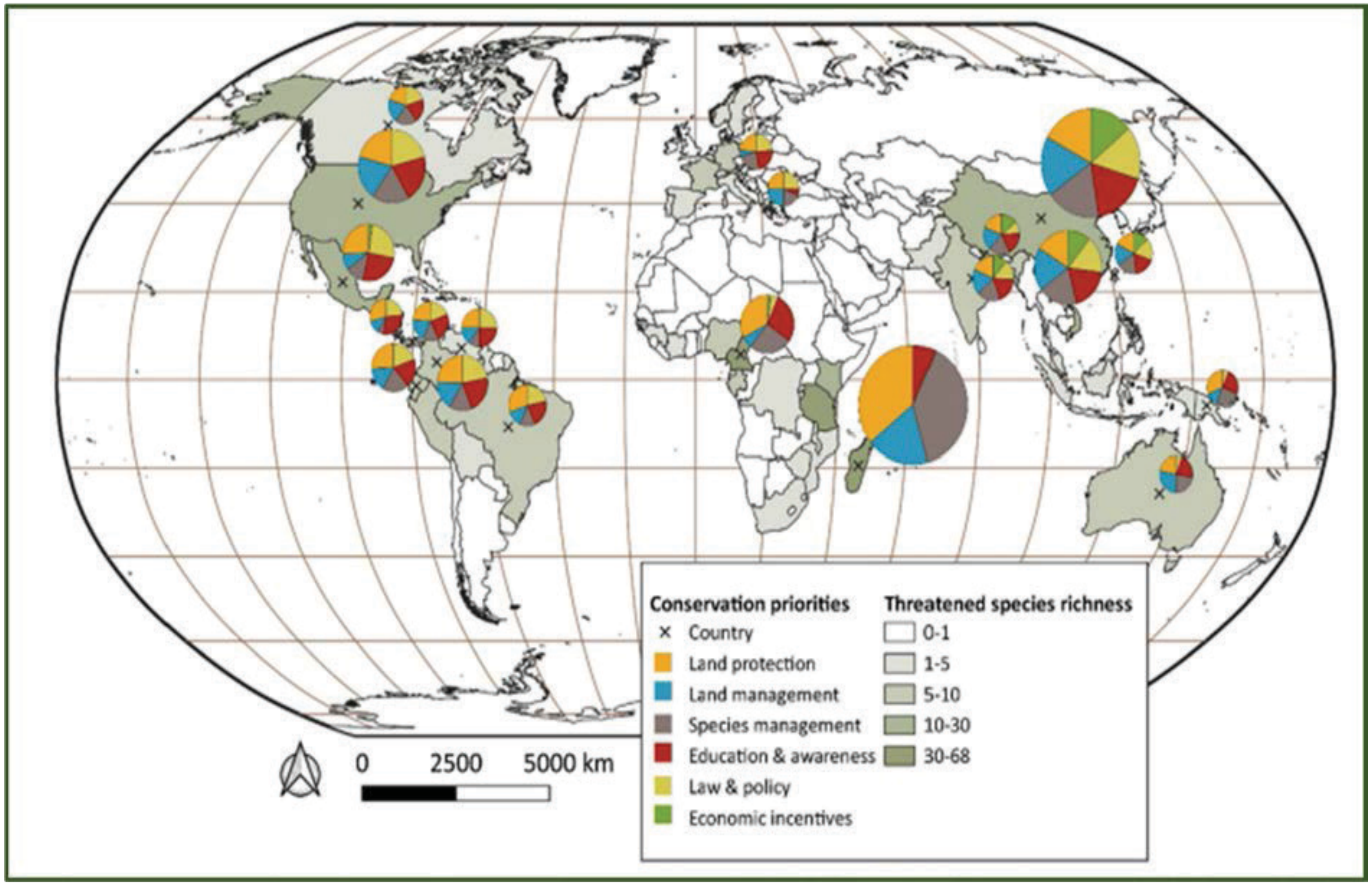
Hence, in light with these discerned knowledge gaps, it becomes imperative to prioritise research efforts judiciously by directing attention towards specific areas to effectively counteract OEC (Figure 1-4). The pervasive threats to global biodiversity exhibit a widespread pattern, with the acceleration of OS decline in terms of rate and the comprehensiveness of the challenges faced (Larsem, et al., 2011; Wraith & Pickering, 2019). Figure 1-4 illustrates the distribution of research and conservation, priorities across 20 20 identified countries.

Figure 1-3



Orchid Conservation and Research: An analysis of gaps and priorities for GloballyRed Listed Species. Source: IUCN Red List, 2019

Figure 1-4



20 Countries with the most threatened species of orchids and their associated conservation priorities (pie chart) – Source: IUCN RedList, 2019

Despite the fact that Sarawak has 2500 OS and its primary forest has deteriorated by 35% (Figure 1-1) since 2001 compared to the UK who only have 52 OS, Sarawak is not even included in IUCN red listing of key research and conservation data (IUCN, 2019). Therefore, based on the above review and the fact that Sarawak OS are declining mainly due to habitat loss (Schuiteman, 2016; GFW, 2019), ignorance among locals (Corlett, 2016; SARORSO, 2019) on OS and their conservation and the absence of botanic garden in Sarawak, there is a need to carry out research on investigating effective solutions to mitigate threats and address the **gap on orchid awareness, education, and as defined in Wraith et al, 2019** among the locals (Wraith, et al., 2019).

Thus, this research aims to address the gaps as mentioned above and also develop a theoretical framework which will create an effective way to promote awareness on OC, enhance education and improve communication in order to arrest the issue of SLEO extinction. This aims is achieved through the development of a UOBG in Sarawak maximizing the use of standard UBG features, facilities and resources available (BGCI, 2010; BGCI, 2019; Kew, 2019). The research also aims to develop a basic scientific (Seaton & Ramsay, 2005) method of the sustainable supply of seedlings as well as educational hands-on practice for school children, staff and parents (Kew, 2019) to reflect and obtain an insight into the ways that theycan be a part of the OC effort. The research aims to also explore the inclusionof arboretums in the UOBG (Volis, 2017) representing both the natural and artificial landscapeof Sarawak. The artificial landscape which is a model of a monoculture plantation acts as an alternative habitat (Liu, et al., 2018) for the ex situ conservation of orchids involving translocation, relocation and growing of OS in these arboretums (Volis, 2017; Liu, et al., 2018). It also aims to introduce the community and foreign visitors to the unique integrative ex situ OC programmes (Seaton, et al., 2010) being executed in Sarawak which in turn could inspire others to do the same. It is intended that these aims, applied as a collective effort which couldaddress the challenges relating to orchid conservation in the twenty-first century (Fay, 2018).

1.4 Research Questions

The research questions below were derived from gaps in research literatures discussed in 1.3 (e.g. a lack of research on the collaboration between a UBG and the ex situ conservation of OS, taking advantage of the facilities, resources and the potential visitors as a process to create awareness; a lack of research on collaboration with schools maximising natural resources, school laboratories and extra curriculum to create awareness, education,communication and participation among school children, staff and parents) and from the development of government policy to increase monoculture plantations (SOPB, 2012; Wong, 2018) which could act as an alternative habitat. Finally, what role does the landscape architecture play in developing the strategic landscape and public realm elements of a UOBG addressing historical heritage, roles, education, physical learning environment, structure, future roles and other aspects. It is important that the UOBG, orchid conservation, schools with orchid projects and monoculture plantations should not be regarded as individual islands but as part of the main structure. Each stakeholder including other government agencies and localscience community will need to play their role in creating awareness, education and communication through this 21st century UOBG. The research questions are as follows:

RQ1. What factors contribute to the successful collaboration between an urban botanic gardenand SLEO orchid conservation with the intention to improve visitors' experiences in relation to awareness and interest acquirement about SLEO, its conservation and its importance to ecosystem and biodiversity while visiting the UBG.

RQ2. Would an unexpected and unique experience while visiting in the proposed UOBG educate visitors (both local and foreign) to create awareness and update their knowledge, education, learning interest and commitment on SLEOs, its conservation technologies and actions which could lead to a positive impact on conservation efforts knowing that today publicEDUCATION is not the primary and initial objective of most existing BG visitors (Ballantyne,et al., 2007) ?

RQ3. Could the Monoculture Plantations be part of ex- situ conservation in cultivation of orchids in living collections?

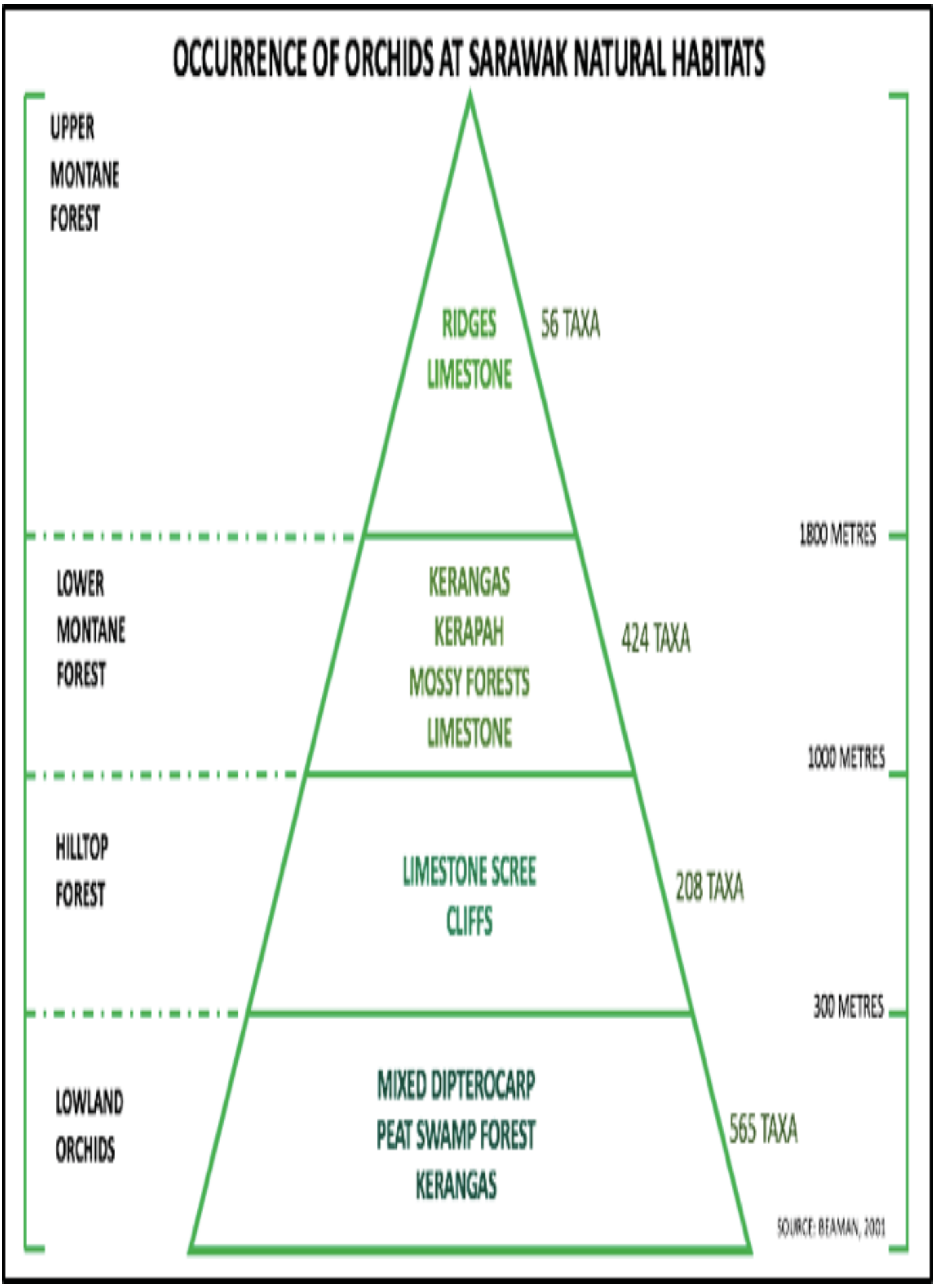
1.5 Findings

The research has identified three main factors that influences the success of the alliance between UOBG and SLEOs. Firstly, the partnership between both the UOBG (Bean, 1903; Minter, 2000) and SLEO themselves. Their challenging and complex positive history together since the 18th century, their evolution, the current global sixth extinction event as a product of human activity and their aesthetic characteristics are all points that will draw interest. Together these represent the first set of unique selling points that will be able to attract visitors which independently would lack context and not be as effective (BGCI, 2010; Kew, 2019). Interdependency is the cornerstone of effective coordination between urban botanic gardens and OS, as when they are unified, they become symbiotic for future endeavors. Factors such as: why lowland orchids were chosen, which type of habitats were suitable to be included in the proposed UOBG are based on the occurrence of OS at its natural habitat (Figure 1.5).The proposed layout of the UOBG and the clear roles of stakeholders are discussed further in Chapters 4 and 7.

Orchidologists, botanists and scientist are comparable to doctors working to battle the current Covid-19 pandemic - fighting challenging battles in monitoring the descent of orchid species on their road to extinction whilst a significant section of the public do not share the belief in taking the necessary precautions (Wolf, et al., 2018). To remedy this, the second factor is the expansion of awareness, especially in the younger generation and their parents (Eberbach & Kevin, 2017). Therefore, exposing younger children by successfully (high attendance, active participation- Plate 1.6) involving them in producing seedlings (Plate 1.7) not only as in this successful trial (86.7%- refer to Chapter 5) proves that propagating seedlings *en masse* are not an impossible task, but it also helps the children make the transition from seeing the natural world to scientifically observing the natural world (Eberbach & Kevin, 2017). Thus, successfully creating awareness and potential alliance between younger students and orchidologists/scientists in BGs (Krishnamurthi, et al., 2014). This new alliance also provides younger school children exposure to state-of-the-art facilities which complements what they practiced at school (Writhlington, 2017; SAP.ORG, 2019).

To introduce UOBGs to the younger generation, experiences found at a UOBG could also be made available at school gardens, encouraging and deepening interest in orchids whilst creating enthusiasm (Eberbach & Kevin, 2017; WSBE, 2018) and private UOBGs. Doing so could also shape school children into ambassadors for BG messages in relation to environmental and orchid conservation, contributing to the wider spread of awareness and commitment among locals (CBS, 2019). This would give rise to increases in general public visits as well as creating more awareness, interest and commitment to arrest the concern of habitat destruction and degradation. In addition, it was found that the involvement of younger children in both local and international conventions/events would draw interest from a wider audience, including other children and older groups (OCCC, 2019; APOC13, 2019; WOC 23, 2021). Issues such as a limited sample size for a micropropagation experiment (less than 1% of the number of species orchids), cost, policy and legislations, commitment, mutual respect, responsibilities and understanding are found in both in the literature review and chapter 5.

Figure 1-5



Selection of types of orchids in the UOBG is based on the above occurrence and that habitat destruction of non-Montane Forest area accounts for 61.7% of total Sarawak species of orchids. For the initial stage of the UBG, all orchids areplanted outdoors to simulate a natural environment. Source: Beaman, 2001

Plate 1-5

Four students from MRSM Kuching successfully germinated 500,000 protocorms from two green pods. As of February, there wasa100% success rate for propagation using green pods, and a 60% success rate for propagation from refrigerated seed pods Source: TATA, 2019

Plate 1-6

Twelve students from MRSM Kuching looking forward to performing experiments in the orchid propagation laboratory. Initially, just four students volunteered to participate in the Orchid Project, but in September 2019, eight additional students joined. There is still a waiting list of Year 7 students wanting to join; however, limited equipment means a limited number of participants. Source: TATA 2019

Finally, the research also investigated how the functional arboretums (Povis & Welte, 2010) representing the monoculture plantation with introduced SLEO has lead to opportunities to improve orchid conservation management, reintroduction, translocation and long term orchid ecological restoration outcomes. Therefore, representing the artificial landscape of Sarawak can shape not only the environmental learning experience but exposure to new perspectives ofvisitors to the botanic garden (Oldfield & Newton, 2012) The concept of these arboretum is based on the trial involving the introduction of either rescued orchids from areas being clearedor new seedlings, both for conservation purposes. The findings from the trial introducing SLEOinto a monoculture forest showed that success can be had when combining conservation of orchids and a monoculture plantation. The success of the trials drew interest from parties suchas other plantation owners and farmers (who were keen on replicating the trials in their own plantations) as well as international groups (who were keen on further understanding the trial as well as contributing the efforts (plate 1.7).

Establish constructive links between the public, industry stakeholders, policy makers, and the effective dissemination of scientific messages can be realised through experiential environmental learning within the BG. The interactive aspect of this experience is underscored by fostering connections among stakeholders, while an embodied perspective is emphasized to ensure direct engagement within the UOBG environment. Nevertheless, certain visitors may not establish meaningful connections before or after the experience, influenced by external factors such as political or personal interests. In-depth discussions and research among stakeholders are imperative to comprehend and address these behaviours, elucidated further detailed in chapters 2, 6. and 7.

Fig 1.6 summarises the whole research paper. The following chapters addresses a review of existing literature and discuss in detail the context of the research, its location, relevant policies, OS their conservation, threats, challenges as well as other significant limitations that will impair the effectiveness of the research.

Words 4686

Plate 1-7

The positive impact of a successful trial involving the introduction of species of orchids onto an oil palm plantation – drawing local and foreign interest and attention. Source: TATA, 2019

Plate 1-8

"A Study on the Introduction of *Dendrobium anosmum* (an Endangered Species Orchid), *Dendrobium crumenatum* and *Arundina graminifolia* into an *Elaeis guineensis* (Oil Palm) Estate in Kuching, Sarawak"

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AIM

This study aims to prove that epiphytic and terrestrial lowland species orchids can thrive when introduced into an oil palm plantation.

ABSTRACT

40 specimens of 2 epiphytic species orchids *namely Dendobium crumenatum* and *Dendrobium anosmum* where each species are mounted onto 40 palm oil trees of a small oil palm plantation. A terrestrial species orchid *Arundina graminifolia* was also introduced on the ground. Their flowering status, natural seed production and survival is monitored and recorded monthly. The results revealed that for the epiphytes, they would produce flowers collectively with a mean flowering of 10.4% across the 7 flowering periods after every rainfall event followed by production of new seedlings. It was also observed that both the *Dendrobium crumenatum* and *anosmum* growing on two different hosts produced seed pods after day 474 and 498 respectively. This signified that pollinators were present in the oil palm plantation. These results underline that oil palm plantations can be a sanctuary for the conservation of orchids and could be transformed into a biodiverse ecosystem serving as a model for future undertakings to conserve orchids with other perennial monoculture plants. Inevitably, this study will pave the way into further research and introduction trials to be done on other lowland species orchids and on other tropical green deserts.

Plate 1. Each specimen is labeled D. anosmum flowering on one of host. Source: TATA, 2018

Plate 2. Each specimen is labeled D. anosmum flowering on one of host. Source: TATA, 2018

Plate 3. Each specimen is labeled D. anosmum flowering on one of host. Source: TATA, 2018

INTRODUCTION

Orchids are one of the largest plant families and historically are commercially traded due to their economic value in industries such as pharmacology, floriculture and ecotourism as well as being known for other importance such as scientific, economical, ecological, religious and many more. 2,500 of the world's 35,000 known orchid species can be found in Sarawak. However, as the population increased and Malaysia faces increasing development in order to continuously improve the living standards of its population, corresponding natural areas, home to the orchids decrease in size and become increasingly under threat. As such, with the threats that species orchids are facing due to direct and indirect human actions and their great importance to humankind, enhancement of survival efforts such as introduction to oil palm plantations which covers approximately 12% of the State's land area is needed. These plantations are largely seen as monoculture forests and detract from the biodiversity that is present in naturally occurring forests. Other monoculture plantations such as Sago, Rubber plantations found in Sarawak, need be considered to be involved in this conservation programme. Nevertheless, low awareness among the public with regards to the importance of orchids as compared to wild animals coupled with the abundance of illegal trade has increased the exposure of orchids to depletion and extinction.

OBJECTIVES

1. To explore ways to conserve endangered Epiphytic and Terrestrial species orchids in alternative appropriate habitat
2. To examine the extents of success of the introduction of two Epiphyte and a Terrestrial species orchid (Dendrobium anosmum, Dendrobium crumenatum and Arundina graminifolia) in establishing or significantly augmenting viable, self-sustaining populations in nature; emergence of flowers, roots, shoots, new seedlings and seed pods.
3. To determine the conditions under which we might expect species orchid introductions to be most successful; productive rates as well as dormancy periods and the species orchids response to different climatic conditions.
4. To make the results of a survey available for future orchid introduction trials in oil palm since oil palm and other alternative areas, to assist medium to long term conservation planning of future lowland orchids.
5. To act as catalysts for the restoration of at least part of the original ecosystem which is badly effected - the lowland and wetland.
6. To encourage more pollinators to be attracted to the trial site.
7. To investigate the existence of mycorrhizal fungi and its symbiotic relationship with orchids.
8. To encourage natural propagation, development of orchid seeds that are produced from naturally pollinated flowers may be blown to the safe sites where appropriate mycorrhizal fungi are present, thus creating natural germination and subsequent establishment.

METHODS & MATERIALS

- *Dendrobium anosmum*: regarded as an endangered species with high economic value
- *Dendrobium crumenatum*: regarded to have medicinal value
- *Arundina graminifolia*: endangered due to development

EPIPHYTIC ORCHIDS

- 40 specimens of each orchid species were prepared and labelled. (Plate 1 & 2)
- To protect exposed roots, they were wrapped in soaked coconut husks, anchored to the host using eco-friendly rope.
- Labelled plant specimens
- Orchid specimens are arranged on each of the 10 selected hosts each row for each of 4 rows of oil palm trees. This is referred to as a Trial.
- The observation of the orchid specimens last for a period of 474 days.

TERRESTRIAL ORCHIDS

- The specimen was prepared and labelled.
- On the plantation, the location with highest sunlight intensity was identified and a 1-foot deep hole was dug.
- The specimen was placed in a 1-foot deep hole and its roots covered.

IMAGES

Plate 4. *Den anosmum* translocated onto Oil Palm trees. Source: TATA, 2018

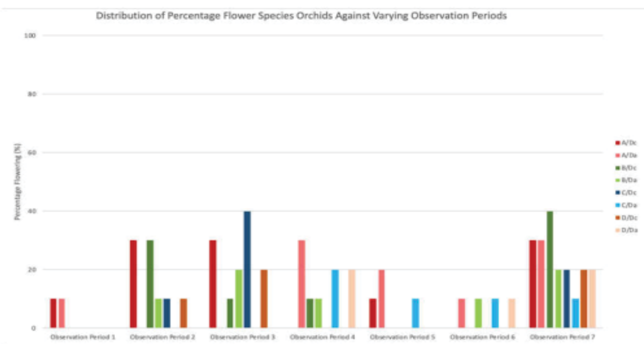
Plate 5. Development of *Den anosmum* after 31 months of translocation. Source: TATA, 2020

Plate 6. *Den crumenatum* flowering on a host. Seen here in yellow is the first seed pod. Source: TATA, 2018

Plate 7. *Arundina graminifolia* after 4 months of planting. Source: TATA, 2018

Plate 8. Oil palm plantation, SABAKI farms taking part in conservation efforts. Source: TATA, 2018

RESULTS



The chart above depicts the data recorded during the 7 Observation Periods from June 2018. Flowering status and life of plant were the only criteria recorded as orchids are commercially valued based on aesthetics and flowers are key for pollination purposes.

DISCUSSION

The flowering event of both fragrant tropical *Dendrobium crumenatum* and *anosmum* seem to be associated with temperature change. It is observed that after a period of heavy rainfall (exact temperature was not recorded) the development of flower buds was promoted. Unlike the flowers of *Dendrobium crumenatum* which lasted only for 24-48 hours, *Dendrobium anosmum* flowers have potential commercial value as the flowers lasted for more than 7 days after blooming and could potentially last longer if the temperature remained cool after blooming. After the development and wilting of flowers, keikes and minimal seed pods were produced. However, it was noted that *Dendrobium nosmum and crumenatum* which were mounted on a fruit tree *Annona muricata* nearby, produced seed pods consistently after most flowering events (not part of experiment). *Arundina graminifolia* grew from a single plant to a healthy clump of 37 plants within 5 months. It continued to flower with or without rain and produced seed pods.

CONCLUSION

This trial is at a very preliminary stage. More detailed data on growth, foliage and pseudobulb recording needs to taken. Nevertheless it has shown positive results towards orchid conservation and sustainability. Time is a factor and the number of species orchids introduced in the trial needs to be increased.

Despite *Dendrobium crumenatum* being highly scented and commonly found and producing plenty of seedpods in its natural habitat, *Dendrobium crumenatum* did not seem to be as easily pollinated in the trial site. Fragrant *Dendrobium anosmum* (already classified as an endangered species and last found in the wild in 2002) on the other had naturally produced two seed pods a month earlier than *Dendrobium crumenatum* in trial site. It can be understood to mean that the pollinators of both Dendrobium crumenatum and anosmum are present at the farm. The presence of seed pods of *Dendrobium anosmum* and *crumenatum*, naturally pollinated by its respective pollinators send an invaluable message important for conservation efforts on species orchids in Sarawak supporting the species survival. With this finding, the massive 1.58 million hectares of oil plantations could very quickly be the 'Noah's Ark' for endangered Sarawak epiphytic orchids which would also potentially improve the biodiversity of oil palm plantations, encourage new seedlings of orchids without affecting the productivity of oil palm. Terrestrial orchids could act as hedges due to how it thrived.

THE FUTURE

The establishment of an ex situ orchid conservation database would greatly facilitate conservation efforts involving the public through awareness programs regarding plant extinction carried out by botanical gardens which will represent the daily life of the community (e.g. the oil palm workers and shareholders, and secondary school children and their family). With refinement, the database could be used for conservation breeding of native SLEO. With a database, it helps better the understanding of the strengths and weaknesses in terms of which species are growing and thriving ex situ and which are still in situ, in need of immediate protection. We could then better focus our limited resources towards ex situ conservation on orchids that are threatened with extinction in situ. A "proof of concept" example of a database is the Living Orchid Collection. If and when the ex situ conservation database is established, it will require dedication and commitment from the orchid world in South East Asia in order to further improve the region's ecosystem. Oil palm trees are perennial with 30 years of productive life span and this could increase further as new varieties of oil palm is developed. Hence, they and other perennial monoculture estates need be explored as alternative habitat sites for lowland Epiphytic and Terrestrial orchids. In addition, integration of orchids into oil palm estates holds enormous potential of a sustainable orchid floriculture industry and creates a sustainable value added product to the oil palm committee which can be applicable throughout the whole of Sarawak.

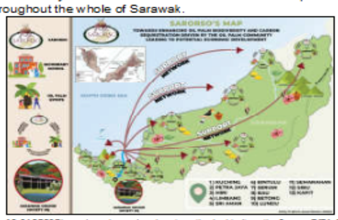


Plate 10. SARORSO's roadmap towards enhancing oil palm biodiversity. Source: TATA, 2021

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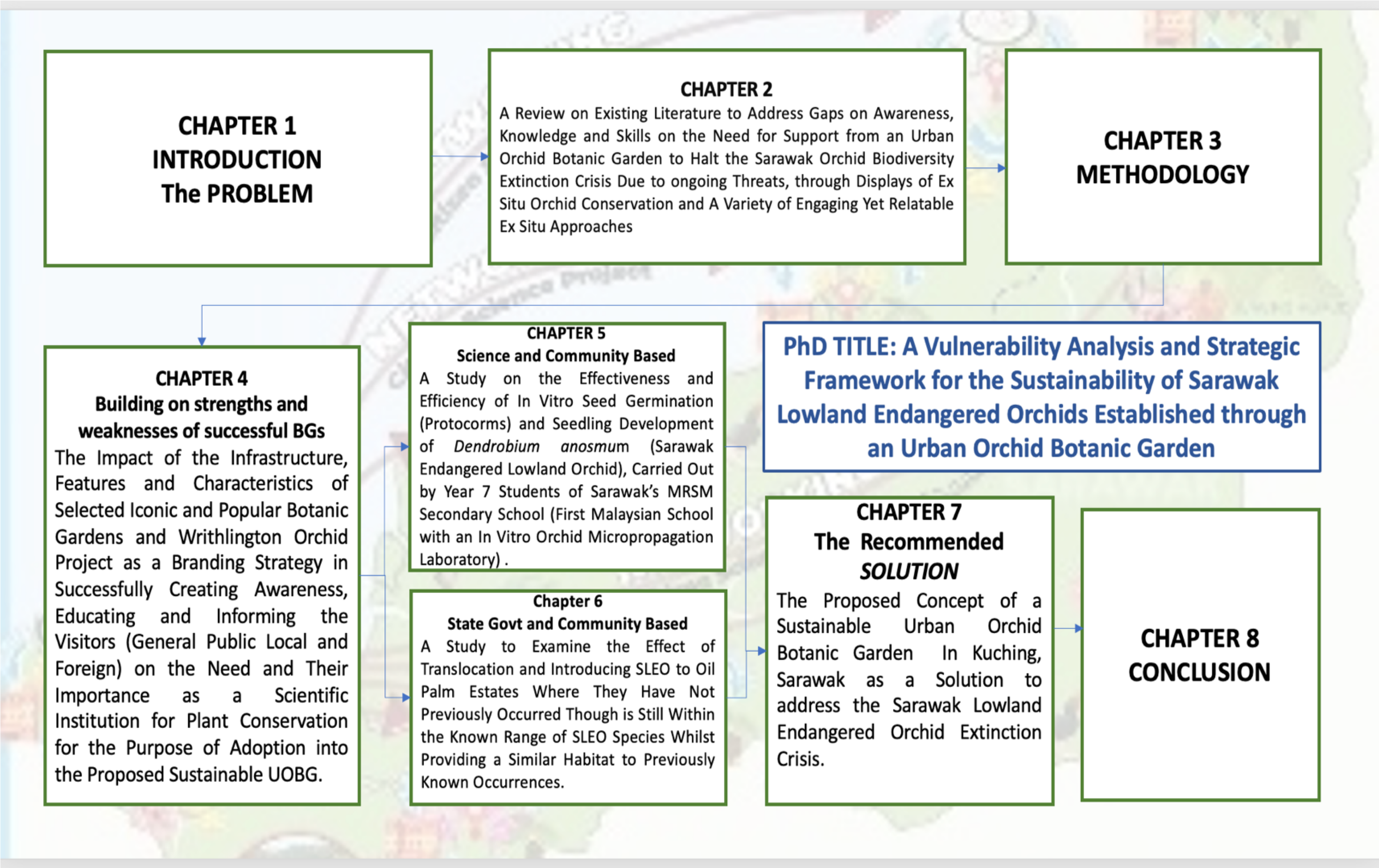
An invitation to present a paper – A Study on the Introduction of Endangered Dendrobium anosmum, Dendrobium crumenatum and Terrestrial Arundina graminifolia – with Medicinal Value,onto an Oil Palm Estate for Orchid Conservation Purposes. Source: TATA, 2020

Plate 1-9

Participation by the MRSM Form 2 students representing Malaysia for the first time regarding Orchid Ex Situ Conservation at international level during the Virtual World Orchid Conference in 2021. The conference was supposed to be held in Taiwan in March 2020, but, due to COVID-19, was postponed to 2021 and held virtually instead. Awareness programme well acceptedby students. Source: WOC, 2021

Figure 1-6



The diagram denotes the chapter schedule for the thesis

CHAPTER 2

2 Literature Review- Bridging Knowledge Gaps In Species Orchid Botanic Garden for Effective Ex Situ Conservation in Sarawak

2.1 Background of Study – the Problem

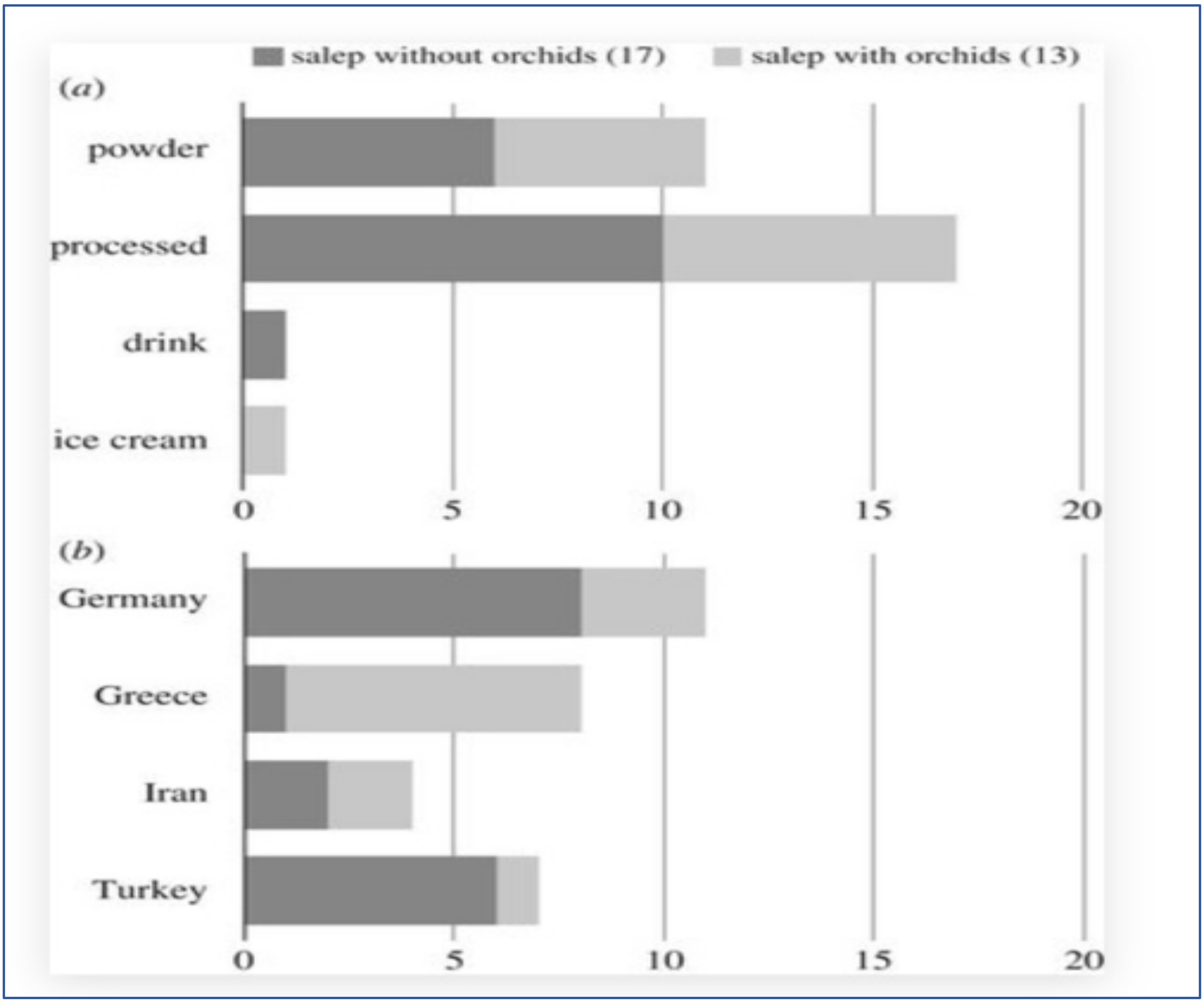
A comprehensive literature review is undertaken to address lacunae in awareness, knowledge, and skills pertinent to advocating support for an Urban Orchid Botanic Garden (UOBG). This endeavour aims to mitigate the ongoing Sarawak OS biodiversity extinction crisis, attributable to persistent threats, through an exploration of ex situ conservation approaches. Firstly, to address the gap in awareness, knowledge and skill in relation to OS extinction crisis in Sarawak , one need to understand the current situation of Sarawak, its dynamic history since the arrival of James Brooke in 1839 (Brooke, 2018) needs to be understood. Local literature on the Sarawak orchids species (OS) is scarce; hence most of the information was sourced from books written by European travellers since 1841 (Russan & Boyle, 1893; Mjoberg, 1930; Low, 1968). A comprehensive literature review is undertaken to address lacunae in awareness, knowledge, and skills pertinent to advocating support for an Orchid Botanic Garden. This endeavour aims to mitigate the ongoing Sarawak Orchid Biodiversity Extinction Crisis, attributable to persistent threats, through an exploration of ex situ conservation approaches.

With over 35,000 documented species (Go, 2019; Go, et al., 2020) and the ongoing identification of 300 to 500 new types annually (Hind, 2019), Orchidaceae is the largest family of angiosperms globally, affirmed by Dr Philip Cribb, an esteemed orchidologist and Honorary Fellow of the Royal Botanic Gardens, Kew (RBGK). This assertion finds support in the 2020

IUCN SSC Orchid Specialist Group Reported by Dr Michael F Fay(Stone & Cribb, 2019; Fay, 2020). Despite an earlier proclamation in the 'State of the World's Plants' report from RBGK, in 2017, that the Asteraceae family held the title of the largest, comprising about 9% of all angiosperms (Willis, 2017; Hind, 2019), OS persists as paramount species for plan conservation and ecological monitoring (Basu & Cetzal, 2015; Nossa, 2016; Fay, 2018). This significance is particularly emphasized in mega biodiversity-rich countries due to their intricate abiotic and biotic dependencies (Gale, et al., 2018). OS also wield economic importance in horticulture and floriculture, as exemplified by the Netherlands' orchid exports valued at €69.39 million in 2019 (Gleder, Von Koen, 2021).

Beyond their role in mega biodiversity-rich countries, OSs carries ancient economic importance with documented medicinal value in China dating back to 2800 BC (Petrovska, 2012; Hinsley & Fay, 2018). Their pharmaceutical qualities have been explored (Bulpitt, 2005; Pant & Raskoti, 2013), and they are traditionally utilised in food and beverage in Sarawak (Bodos & Sang, 2019), Turkey, Zambia (Pain, 2017; Edrogan, 2018; Zhang & Hu, 2018) and other countries (refer to Figure 2-1) .(Subedi, et al., 2013; Hinsley, et al., 2017; De Boer, et al., 2017; De Boer, et al., 2017). Consequently, in addition to their ecological and economic value, the extinction of OS prior to comprehensive scientific study would entail the loss of invaluable traditional knowledge which intertwined with their cultural significance (Bodos & Runi, 2019; Seyler & Ya Tang, 2020).

Figure 2-1



Huge demand for orchid tubers as food led to illegal harvesting and trading. The presence of orchid species (terrestrial) in food products has been detected in various countries and samples. Harvested tubers are washed in water, dried and processed. Up to 30 tons of orchid tubers are processed annually just in Turkey; In Iran, 5.5-6.1 million orchids are harvested and exported for consumption; Prices in Greece range between €55-€150 per kilo. Source: De Boer, 2017

This substantiate scientists' apprehensions about vanishing forest, particularly in developing countries, characterised by extensive floristic diversity. Dr Michael Fay, a Kew scientist, underscores this concern, reporting 90% of Orchidaceae face a severe and unprecedented threat of extinction (Fay & Rankou, 2015; Fay, 2018). Dr Andre Schuiteman the RGBK Asia research leader, further supports this claim, attributing the OECwho has claimed that the (OEC) primarily to extensive and unsustainable deforestation, leading to habitat destruction in biodiversity 'hot spots' (Schuiteman, 2016). Given that 80% of Orchidaceae are epiphytes (Beaman, et al., 2001; Zhang & Hu, 2018), relying on tree limbs for support and using dangling aerial roots to gather moisture, their survival is intricately tied to Tropical Forest environment (Fay, 2018; Go, 2019; Go, et al., 2020). In mega biodiversified tropical developing nations, the OS biodiversity decline is exacerbated by factors like global warming, urban expansion-driven infrastructure development as in developed countries, unsustainable harvesting for survival, illegal trading in extensive international markets, and insufficient enforcement of legal protections along with sluggish OC legislation (Gao, 2018) (refer Table 2-1) (Fay, 2018; Gale, et al., 2018; BGCI, 2021; BGCI, 2021). Consequently, BGs strategically placed in different regions, with a focus on endemic orchids, become imperative in these OS-rich, biodiversified nations. Each BG can contribute significantly by undertaking diverse ex-situ conservation initiatives and advancing the understanding of OS pollination biology to mitigate the risk of extinction (Heywood, 2010; Gao, 2018).

Table 2-1

CHALLENGES FACED BY ORCHIDACEACE GLOBALLY			
	Threats	Details	Actions Taken
1.	**Global Change**	Influences species distribution due to migration and translocation to climatically suitable localities. May effect propagation due to absence of pollinators.	Conserving the habitats where orchids and their host trees grow and establish reserves.
2.	**Habitat loss/destruction**	25 'Hotspots' of biodiversity have lost two-thirds of their pristine habitat, many about to go extinct or are threatened with extinction.	Orchid Conservation Alliance (OCA) establishes reserves preserving habitats, orchids, pollinators and genetic biodiversity, where they exist. This includes translocation and seedbanks.
3.	**Changing land Use**	High turnover in species composition of orchids in communities because of changes in land use.	Need for knowledge of the full components necessary to ensure the presence of pollinator, successful pollination, pollinators sources of food, nesting sites, shelter for reintroduction programmes.
4.	**Illegal Trade**	Species collected in developing countries illegally and sold across international borders illegally for traditional consumption or medication or under the pretext of scientific purposes.	Convention on International Trade in Endangered Species (CITES) to monitor and address online illegal orchid trade and all platforms
5.	**Unsustainable Utilisation of Biodiversity**	Population increases put pressure on the ecosystem by increasing productivity, exceeding the limit of the earth's capacity.	Addis Ababa Principles and Guidelines for the Sustainable use of Biodiversity
6.	**Unsustainable collection/ harvesting**	Indiscriminate and systematic collection for horticulture has had major impacts on certain orchids, e.g. Renanthera, Bulb kubahenses to the point of extinction.	To regulate and document orchid trade, research trade dynamics and impacts of harvest, strengthening and tracking legal trade and raising the profile of the orchid trade among policymakers, conservationists and the public.

Orchidaceae are facing severe and unprecedented threats globally. Source: Fay, 2018

2.2 Global Conservation Orchid Conferences and Conservation Organisations

For three decades, since the Rio Earth Summit in 1992 (UN, 1992) scientists, orchidologists, horticulturists, researchers and orchid enthusiasts worldwide have been making concerted efforts to understand the biology of OS. They have increasingly called for more OS conservation efforts, which led to the First International Orchid Conservation Congress (FIOCC) in Australia in 2001 (Cribb, et al., 2003). This resulted in various conferences and the publication of papers (CBD, 2019; CBD, 2020; CBD.int, 2020; Seaton, et al., 2021). However, despite the above efforts, treaties such as the Convention on International Trade Endangered Species (CITES) of Wild fauna and Flora also known as the Washington Convention, the implementation of wildlife protection laws by many countries, establishments of organisations such as the International Union for Conservation Nature (IUCN) Species Survival Commission's Orchid Specialist Group (OSG, 2020), and the existence of 3,735 BGs around the world (BGCI, 2021) as major centres for attracting visitors (Pautasso, 2007; BGCI, 2021), there is still a documented increasing trend in the decline in the number of OS, as recorded in the IUCN Red List. This list excludes most orchids from South-East Asia, where listing is still very poor (Seaton, et al., 2013; Saw, 2015; Wraith & Pickering, 2018).

Based on the increasing OEC leading to a decline in orchid population and biodiversity worldwide, different strategies for addressing the worldwide OEC have been highlighted, discussed and adopted by scientists and relevant stakeholders. These are more action-oriented and involve the community (BGCI, 2017; IUCN, 2019; Sarasan, 2020; BGCI, 2021). Besides the establishment of a Global Network of Orchid Seedbanks (GNOS) as a practical and effective ex-situ conservation method (Seaton, 2007; Seaton, 2011; Liu, et al., 2020), BGs are traditionally known to devote their resources to studying and highlighting conservation efforts in countering plant extinction (Swarts & Dixon, 2009; Mirenda, 2011; Gao, 2018; Smith, 2018) as well as displaying the importance of plant diversity in order to create awareness and educate the orchid community and the public (Swarts & Dixon, 2009; Oldfield, 2010; Gratzfeld, 2016; Gao, 2018; Westwood, et al., 2020).

Swarts and Dixon (Swarts & Dixon, 2009) reviewed the role of BGs in supporting OC scientifically and horticulturally through their orchid displays as living museums, best defined by Dr Timothy C. Hohm, as a 'collection of plants for documentation, preservation for current and future research, conservational, educational and exhibition/display needs' (Hohn, 2004). Pedersen and Sebree (Pedersen & Seberge, 2018) discovered that BGs with living collections offer a more diverse contribution, with the application of new technology such as DNA barcoding, which provides new identification and inventory tools, phylogenies for improved conservation priorities, cryopreservation for millennium-long ex-situ conservation and large-scale micropropagation for recovery programmes.

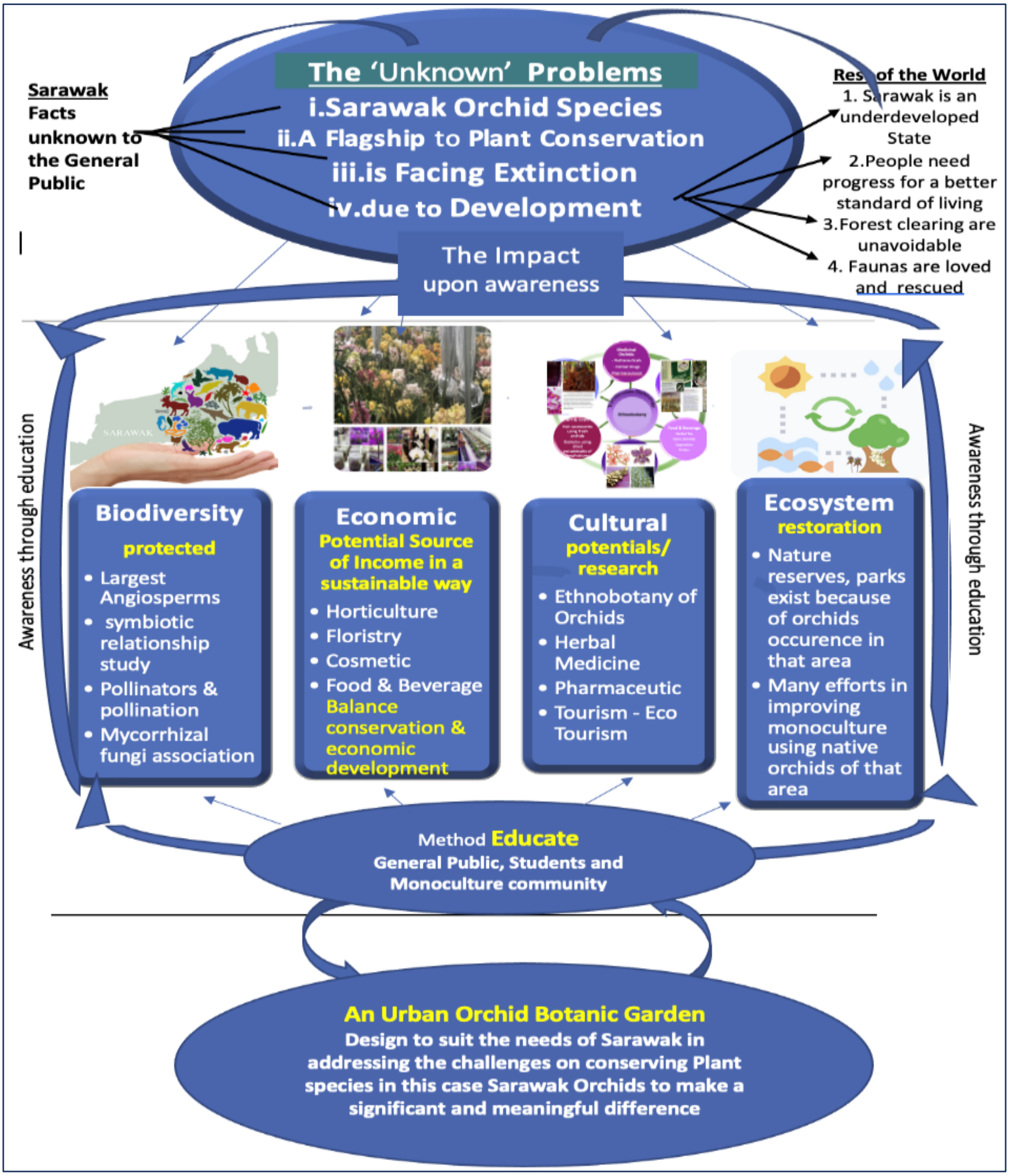
However, according to Fay (Fay, 2018), with the accelerating decline of the earth's natural life-support systems, there is a demand for more action-oriented measures to address the OEC with various integrative conservation approaches in order to effectively create awareness and educate the urban public through Urban Botanic Gardens (UBGs), such as the Kew Gardens' Annual Orchids Festival's vibrant and educational display in the historical Princess of Wales Conservatory, RBGK (RBG, 2019), the educational Evolution of Land Plant Display of University of Bristol Botanic Garden (UOB(UK), 2021) and the Garden of Medicinal Plants in Chelsea Physic Garden (Minter, 2000; CPG, 2020). Other approaches are habitat protection (such as the Western Australian Environment Protection Authority-WAEPA project); buying and preserving 'hot spots' (Hennigan, 2007), creating horticultural reserves through necessary and sustainable collections (Nandwani, 2014; Fay, 2018; Plant Heritage, 2021) seed-banking

(Minter, 2000; Ray, 2007; BrisBG, 2021; Seaton, et al., 2021) and the Access and Benefit-Sharing (ABS) partnerships projects (Normand, et al., 2020). These are just some of the activities of some of the 3735 BGs around the world, representing biological institutions that perform effective plant conservation. Some of these BGs are either under the Botanic Gardens Conservation International (BGCI, 2021) and the American Public Garden Association (APGA, 2021), having the same objectives of creating awareness, educating and delivering effective OC messages as well as developing skills in visitors.

However, the BGCI's Manual on Planning, Developing and Managing Botanic Gardens (BGCI, 2016) proposed that a new UBG should be tailored according to the objectives and conservation gaps in the area, addressing both the environment and community needs in order for the BG to be effective and successful (Dodd & Jones, 2010; Gao, 2018). Therefore, using selected successful BGs as yardsticks, and based on the Global Strategy for Plant Conservation (GPSC) 2011-2020 goals (Sharrock, 2020), whether these BGs have successfully delivered effective OC in preventing the loss of OS, as well as essential genetic diversity by meeting the GSPC goals in each respective country, needs to be investigated and assessed (Chapter 4). This is to ensure that the layout and features of the new BG meet the conservation need of the country and the use of prime urban land with the projected costly development and high maintenance of the BG, as experienced by successful BGs around the world (RBGK, 2020; NParksSGB, 2020; CPG, 2018).

Next, lessons from existing established BGs in both developed and developing countries, especially in the tropics and subtropics, which are either ineffective, moribund or barely functioning in addressing OEC issues (Qumsyieh, 2017; Mounce, et al., 2017), need to be assessed too. This is because, despite the extensive efforts by local scientists and law enforcement agencies, the remaining orchid habitats are currently still being unsustainably cleared in both developed countries, such as the High-Speed Rail (HS2) London-Birmingham project, UK, which destroys ancient woodlands (Woodlandtrust, 2020) and the Rail Corridor Project in Kranji Woodland, Singapore (Qing.Ang, 2020), and in developing and countries in Asia which have established BGs. Finally, there is also a need to assess the effectiveness of the display and set up of highly visited BGs, which attract millions of visitors (Ballantyne, et al., 2007; Smith, 2017; RBG, 2019; Giovanetti, et al., 2020), such as RBGK and Singapore Botanical Garden (SBG), thus creating public awareness, education and knowledge around addressing the OEC in various countries. Therefore, in this context, the establishment of the first UOBG in Sarawak based on existing successful BGs (Smith & Brown, 2017) with a modern integrated concept (Mounce, et al., 2017) could play an effective role in the conservation of orchid biodiversity (Dumont, et al., 1996; Go, 2016; IUCN, 2019; IUCN, 2021). This, this would address the prioritised knowledge gaps mentioned in Chapter 1 (IUCN, 2019; Wraith, et al., 2019), as well as the Sarawak OS identified ‘problems’ (Figure 2-2) of the current Orchid Extinction Crisis (OEC) resulting from pristine forests being cleared for development.

Figure 2-2

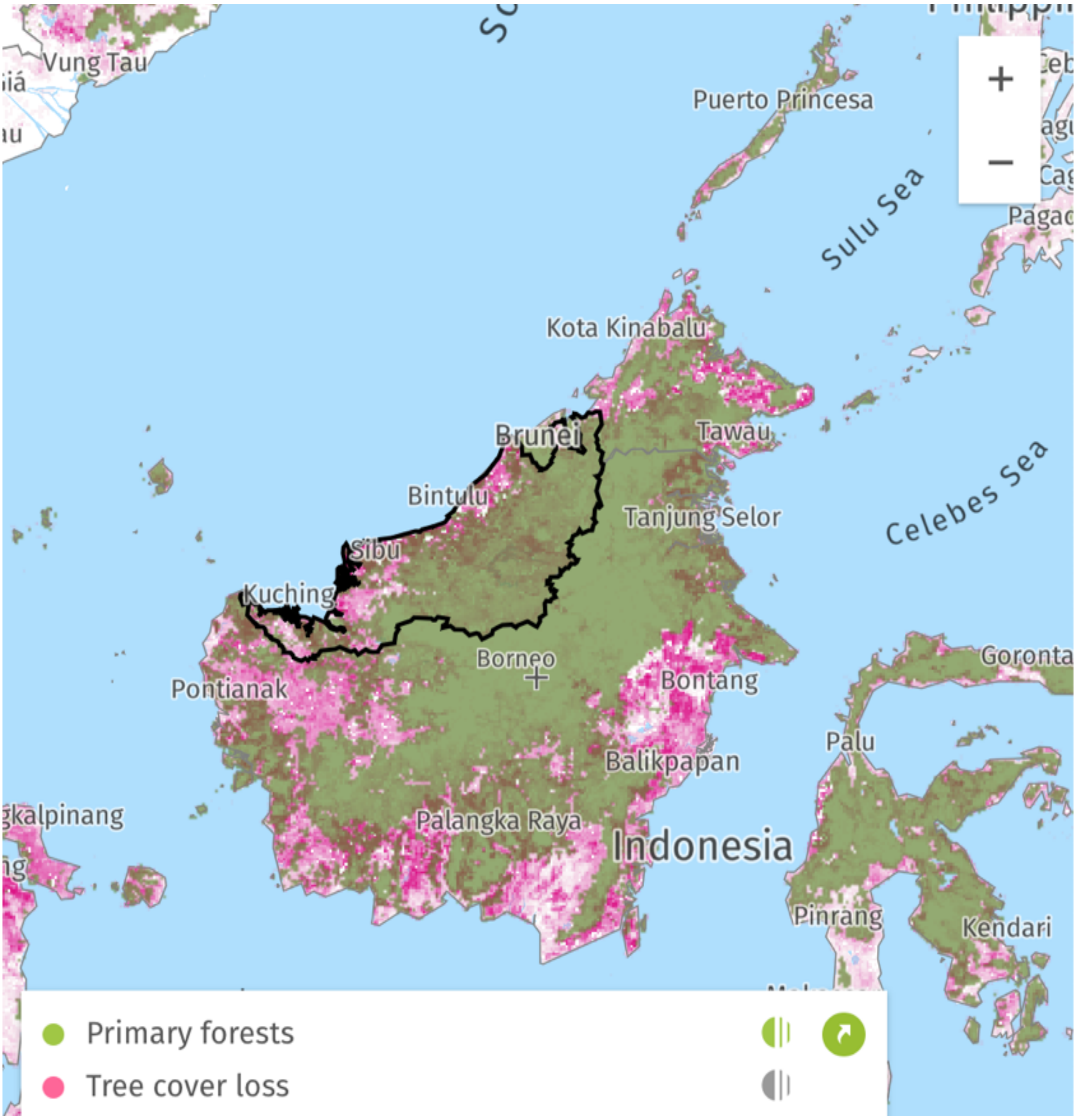


Denotes the current problems exacerbating the OEC. It is clear that OS plays a significant role in many aspects, such as biodiversity, economy, culture and the ecosystem. However, despite its importance, the OEC persists due to the public being unaware of OS and its significance. OEC is claimed to be the direct product of development and one of the keys to helping scientists combat it through raising awareness among the public. Source: Tengku, 2021

2.3 Review of Study Area

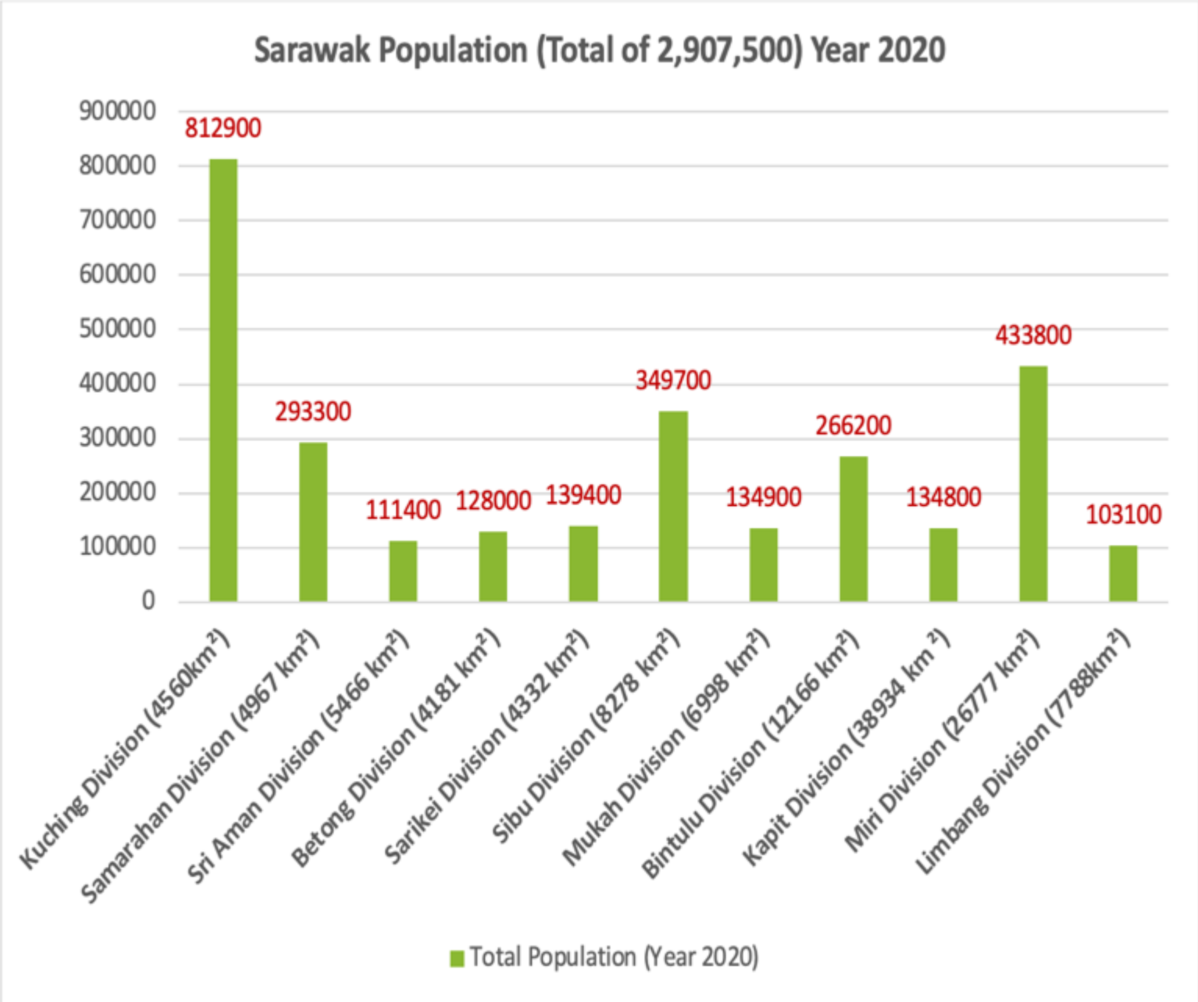
Sarawak, with an area of 124,450 km² – a state the size of England, is also known as the 'Land of the White Rajahs' (Reece, 1993; Reece, 2004). It is the largest Malaysian state, located immediately north of the Equator between latitude 0° 50' and 5°N and longitude 109° 36' and 115° 40' E, on the north-western shore of Borneo Island (SAR Gov, 2020). To the northeast, the state borders Brunei Darussalam and Sabah (West Malaysia), and to the southeast, it borders Kalimantan (Indonesia). Since the early 1800s, the arrival of James Brooke in 1839 has provoked interest in Sarawak by the English East India Company (Keane & Cawston, 1993; Brooke, 2018) and the British government (Irwin, 1954; ForSar, 2020). Its population is 2.91 million, equating to only 9% of Malaysia's population of 32.58 million in 2020 (SAR Gov, 2020; DOSM, 2020) and 4% of England's population of 67.1 million (ONS, 2020). The average density for Sarawak is 23 people per square kilometre (see Table 2-1below), but the Kuching division (made up of Kuching city, Lundu and Bau town) has a density of 180 people per square kilometre, eight times more than Sarawak's. However, if we only consider the capital, Kuching city, excluding Bau and Lundu towns, the density is 402 people per square kilometre (SAR Gov, 2020), far from London's figure of 5,701 people per km^2 as of 2019 for an area of 1,572 km^2. Meanwhile, the population density of Kuala Lumpur, the capital city of Malaysia, is 6,890 people per square kilometre for an area of 243 km^2. Therefore, Sarawak's cities and towns have a lot of potential to develop further due to having more space for development. However, there are pros and cons to an increase in Sarawak's population for the ecosystem and environment even if conservation and town planning are attended to sustainably. The advantages include innovations to the industrial, medical and agricultural sectors, as well as economic growth. There are also disadvantages, such as food shortages, property shortages and, most importantly in this context, the clearing of forests, which in developed industrialised countries around the world has led to the decline of species diversity and even extinction events (Davis, 2020).

Plate 2-1



Sarawak Primary Forest, which remains at 78.4%. Source Satellite Picture Global Forest Watch, 2020

Figure 2-3



Total population in the state according to its administrative divisions for 2020. With Kuching Division (Kuching, Lundu and Bau) having the largest population (812,900 within an area of 4,560 km)^2, it shows that Kuching is the highest densely populated, at 178 people per square km^2. However, the density of Kuching city 711500/1768km^2 is 402 people square km^2.

Source: Sarawak Government, 2020.

Its unparalleled rainforest is among the 12 mega biodiverse hotspot regions worldwide with a remaining 79% forest cover according to the Sarawak Forest Department Land use classification, 2020. It occupies 9.8 million ha (pristine forest, 64.89% and secondary forest, 14.25%), agriculture, 2.1 million ha (14.25%), settlement, 393.3 thousand ha and water bodies 149 thousand ha (Sarawak Forest Corporation, 2019; Cbd.int, 2021). Its total green cover sustains some of the highest levels of biodiversity and carbon storage in the world, rivalling the forests of New Guinea, Africa and the Amazon (Qie, et al., 2018). It provides vital ecosystem services, which supports the state's citizens, including their indigenous communities of 21 ethnic groups (Lee, 2000), as well as the world's population (Alamgir, et al., 2020). Sarawak, an underdeveloped state, has a complex geology, distinctive ecosystem diversity, a unique topography of large coastal lowlands, comprising peat swamps and narrow deltaic and alluvial plains, a large region of undulating hills ranging to about 300 metres and mountain highlands with peaks exceeding 2000 m.a.s.l. It borders Kalimantan, Indonesia with a matrix of limestone, sedimentary rocks and ecological diversity (Soepadmo & Wong, 1995; Clark, 2010; Go & Pungga, 2018).

Sarawak's equatorial climate provides a temperature consistently within the range of 23°C early in the morning to 32°C during the day for lowland areas, but a lower 16°C (it gets as low as 11°C on some nights) and 25°C during the day for highland areas, with abundant and uniform rainfall. There is an average rainfall per annum between 3,000 and 4600 mm, giving rise to a multiplicity of rivers, the longest flowing from the mountain ranges of the Sarawak-Kalimantan border, and the shortest flowing into the plains of the middle Sarawak (Hansen, 2016; Kuok, et al., 2021). There is a relatively uniform humidity of between 80% and 90% (SAR Govt, 2020). This climate gives ideal conditions for not only the family of Orchidaceae but all other plant life endemic to Sarawak (Beccari, 1904; Wallace, 1962; Low, 1968; Mjoberg, 1930; ForestSWK, 1995; Beaman, et al., 2001; Low, 2002; ForestSwk, 2019).

In addition, Sarawak was highlighted by the botanist and governor of Labuan, Hugh Low, and a resident of Bintulu, A Hart Everet, in their early books (Low, 1968; Everett, 1878; Lusco, 2020) to be rich in mineral resources aside from timber. Everett said: 'Sarawak will be found wealthy in minerals resources at some future day'. Today, Sarawak boasts of a coastline of 1051km rich with high-quality silica sand (SiO_2), with deposits of 73.0 million tonnes (Ali, 2003; JMG, 2019), and other minerals such as petroleum, gas, coal, kaolin clay, gold of 10.66 MT (MT, 2013; Bong, 2020), antimony (Sb) (Dill & Horn, 1996; Tawie, 2018), potential hydrogen power 20,000mega watts (Oh & Goh, 2011; Fam, 2017); and marine fish production potential of 582,800, tonnes per year (DOF, 2020).

2.4 Sarawak Forest – the Threatened Ancient Habitat

The 130 million-year-old mega-diversified Sarawak rainforest (Clark, 2010; Shoumatoff, 2017) once entirely covered a state the size of England (Low, 2002). It comprises nine primary structures of forest, as per

Table 2-2 below, and 10,000 different intermingled species and individuals (30% is endemic), where, within less than a square mile, a hundred or more different types of valuable tree species can be found (WWF, 2010; ForestSwk, 2019). This has made Sarawak known for its timber exports due to the high quality and commercial value of the product (FRIM, 1995; ITTO, 2017; ForestSwk, 2019; ForSar, 2020), such as the durable *Eusideroxylon zwageri* (ironwood tree), which can last for more than 200 years even under adverse circumstances. There are at least 20 types of dark, hardwoods, such as *Diospyros* (Sarawak Ebony), *Koompasia beccarina* and *Koompasia excelsa*, which bees love to nest in, the Sarawak vegan butter tree *Shorea macrophylla* (Engkabang), *Lansium domesticum* (Langsat), used for a range of HIV strain cures, and the *Antiaris toxacaria* (Upas), whose venom is used by the indigenous people as a weapon (FRIM, 1995; ForestSwk, 2019).

Table 2-2

	Types of Forests	Vegetation	Orchids Availability
1	Beach	i. *Casuarina equisetifolia (Rhu Laut)* belt, ii. *Mixed beach fores*t – sandy soil, iii. *Oncosperma horrida (nibong)* forest – unconsolidated sand, iv. Shrub and herbaceous vegetation – rocky areas, cliffs	The lower elevations, from sea level to 800m, have the biggest collection of orchids, from the 19th to the early 20th centuries in contrast to the situation in Sabah. However, this is because many of the higher elevations have not been visited by collectors due to their dangerous physical structure.
2	Saltwater Swamp	i. Sonnratia spp (pedada) forest, ii. Avicennia alba (api api) forest, iii.Rhizophora spp (bakau) forest iv. *Xylocarpus spp (nyireh)* mixed forest, v. *Nipa fruticans* (*Nipah*) Swamp, vi. *Nibong (Oncosperma horrida) swamp*	
3	Peat Swamp	i. *Gonystylus banca* ii. *Shorea albida (alan bunga)* iii. *Shorea pachypilla,(kerukup*), iv. *Dactylocadus stenostacys(jongkong), v. Campnosperma spp (terentang), vi. Alstonia pneumatophore (pulai), vii. Dtyobalanops rapa (kayu paya), Litsea palustreas (medang padang), viii. Combreptocarsus rotundas (keruntum), ix. Cratoxylan galucum (geronggang puteh), x. Tristanopsis spp (selunsor), xi. Palaquium spp (nyatoh), xii Parastemom spicatum (nyalas)*	
4	Mixed dipterocarp	70% *Dipterocarpaceace*	
5	Kerangas (dryland) and Kerapah *(heath)*	i. Flat terrain – unfertile ii. Undulating to low hilly iii. Hilly with bold topography iv. kerapah-flat terrain often marshy or peaty and flooded during rainy seasons	
6	Riverine	i. Riparian forest (occasionally flooded but well-drained) ii. freshwater swamp forest	

7	Montane	i. Lower montane – 1000-1800m – Mossy Forest ii. Higher montane – Upper Montane Forest	Lower collections Many higher elevations have not been visited
8	Limestone	600 species highly endemic, greatest biodiversity	
9	Special Forest	Forest Plantations: newly planted forest trees Non-Forest: Rice fields, temuda, rubber, oil palm, sago, cocoa, mixed garden and open wasteland	

Type of Primary Forest and Vegetation – Habitat for orchids, other plants and fauna. However, it is also home to native peoples, but they no longer live in the trees but in settled communities especially when their children have been schooled, educated and hold positions in private companies and the government. However, the elders still have a great knowledge of the flora and forest products. Source: Beaman, 2001

Unlike the trees in temperate forests and boreal forests, Sarawak's ancient rainforest trees, aside from being valuable in their own right, act as hosts to valuable epiphytes (25% of all vascular plant species), such as Orchidaceae, whose varieties are almost exclusively found here (

Plate 2-2) (Nieder, et al., 2001; Beaman, et al., 2001; Cribb, 2014; Go & Pungga, 2018) The immense forest's diverse natural biodiversity, distinctive ecosystems and extraordinary biological elements make Sarawak a perfect environment not only for flora but for endemic fauna such as orangutans and pygmy elephants, which have also inspired many well-known botanists and naturalists such as the British naturalist/flora and fauna collector, Alfred Russel Wallace (Wallace, 1962)

Plate 2-2

Bulbophyllum becarri (endangered species) growing on a tree in Bau, Kuching. If this tree is cut down and not rescued, the orchid species growing on it will perish with it. Source: Katik, 2020

Regardless of the debate about who was the real founder of the theory of evolution, Wallace or Charles Darwin, Wallace's visit to Sarawak led to him writing the Sarawak Law paper, which presented his view on the famous theory of evolution (Van Wyhe, 2016; Bernadi, 2018). The 'Wallace Line', which separated the eco zones of Asia and Australia in 1859, is used to guide orchidologists today in biodiversity hotspot studies on endemic orchids (Camerini, 2010; Van Wyhe, 2018). However, the general Sarawak populace is unaware of the biodiversity richness around them, especially of orchids, as to date, despite the OEC, not only is there an absence of a BG, but there are no laws or guidelines to rescue orchids before any forest clearance trimming of trees. Instead, there is legislation that forbids the collecting/rescuing or micropropagation of these orchids, except for research purposes (SARGov, 1998).

2.5 Sarawak Forest Change in Land Fragmentation

Comparisons have been made with Sarawak's neighbour, Brunei, which has an area of 5.765km (4.4% the size of Sarawak) and a population of 437,000 (15% the size of Sarawak's population) but a GDP per capita of £20,800 (217% of Sarawak) and it has successfully preserved 54% of its virgin forest (Bryan, et al., 2013; ORC, 2019), against 50% of Sarawak's. The comparison made, however, is not appropriate as the GDP per capita of Sarawak is vastly different. This has resulted in Brunei not experiencing the same kind of commercial pressure for increases in productivity and yields, which require development. Therefore, as Sarawak does not have as many non-land-based natural resources as Brunei, and with its timber products significantly reduced due to constraints in supply (Ten, 2019), Sarawak has started to respond to the heightened global demand for crops, through the provision of cocoa, rubber and palm oil (Collins, et al., 1991; SOPB, 2019; Hirshman, 2020; Salim, 2021), which were introduced in the early 19th century by the British colonialists (Hartley, 1967).

In addition, despite developers being slow to convert Sarawak forestry t large-scale monoculture plantations, as compared to West Malaysia, (Hartley, 1967; FAO, 2002; SOPB, 2019), Sarawak plantations still apply intensive monoculture production models instead of the ideal ecological intensified of mixed species in the plantations (Ching Liu & Krutovsky, 2018).

The availability of land in East Malaysia especially Sarawak, encouraged investors to look for new land to convert both government and private landowners to this activity (Figure 2-6, below) which led to the beginning of a large proportion (1.59 mil ha as at 2020) of Sarawak secondary forests being replaced with monoculture plantations (SOPB, 2019). This added to the challenges of the OEC, as reported by researchers and scientists (Dislich, et al., 2016; Meijaard, 2018). Nevertheless, any agricultural industry faces challenges, from locals (Andersen, et al., 2016; WMJ, et al., 2020) to competitors from developed countries (FAO, 2021), who are also leading contributors to emissions (Byerlee, et al., 2017; Oon, 2020; IUCN, 2020).

Thus, these conflicting arguments on the impact of oil palm plantations on biodiversity and sustainability need further research, as, according to Professor Douglas Shell of the Norwegian University of Life Science, an additional 8% increase in land use of oil palm (OP) plantations could meet the projected demand for vegetable oil in 2050 but the less productive soy will need a 48% increase from now (Meijaard, et al., 2020). Therefore, unless there are other alternatives, oil palm estates that generated a revenue of RM 2.8bn in 2021 (Hirschmann, 2021), will be in Sarawak for the foreseeable future. This is why plantations need to be a part of OC programs in BGs so that locals, as well as international scientists, can carry out further detailed research with the involvement of the local community. This will help them to understand the issues around developing a better OP production model so that the country's ecological, socioeconomic, and historical characteristics are developed (Fentrene, et al., 2016; Meijaard, et al., 2020).

Because of the threat of disappearing orchid habitats, concerted efforts need to be to raise awareness of OS conservation. One of the ways of doing this is through developing a longoverdue UOBG, whose role could address the OEC (Swarts & Dixon, 2009; Dossmann, 2006). Sarawak has many green spaces, comprising recreational parks, national parks and forestry, which include virgin forest reserves and perennial monoculture plantations (SFC, 2019). But at the rate the forests are disappearing, in situ conservation efforts for orchids would not be a solution (Gale, et al., 2018; Fay, 2018). It is time for orchid herbariums, biodiversity research centres, orchid museums, libraries with rare orchid books and higher education institutions conducting in vitro orchid propagation activities to come together in an Urban Orchid Botanic Garden (UOBG) similar to the Royal Botanic Gardens, Kew (Bean, 1903; Smith, 2004; Teltscher, 2020) model. Doing so would allow for locals to be exposed to the history of Sarawak orchids, which has massive potential in terms of socio-economic returns and the scientific aspects, including OC and encouraging locals to contribute to the revamping of the orchid industry in Sarawak.

Thus, in response to the above, where Sarawak has one of the greatest diversity of orchid plants as well as a rapidly vanishing natural habitat – the primary forest – and the absence of a BG, the author has developed a strategy to create a framework for a model to effectively link collaborations of orchids within ex-situ conservation projects in a UOBG, which would educate and create awareness amongst the public when visiting it. The strategy is as follows:

. To produce sustainable small scale mass commercial production (through seeds) of native orchids (Seaton & Ramsay, 2005), to create awareness and engagement among the younger generation of Sarawak (the future policymakers), to connect them to orchid species (OS), which are Sarawak's own natural resource, the OEC and the community surrounding them, aside from developing skills, knowledge, values, attitudes and motivation towards SLEO, conservation action and participation in local restoration projects (Chapter 5) in order to assist in addressing OEC. When successful, this could be repeated in other secondary schools throughout Sarawak to cover the different types of habitats and the native orchids of respective divisions where there are schools. This commercial seedling production would be similar to that of Writhlington School Orchid Project's (Pugh-Jones, 2020), having the aim of supplying native seedlings/keikes to the proposed UOBG, plantations and forest for both in-situ and ex-situ conservation, simultaneously flooding the market to reduce orchid poaching and the illegal market. Thus, this conservation education awareness programme could form a new kind of collaboration between schools and the wider community, having the potential to evolve into a platform for the children to have their voices heard around OEC and other environmental issues, in line with the United Nations Convention on the Rights of the Child (IUCNWCC, 2021).

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In addition, Sarawak school compounds could be developed into mini orchid BGs, engaging school children with nature, understanding the roles of BGs and creating living museums displays (Bristol Aquarium, 2015; Felton, 2018), which could include their fun ideas, thus opening windows of opportunities for their future in many ways. However, establishing a rudimentary In Vitro Orchid Micropropagation (IVOM) laboratory within the extracurricular framework, devoid of sophisticated equipment commonly present in universities labs, poses challenges in maintaining adequate humidity control and preventing contamination. Specially, the initial early stage of of the cell culture process may present monitoring difficulties for new year 7 students adhering strictly to aseptic procedures (Ryan, 1997; Yam & Aditti, 2018).

Plate 2-3

6 | HOME

NEW SARAWAK TRIBUNE • THURSDAY JULY 18, 2019

Lab to preserve local orchid species

BY LYNCH COWAN

KUCHING: The Sarawak Orchid Society (Sarorso) is committed to preserving the local orchid species by creating the "Juma'ani In Vitro Laboratory" at Maktab Rendah Sains Mara (MRSM) here.

Sarorso president Zurenawatee Zaidel said the laboratory was for seed germination and micro-propagation of orchids. It was also to promote the involvement of educators, especially among schoolchildren and prevent the extinction of the orchid species.

"The orchid seed project in this laboratory is the first to be carried out in Malaysia. We involve students because they are the generations which will inherit the orchid species in the future," she explained after the launch of 'Juma'ani In Vitro Laboratory' at MRSM.

The event was officiated by the president of the Sarawak Association of Wives of Ministers and Assistant Ministers (Sabati) Datuk Amar Juma'ani Tun Tuanku Haji Bujang.

Zurenawatee revealed that Sarorso was also working with Kuching North City Hall (DBKU) on the orchid seed project at the school.

"Currently, it is still in the trial period and if it's successful, we will expand it to other parts of Sarawak.

"In the future, we will invite other schools to come to conduct experiments and learn about the micropropagation here. Within two days, the seed project has involved more than 20 species of local orchids,," she explained.

Zurenawatee said representatives from the Writhlington School Orchid Project, namely Dr Simon Pugh Jones and his entourage also came to share knowledge about orchid seedlings.

"They will continue to cooperate with us in this project," she added.

JUMA'ANI (centre) presents a certificate to a student from the United Kingdom Chloe Mc Giverson, 17, as Abang Wahab (right) looks on.

"The orchid seed project in this laboratory is the first to be carried out in Malaysia. We involve students from the school because they are the generations which will inherit the orchid species in the future."

JUMA'ANI (left) and Abang Wahab launching the 'Juma'ani In Vitro Laboratory' at Maktab Rendah Sains Mara (MRSM) in Kuching. Photos: Ghazali Bujang

Bring orchid project to school: Mayor

KUCHING: Kuching North City Hall (DBKU) Mayor Datuk Abang Abdul Wahap Abang Julai wants the orchid micropropagation project to be brought to schools and institutions of higher learning in the state.

Besides spurring an interest in science among the students, he hoped the project would teach the younger generation how to take care of the environment as well.

"I hope this project will be an example and inspiration to other parties," he added at the launch of the 'Juma'ani In-Vitro Laboratory' at Maktab Rendah Sains Mara (MRSM) here yesterday.

DBKU, Abang Wahap said, was proud to be involved in the orchid micropropagation in school project.

"This project creates a platform to promote awareness of orchid species in the state. I hope it will also mark the beginning of a technological transition in the community. This will be a new investment in orchid parks in the state," he added.

Abdul Wahap pointed out that Sarawak's wild orchids were unique and beautiful and had commercial value for future research purposes.

"Orchid industries in countries such as Thailand, Taiwan and Singapore are highly developed as they affect their tourism and floriculture industries. In many orchid deals, they are willing to invest in commercial micropropagation," he added.

JUMA'ANI (centre) and Abang Wahab at a photocall with VIPs, Sabati members and MRSM students after the launch of the 'Juma'ani In Vitro Laboratory'.

Introducing Sarawak Natural Resources. Preparation for the MRSM/ Writlington Orchid Project Trial started in December 2018 and took off in June 2019. The proposal was well accepted by the school, the Sarawak Orchid Society (SARORSO), the Mayor and the Chief Minister's office. Source: SARORSO, 2019

. An experiment on the possibility of mass growing of OS on OP trees in an estate (Chapter 6) which could be repeated in 1.54 million hectares of oil palm estates (OPE) throughout Sarawak which could be an alternative sustainable restored habitat for Sarawak Lowland Endangered orchids (SLEO). The experiment could also create potential new agroforestry models (Webber, 2020), which would enhance the ecosystem and biodiversity of OPE as in some areas, we may no longer have pristine forest or natural resources. Therefore in the long-term, new creative revised models of OPE could be used to create a valuable endangered 'wildlife' friendly area (Levitt, 2015). This concept is similar to the Community Baboon Sanctuary (CBS) in Belize (Alexander, 1999; Korach & Myers, 2020), except that the wildlife here focuses on lowland OS, other Sarawak endemic floras such as the Amorphalus hewetii, Rafflesia, lowland Nepenthes and Tacca chantrieri, and perhaps endemic fauna, for example, birds, monkeys and cats. Nevertheless, to obtain more detailed and accurate data when investigating the success of translocating orchids into an OPE as established breeding colonies and a suitable habitat which does not affect the productivity of the farm and security of the community, a longer period of experimentation is needed. The Covid 19 pandemic has compressed this research into two years.

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. A customised sustainable UOBG according to the OC needs of Sarawak with a unique functional arboretum and features incorporating the above two ex-situ conservation methods as models which are relatable to a wider community is proposed (Chapter 7): Investigations were made conducted on the Botanic Gardens Conservation International's (BGCI) Manual on Planning, Development and Managing Botanic Gardens (Patzielt, et al., 2016) comparing them to the basic features of selected successful international BGs, which have a high number of visitors annually (Chapter

4). The goal of this proposed UOBG is to not only educate and create awareness on the SLEO and the OEC it is facing but to inspire and motivate and encourage ideas and feedback from the visitors on conservation and economics. Consequently, visitors from all educational backgrounds can be involved and be a part of conservation projects wherever they are to address the OEC when they understand the importance of their role. This OUBG would also serve as a hub to all the schools' mini BGs involved in tissue culture as well as oil palm estates which are involved in orchid ex-situ conservation programmes.

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. The existence of a SUOBG and the setting up of mini BGs in schools, as well as the creation of functional living museums of OS in OPE, would enable more visitors regardless of their locale to observe OS in alternative habitats so that that they can emulate and at the same time be able to purchase sustainable seedlings. This would also decrease pressure on orchids in native habitats. This value-added integration, if successfully implemented and accepted, would engage a broader audience, generate income for the state (BGANZ, 2017) and present the UOBG as a functional historical, conservation, education, horticulture centre (Dodd & Jones, 2010; Wassenberg & Soule, 2015), as well as a visitor-friendly organisation which addresses the community's environmental concerns and needs and demonstrates relatable economic opportunities and benefits through participating in OC.

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2.6 Orchids of Sarawak – Culture and History

With its relatively small size, Sarawak (124,450 km2) compared to other orchid-diverse regions such as Ecuador (283,560 km2), Sichuan (485,000 km2), Madagascar (587,040 km2) and Columbia (1.143 million km2), has 2,500 known (with the figure still rising) OS (Plate 2-4), 50% are endemic (Beaman, et al., 2001; SGov, 2014; Go & Pungga, 2018; Goh, 2019; Entalai, et al., 2020), Sarawak ranks at the top as it sits on the most botanically diverse region on earth (Low, 1968; Mjoberg, 1930; ForestSWK, 1995; Low, 2002; Beaman, et al., 2001; ForestSwk, 2019). Due to the above fact, not only is Sarawak known as a centre of distribution and species diversity, but Sarawak OS are widely regarded as the most enchanting and beautiful orchids(Beaman & Beaman, 1990; Low, 2002; Beaman, et al., 2001). Sarawak OS are classified into four categories, where 82% are epiphytic (plants that grow on other plants) and the remaining 18% are made up of terrestrials (plants that grow on land), lithophytes (plants that grown on rocks) and saprophytic or mycoheterophic (Beaman, et al., 2001; Wood & Cribb, 1994).

The natural germination rate of these orchids is reported to be 0.3% due to the microscopic size of OS seeds, which lack nutritional storage capacity and need mycorrhizal fungi to germinate (Seaton & Ramsay, 2005; Shefferson & Kull Tiiu, 2020). Besides that, in nature, OS require pollinator specialisation (Darwin, 1904; Gravendee, et al., 2004; Perez- Hernandez, et al., 2011), specific habitats (Zhang & Hu, 2018; Phillips, et al., 2020), and time to produce flowers (Zhang & Hu, 2018; Wang, 2019) while epiphytic orchids need specific hosts. Therefore, the mass volume of Sarawak OS currently found in the different virgin habitats, including the millions collected during the 19th century by OS hunters (Wraith & Pickering, 2018) are a result of many favourable factors which took place over centuries, much longer than their first mention around 300 B.C. (McHugh, 2021). As such, the process of breeding orchids naturally is a slow and complicated process (Zhang & Hu, 2018). It is important, therefore, for the community to know the value of OS as well as the importance of OC and to be involved in efforts to prevent the 2,500 species of OS from going extinct.

Plate 2-4

The enchanting and unique Sarawak orchid species are rich in history. With the pace of Sarawak development, orchid species may become extinct. More action-oriented efforts on orchid conservation involving the local community need to be taken. Source: SARORSO, 2018.

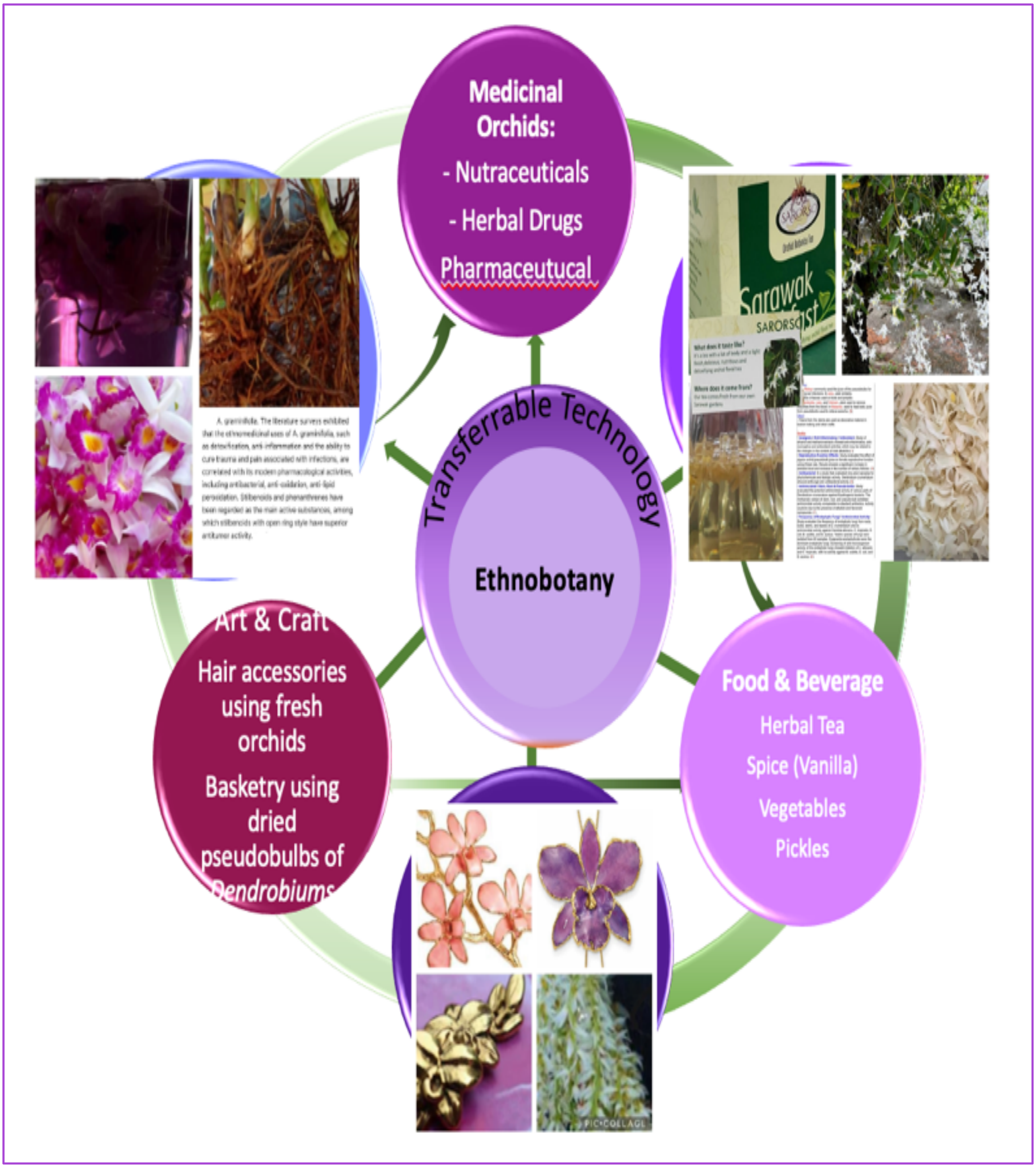
Plate 2-5

A picture of the symbiotic relationship between an orchid with the living organism supporting it. The tree here plays the role of host. Mycorrhizal fungi are associated with the roots of higher plants.

2.6.1 Cultural Use – Ethnobotany and Medicinal Uses

Long before the west labelled their collections as orchidaceous, meaning a flower that is an effete exotic or a pointless luxury, which aptly symbolises western richness and status (Hansen, 2001; Endersby, 2016; Harris, 2018), in Sarawak, OS had been long exploited by the various indigenous people (Figure 2-4) for their nutrients, as medicine and in traditional rituals and cultural beliefs, which provided for their daily needs and 'protection' in the forest (Christenses, 2002; Eng, 2016; Bodos & Sang, 2019; Eng, 2016). This knowledge has been passed down by the generations through word of mouth but fell out of favour as they were exposed to western culture during the colonial era (Dr Nieuwenhuis, 1929; Lee, 2006).

Figure 2-4



Traditionally, before modernisation or Sarawakians did not term orchids as 'orchids' but gave them their own local names. Based on research by the Sarawak Forest Department and that found in orchid medicinal books, orchids have long been used by Sarawakians for medicine, food and drink and as a spiritual resource. Source: Tengku, 2021

In addition, from the sixties onwards, the best orchids were sent for further studies to towns and some were even sent abroad (Eaton, 1979; Lee, 2006) to highly industrialised countries, for example, Britain. These western graduates had different views on nutritious food and effective medicine (Kearney, 2010; Sproesser, et al., 2019). Consequently, due to modernisation, the knowledge and interest in the traditional application of OS as a necessity fell out of favour like other traditional ethnographic practices (Saupi, 2018). Amongst natives, OS were known by their local names, for example, *Kambang Alo* for the *Phalaenopsis bellina* (Ramoh, 2008) making it challenging to relate them to their scientific names (Plate 2-6).

Plate 2-6

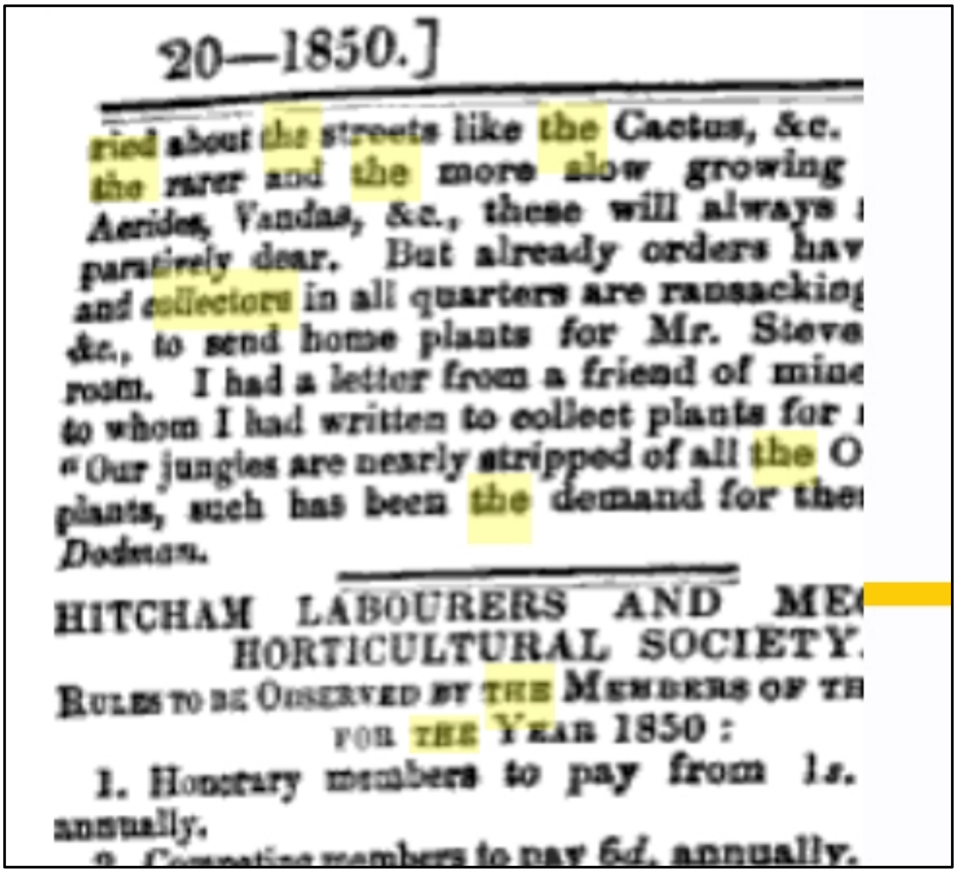
(Left) Bromheadia finlaysonia was used to treat asthma (flower stalk chewed) and snake bites (the leaves were pounded into paste)(Sarawak Forest Corporation, APOC 13). Right: Phalaenopsis bellina (Kambang Alo). A popular fragrance used by the Taiwanese for their Phalaenopsis - biopiracy. Information obtained during EOCC, Paris. Source: Sa'di, 2019

Nevertheless, many studies on ethnobotany have been conducted by the Sarawak government agencies, with the help of the elder community, on the pharmacological application of Sarawak OS by the 31 ethnic groups (Christenses, 2002; Bodos & Sang, 2019). On the other hand, Sarawak ethnobotany practices may have been influenced by the Chinese, who migrated to Kuching (Russan & Boyle, 1893, p. 119) long before Rajah Charles promoted Chinese black pepper growers from Singapore (Zepp, 1989). The Chinese have been known since the Three Kingdom Period and the Tang Dynasty to use orchids for medicinal purposes (Hew, et al., 1995; Bulpitt, et al., 2007). The ethnobotanical application of orchids in Sarawak has not been exploited and there is potential for more research in this area.

2.6.2 Horticultural Importance

The economic and commercial value of OS and later hybrids in the western world (Beaman, et al., 2001, pp. 41-60; Cribb, 2014) came about when British naturalist William John Swainson brought back a collection of plants, not knowing some were orchids, from Brazil to England in the early 1800s (Harris, 2018). This led to the birth of orchidelirium (Hansen, 2001; Grienfield, 2021), attracting western plant collectors, resulting in European royals and Victorian scientific travellers, who would travel to the 'New World' (Brennan, 2006; Lawrence, 2015), to collect a diverse range of valuable and enchanting flora, including endemic orchids (Holtum, 1953; Low, 2002; Wallace, 1962; Beaman, et al., 2001). According to Tuffrey Faye, the garden plant collections and learning manager at Chatsworth House, during the orchidelirium era, a customer would pay between £100 and £1000 (the current equivalent of between £10,000 and £100,000) for a new and rare OS (Li, 2015; Tuffrey, 2021). In further describing the horticultural value of OS in that period, William Bull, an English botanist, was reported to have received the largest consignment of rare flora, totalling two million specimens, in 1878 due to the high demand (Swinson, 1970). In addition, an article in the *Gardener's Chronicle*, 1850,(Plate 2-7) mentioned that someone from Penang, Malaysia, had reported to a friend that collectors were ransacking forests until they were nearly stripped of all orchids (Swinson, 1970). OS illegal trade for economic purposes was rampant then.

Plate 2-7



20—1850.]

ried about the streets like the Cactus, &c. the rarer and the more slow growing Aerides, Vandas, &c., these will always paratively dear. But already orders hav and collectors in all quarters are ransacking &c., to send home plants for Mr. Steve room. I had a letter from a friend of mine to whom I had written to collect plants for "Our jungles are nearly stripped of all the O plants, such has been the demand for the Dodman.

HITCHAM LABOURERS AND ME HORTICULTURAL SOCIETY.

RULES TO BE OBSERVED BY THE MEMBERS OF TH FOR THE YEAR 1850:

1. Honorary members to pay from 1s. annually.
2. Competing members to pay 6d. annually.

An excerpt from the Garden's Chronicle about the millions of orchids extracted from orchid diverse countries. Source: Garden's Chronicle, 1850

For Sarawak, the presence of the historical James Brooke in Sarawak, 1839 (Brooke, 2018), who later became the White Rajah of Sarawak in 1840 (Runciman, 1962; Reece, 2004), opened the doors to at least 30 established foreign scientists, orchidologists, botanists, naturalists and horticulturists (Appendix 2.1) creating the most important single occurrence in the orchid history of Sarawak (Beccari, 1904; Mjoberg, 1930; Wallace, 1962; Low, 1968; Beaman, et al., 2001; Russan & Boyle, 1893). Two of the famous scientific travellers, known to be among the White Rajah's key government officials, were botanist Sir Hugh Low, who became Colonial

Secretary of Labuan (Low, 1968; Low, 2002; Beaman, et al., 2001), and Swedish Zoologist Eric Georg Mjoberg, who then held the position of the curator of the Museum of Sarawak (Mjoberg, 1930; Beaman, et al., 2001). They were responsible for the early specimens arriving in European BGs, such as the Royal Botanic Gardens, Kew (RBGK). This included contributions by Italian botanist Odoardo Beccari (Beccari, 1904; Burkill & Moulton, 1921), who collected 190 species of orchid (Beaman, et al., 2001). He was also well known among Sarawak locals for the experiment he conducted on several orangutans (Beccari, 1904). The high demand justified the overexploitation which, for some, cost them their lives (Mjoberg, 1930; Swinson, 1970).

On a positive note, the scientific studies brought about by the 19th-century mass orchid extraction demonstrated that Sarawak OS were valuable. For example, studies were conducted by Taiwanese scientists on the possibility of applying the floral scent of endemic *Phalaenopsis bellina* to their scentless commercial hybrid, Phalaenopsis (Hsiao, et al., 2006; Hong, 2018). Secondly, due to the early collection by Hugh Low, early-labelled permanent preserved specimens (Bynum & Bybum, 2016) of tropical OS are available in herbariums of BGs in industrialised countries, such as in the RBGK, UK (Thurlow, 2020), and the Singapore Botanic Gardens (SBG). In addition, DNA research in horticulture and floriculture has made the orchid horticulture industry successful in many countries (AR Research, 2020). This includes the latest innovative technologies on micropropagation for economic and conservation purposes. However, Sarawak has yet to tap into the orchid horticulture business, as information on the cultural and economic horticultural value of Sarawak OS abroad is not known widely (Saupi, 2018; SARORSO, 2019).

Thus, based on these factors and in line with the global critical OEC, awareness should be developed among adults and school children. They need to be educated on OS being a valuable natural resource. Despite calls for plant conservation almost 32 years ago by the United Nations through the Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992 (United Nations, 1992), followed by the improvised United Nations Sustainable Development Goals (UNSDG) number 15 (OsloGC, 2012; United Nations, 2020; United Nation, 2021), efforts at conservation have not been sufficient, especially in Sarawak (UNSDGs, 2021). As the situation is critical, a more proactive action closer to the needs of Sarawak, such as the engagement of secondary students, as has been successfully carried out by the Writhlington Orchid Project (WSBE) for 30 years (Pugh- Jones, 2020; Pugh-Jones, 2020) and the Chikanda Orchid Project by Kew, is required. WSBE's ambitious efforts from 30 years ago to educate and create awareness among secondary students on OEC have been fruitful, as can be seen among their students and in the impact it has had on the MRSM Kuching secondary school students involved in the Orchid Project (Shukur, 2019; Choo, 2019; Otsman, 2019; Cowan, 2019; New Sarawak Tribune, 2019). Exposing the public to the rich history of Sarawak OS, its culture and the many values of Sarawak OS would develop feelings of belonging and connectedness to the conservation effort (Muir, 2012; Bowler, 2021).

2.7 Sarawak Orchid Species – Anthropogenic Threats

2.7.1 Unsustainable Deforestation

The frequently highlighted driver of OEC in Sarawak is unsustainable forest clearing. The problem is 180 years old. The first wave of deforestation was precipitated during the rule of the Englishman, James Brooke (Keppel, 1847; Reece, 1993; Reece, 2004). This was mentioned by orchid collector/naturalist FW Burbidge in his book, 'The Gardens of the Sun or A Naturalist's Journal of Borneo and the Sulu Archipelago' (Burbridge, 2013) and deforestation for timber has taken place since then (Threacher, 1891). The right to cut timber free of duty was given to the Oriental Coal Company of London and Burbidge writes: '…[the] whole island of Labuan was entirely covered with forests, yielding fine timber… and at present time but little old forest remains". Thus, deforestation due to the need for development in the White Rajah's era represents the first wave of the OEC and destruction of habitat.

In the 21st century, Sarawak's orchid perspective on OEC is still present: the world's OS is only of secondary importance to policymakers (SARGov, 1998). Despite having 2,500 OS, which are classified as endangered by IUCN (IUCN, 2019; IUCN, 2021), there is still no department in the state administration to look at the fate of Sarawak's orchids. The second wave of logging activities continues (Burbridge, 2013) without any strategic attempt at halting the OS (Go, 2016; Go, et al., 2020; Goh, 2019) whereas they would rescue the local fauna (SFC, 2020; SFC, 2020). Conservation of OS seems to be for the future, with innovative horticultural techniques for mass production (to flood the market and prevent the exploitation of OS in their natural habitat and for in situ conservation purposes) is still restricted despite the ongoing OEC (SARGov, 1998).

2.7.2 Population Increase

Studies on developing tropical countries with high percentages of forest cover indicate that the increase in human population and development has affected the rate of deforestation through expansion of agricultural land, logging, infrastructure and other human activities for the purpose of improving quality of life, education and healthcare (Jha & Bawa, 2006; Mapulanga & Hisahiro, 2018). The long-term effects of population growth, subsistence living and poverty (Babigumira, et al., 2014) have elevated the pressure for further development of forest land with the hope of increasing the developing country's status and prosperity. This is similar to Sarawak's situation nearly two centuries ago, when Rajah Brooke assumed his rule of Kuching in 1841 (Brooke, 1853; Reece, 1993; Reece, 2004; Brooke, 2018; Burbridge, 2013). With a reported population of 10,500 in 1841, where 76.15% of the population lived in the forest, and the Chinese were a minority of 9% (Rutter, 1935), forests were cleared for infrastructure and economic activities. These comprised mainly labour-intensive agriculture, logging and gold mining (Brooke, 1853; Keppel, 1847; Low, 2002; Burbridge, 2013). As Brooke expanded his dominance into other parts of Sarawak in 1853 and from 1861 to 1894, the population increased accordingly (Figure 2-3) and so did logging activities, including OS extraction (Sarawak Gazette, 1871; Russan & Boyle, 1893; Low, 1968; Low, 2002; JH, 2005; Burbridge, 2013). When the first census was carried out in 1947, the population was reported to have increased by 510%, with the Chinese population increasing by 14510% compared to the Malays and Dayak populations' increase of 6,497% and 3,797% respectively (Noakes, 1950). This was due to the immigration of Chinese entrepreneurs brought about by Brooke's family, through Singapore and Dutch West Borneo, and directly from South China, to work on cash crop (Pepper, Gambier, Tobacco), which were placed solely in the hands of the Chinese for political and economic reasons. This led to the clearing of hectares of both virgin and secondary forest, whereby these foreigners were granted ownership of the land (SG, 1872; SG, 1877; Noakes, 1950). The forest clearings and the progressive importation of Chinese immigrants were also meant for the gold mining activities by the Borneo Company in 1856 in Bau (Ishikawa, 2009; Bong, 2020; Besra, 2021).

In 1960, Sarawak's population was 744,529 (Jones, 1962) and since then, it has increased by 291% to 2,907,500 in 2020 (DOSM, 2021). Sarawak was ruled by Brooke's family from 1841-1941 (Reece, 2004), the Japanese during the Second World War, from 1941-1945 (Reece, 2002; Oii, 2015), and as a British colony from 1946-1963 (SG, 2014). After independence, it was administered by local leaders who mostly had a British education(Sar Govt, 2017). They faced the growing demands of an educated citizenry to improve the economy (FMT, 2021).

The state's main objectives were to eradicate urban and rural poverty. Its digital economic drive was made through sustainable urbanisation, agricultural expansion by intensive farming, the mining of minerals, the development of infrastructure, and the provision of education and information technology have been contributed to deforestation and the destruction of biodiversity, which led to OEC (Allen & Barnes, 1985; FAO, 2020).

Table 2-3

YR	Sarawak Total No		Malays		Dayak		Chinese		others	
	No	Inc by %	No	%	No	%	No	%	No	%
1841	10,500		1500	14.2 8	8000	76.1 9	1000	9.5 2	n/a	0
1947	546,385	510. 4	97,469	17.8 4	303,758	55.5 9	145,15 8	26. 5	5,810	1.0 6
1960	744,529	36	129,30 0	17.3 6	377,952	50.7 6	229,15 4	30. 7	8,123	1.0 9
2020	2907,50 0	289. 5	479,73 8	16.5	1,997,45 2	68.7	389,60 5	13. 4	40,70 5	1.4

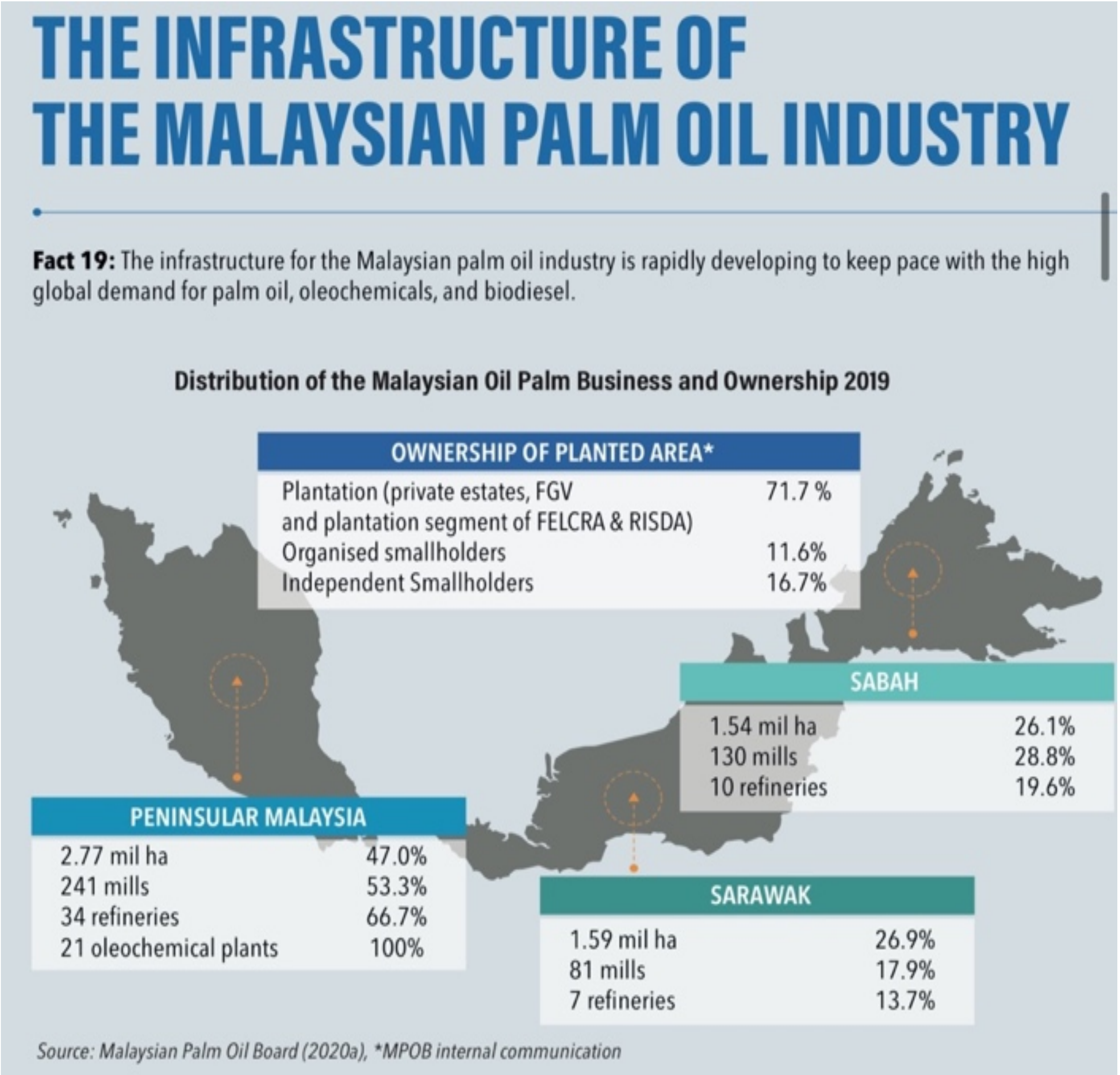
Sarawak's pop ululation growth according to ethnicity, 1841-2020. The huge leap led to immigration from China and Singapore during the occupation by the Brooke family from 1841 (only of Samarahan) to 1853 (expanded to Batang Rajang), up to Kidurung (1894) until the Trusan Basin. Source: Sarawak Gazette, 1947; Data of Statistics Mayaysia, 2021

2.7.3 Monoculture Plantations

Several scientists have discovered that while monoculture plantations are destructive to the environment, especially OPEs (Dislich, et al., 2016; FasslJoeer, 2016; Meijaard, et al., 2020; Meijaard, 2018), the biology of oil palm trees allows them to act as hosts to epiphytes (Barcelos, et al., 2015; Suzanti, et al., 2016), which structurally depend on trees (Plate 2-8). . The life spans of other vegetable oil plants are short, so they need to be replaced more frequently (MPOC, 2020). On top of that, it has been reported that no other crop to date (Figure 2-6) can yield oil even a third of the amount that oil palm can for each acre planted, meaning that less land will be required to be converted into monoculture plantations in order to meet the needs of the population by 2050 (Oil World, 2020; MPOC, 2020). It is also claimed that oil palm estates in Sarawak are applying fewer pesticides and chemical fertilizers (this is further discussed in Chapter 6) than other vegetable oils (Meijaard, 2018; Zulkefli, et al., 2021), allowing valuable epiphytes such as Orchidaceae to naturally grow on tree trunks, and edible epiphytes such as *Stenochlaena palustris* (Plate 2-11), locally known as Midin (Burkhill, 1936; Chai, 2016) and terrestrial orchids to grow on the ground (Plate 2-10). It also provides a valuable resource and habitat for arthropods and micro-organisms (Plate 2-9) (Einzmann & Zotz, 2016).

However, due to ignorance, farmers tend to ‘weed’ all of these vascular epiphytes from the host, which can affect both valuable arthropods and microorganisms living on the bark. Left undisturbed, these contribute to the ecosystem as well being a potential value-added income to the farmers. Finally, the claim that sustainable OP plantations have the potential to increase carbon storage as effectively as rainforests in acting as a carbon sink (ABesar, et al., 2020) gives hope for potential ex-situ conservation efforts (e.g. translocating rescued OS into existing palm oil estates) to arrest the OEC.

Figure 2-5

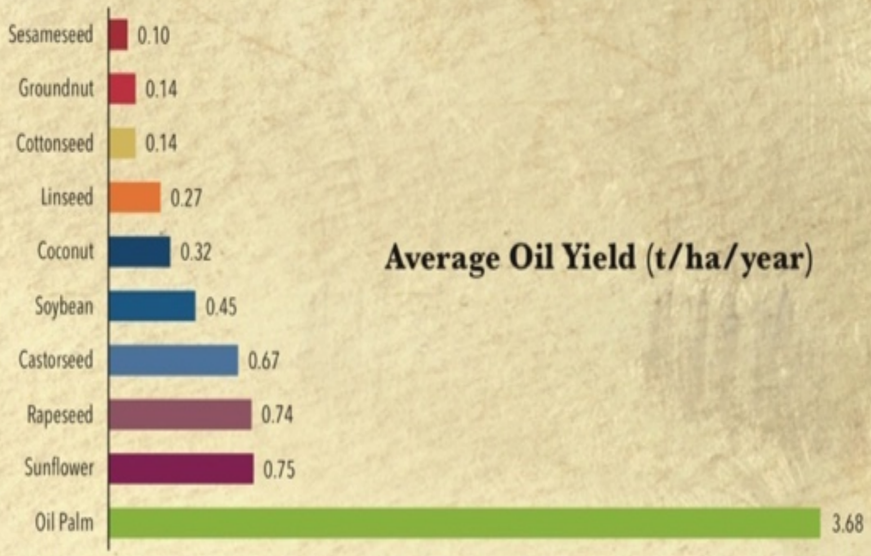


Total area (ha) of oil palm plantations in Peninsular Malaysia, Sabah and Sarawak as at 2020. Source: MPOB, 2020

Figure 2-6

Fact 10: The oil palm is the most productive oil-bearing crop in the world.

The figures below show that of the world's 10 major oilseeds, the oil palm produces the highest tonnage of vegetable oil per hectare per year.



Average Oil Yield of World's 10 Major Oilseeds

Oil Crop	Oil Production (mil tonnes)	Harvested Area (mil ha)	Average Oil Yield (t/ha/year)
Sesameseed	0.88	8.85	0.10
Groundnut	3.67	25.76	0.14
Cottonseed	4.59	33.03	0.14
Linseed	0.86	3.13	0.27
Coconut	2.91	9.17	0.32
Soybean	56.88	126.07	0.45
Castorseed	0.74	1.10	0.67
Rapeseed	24.96	33.59	0.74
Sunflower	20.51	27.22	0.75
Oil Palm	83.88[a]	22.82	3.68
TOTAL	**199.88**	**290.74**	

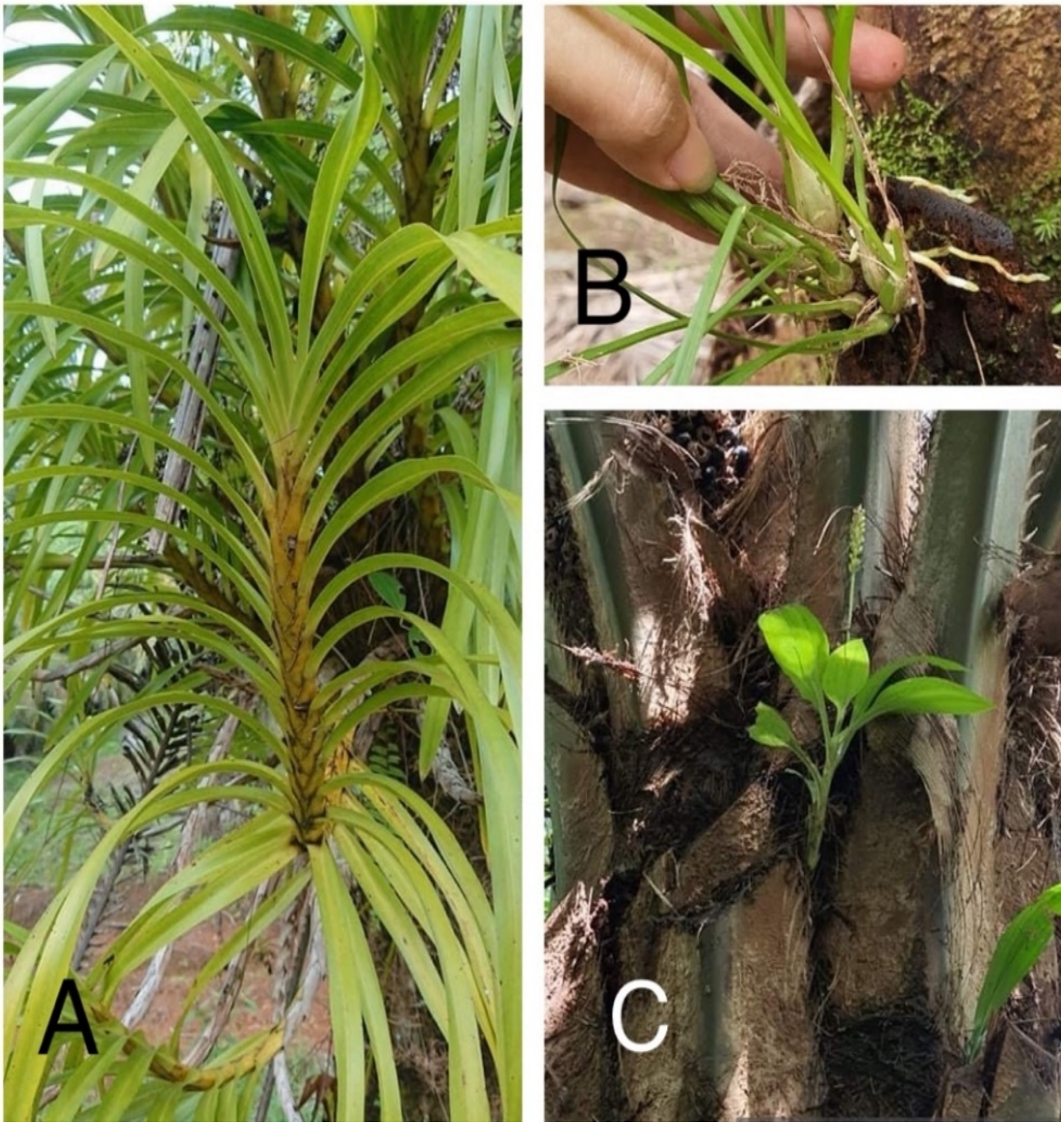
Note: [a] combined tonnage of palm oil and palm kernel oil
Source: Oil World (2020)

Fact Sheets | Malaysian Palm Oil

8

Average vegetable oil yield of the 10 major oil seeds showing oil palm produces at least four times a higher yield per hectare. Source: Oil World, 2020.

Plate 2-8



Orchid species (A. Grammatophyllum, B. Acriopsis and C Malaxis found on an oil palm estate. Source: A - Gert, 2020; B & C. Loring, 2021

Plate 2-9

Vascular epiphytes growing on the trunks of oil palm trees, which harbour countless arthropods, microorganisms and other groups of living things, serving as a platform for interaction among different species and with the environment, creating an important ecosystem. Source: Loring, 2020.

Plate 2-10

Phauis, a terrestrial orchid, grows wild on a palm oil estate in Belaga, in the northern part of the Kapit Division. Source: SARORSO, 2

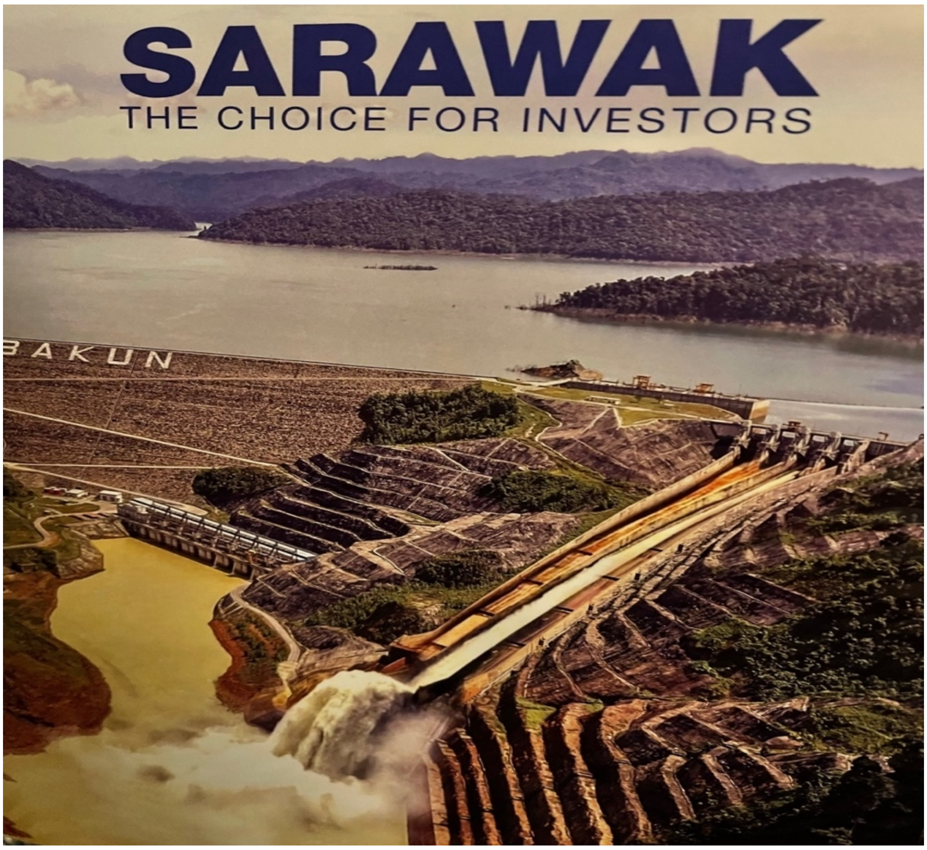
Plate 2-11

Edible Stenochlaena palustris, locally known as Midin, is a highly sought-after exotic vegetable dish for Sarawakians. Oil palm estates could be a potential cash crop farm, providing a second income to the oil palm estate community. Source: Diring,2019

2.7.4 Industrialisation – Infrastructure Projects (IP)

Infrastructure projects (IP) provide the basic needs of the people such as electricity, water, gas to both homes and businesses. IP includes power generation and transmission; highways, roads and streets; bridges; mass transit and expansion of airports; water supply and resources; waste management and wastewater management; telecommunications and hazardous waste removal and storage. These are the various types of IP that have changed the natural landscape in Sarawak, which are either new or have intensified to meet the demand of its people. Such IP activities have resulted in adverse impacts, increasing threats and causing the ongoing decline of biodiversity, as observed in neighbouring developed countries such as Australia (Cresswell & Murphy, 2017) and other developed countries (Roe, et al., 2019; Nhm, 2019).

Plate 2-12



Bakun – the core of the Sarawak Corridor of Renewable Energy (SCORE) project aims to accelerate the state's economic growth and development in order to improve quality of life. Source: Ministry of Industrial & Entrepreneur Development (MIETI) Sarawak, 2019

2.7.5 Non-Agricultural Activities Threatening Orchid Biodiversity Processes

With the Sarawak economy moving away from a primarily agricultural or resource-based industry (timber, sago, pepper, rubber, cocoa) to one based on mass manufacturing, technological innovation is required to increase per capita income (Tawie, 2019; DoSM, 2019). But deforestation is potentially disrupting river ecologies, with the risk of losing both aquatic and terrestrial biodiversity, all contributing to OEC (FAO, 2020). In addition, where projects involve a community living in a particular area, it will displace them and alter the livelihoods of many, affecting the food system, water quality and agriculture (Allen & Barnes, 1985; Solomon, 2004). In addition, Sarawak is also moving towards hydroelectric power (WCED, 2019), a leading source of energy across the world, accounting for up to 71% of energy supply as of 2016 (Moran & Lopez, 2018; BHA, 2021) through the development of the Sarawak Corridor of Renewable Energy (SCORE) (RECODA, 2008).

With hydropower such as the 2,400MW Bakun Dam (SEG, 2018), 944MW Murum Dam (SEG, 2014), 100MW Batang Ai Dam (SEG, 2015; SEG, 2021) and the latest 1285MW Baleh Dam (SEG, 2020), Sarawak aims to encourage investment in power generation and energy-intensive industries, following its world peers (Li, 2012; Paptrotny, 2020). However, in its effort to improve its economy, Sarawak is faced with a double-edged sword. Hydropower facilities are a reliable, renewable, affordable source of green energy, supporting development for people and the environment in line with SDG no 7 (UN, 2019) on Affordable and Clean Energy and no 13 (UN, 2019). Nevertheless, affected areas experience several adverse environmental impacts and, in this research context, affects the irreplaceable OS natural habitat. However, it is similar to the situation in developed countries which have built hydro power facilities, such as the United Kingdom (Topping, 2021; The Switch, 2021), the United States and Russia (Solomon, 2004).

In addition to hydro and gas plants (824MW Tanjung Kidurung), which are significant factors in ongoing biodiversity decline, increasing the magnitude of adverse impacts on the OS, Sarawak has also developed solar power plants to cater to communities of less than 1000 people whose villages are in remotes areas or tough geographical terrain (P) and which are otherwise out of reach of the main grid (SEG, 2021). Previously, the villages depended on generators and fuel, which are costly, unreliable, and inconvenient. These projects are mainly to cater to the basic needs of people and various stakeholders to ensure both short and long-term environmental conservation and livelihood sustainability for local communities. Simultaneously, it achieves sustainable development and prosperity. It does not create hazardous or radioactive waste or cause any other environmental impacts associated with other energy resources (Cada & Dauble, 2004). However, this development comes at the price of plant diversity especially orchids, which has resulted in OEC today, especially when the conservation strategy is limited (Go, et al., 2020).

Plate 2-13

SARES, the Sarawak Alternative Rural Electrification Scheme has created a big difference in the lives of remote communities. Launched in June 2016, it involves changes in land use affecting orchid habitats. Source: Sarawak energy, 2020

Thus, the need to instil awareness of the importance of OS among villagers and the contractors involved in projects in the affected area is vital.

Other types of common unavoidable IP for Sarawak are roads (Plate 2-14), for example, the 1060-km Pan Borneo Highway Sarawak (JKR, 2015), bridges, airports, and water supply and housing developments. On the other hand, highly industrialised countries which are supposed to be leaders in promoting the conservation of forests (UN, 1992) have succumbed to the demands of development, such as the HS2 project (HS2, 2020) in the UK and the Agri-Food Innovation Park, Singapore, which have wiped out 108 irreplaceable ancient woodlands, Wildlife Trust nature reserves and Kranji Woodlands respectively (Woodland Trust, 2020; Marshall, 2020; Li, 2022). The only difference is that the UK government has 16 top BGs (British Gardens, 2018) and Singapore has a BG recognised as a UNESCO World Heritage site (NPG, 2015), which could have at least scientifically addressed and translocated the local endangered species to prevent extinction and create effective awareness among their citizens (Gao, 2018).

Plate 2-14

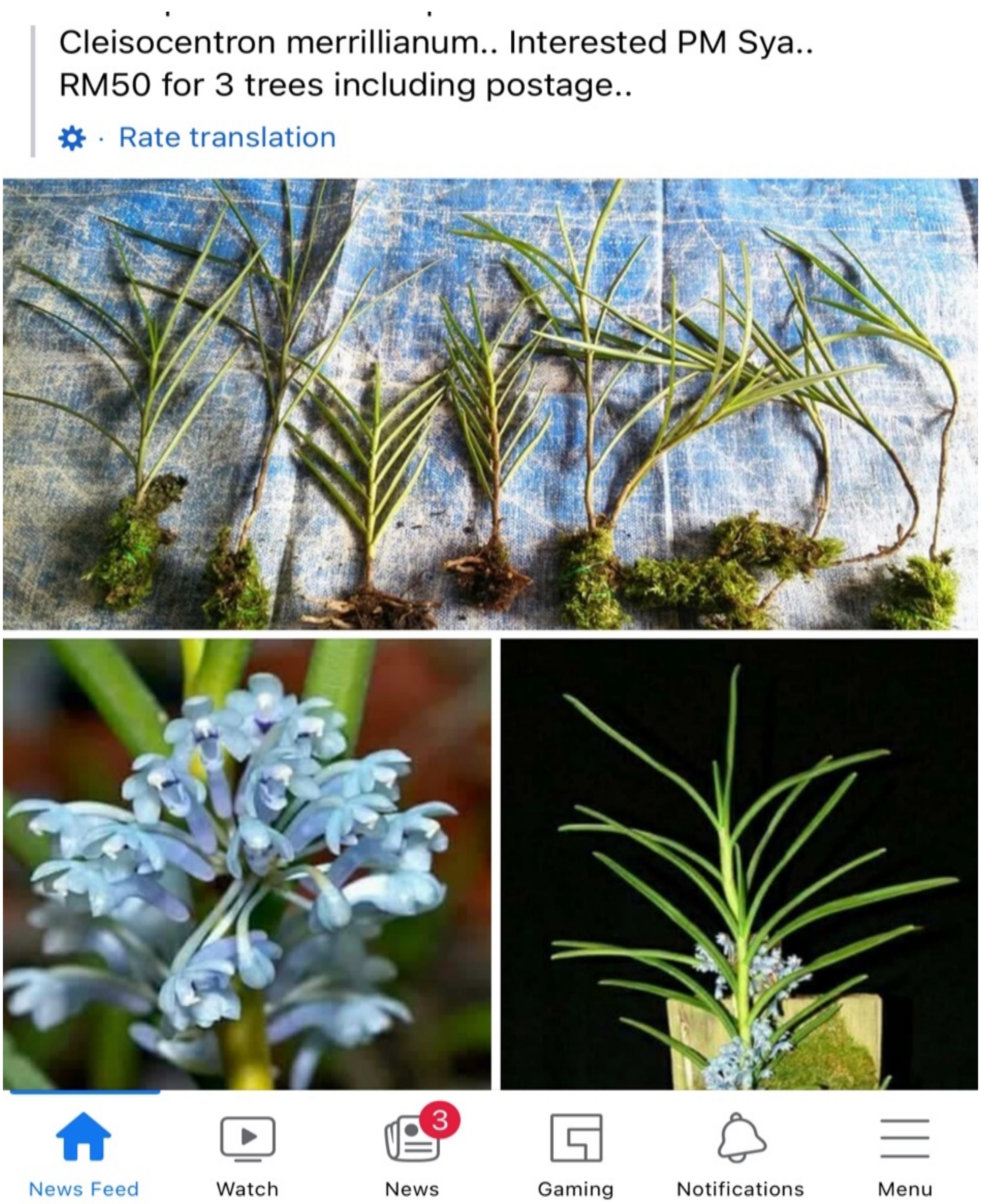
Pan Borneo Highway. This is the first trunk road for Sarawak connecting its divisions. Many foreign NGOs from developed countries criticized this construction due to the deforestation involved. However, with many highways being built in developed countries which sacrifice their few remaining ancient woods, threatening the biodiversity, the call not to clear forest in a state like Sarawak is not effective. All Sarawakian leaders are knowledgeable about what is going on in the world. In fact, the majority of Sarawakian leaders have been educated in developed Countries. Another approach needs to be taken for effective conservation, as this approach may only be effective for political reasons but not for protecting wildlife or forestry. Source: Zecon, 2020

2.7.6 Illegal Collection and Unreported and Unregulated Trade – Collections by Orchid Hunters in the 21st Century

The book, ‘What We Learned in the Rainforest: Business Lessons from Nature’ (Kiuchi & Shireman, 2002), ideally needs to be applied to Sarawak by stakeholders when implementing development projects (OECD, 2020) in order for business to be sustainable and successful. Ecology and economics need to complement each other. Thus, the damage caused by illegal trade, which is a biodiversity crime, causing the overexploitation of species, will need to be made clear and avoided to prevent businesses being regarded as unsustainable and contributing to the current threat of OS (Hinsley & Fay, 2018). There is limited literature on the extent of the illegal species orchid trade in Sarawak because first and foremost, according to state legislation (SARGov, 1998), it is illegal to trade OS without obtaining a license from the Sarawak Forest Corporation (FDS, 2020), which, in the author’s experience, is very difficult. Thus, knowledge and interest among the public on OS were never encouraged and are at low levels (SARORSO, 2018). However, there are local orchid hunters who are knowledgeable in identifying OS. OS are listed in the Protected Plants in the Sarawak Second Schedule [Section 2(1)] PART II on Protected Plants from the Wild Life Protection Ordinance, 1998 (Chapter 26) and are categorised by CITES in the endangered species category close to extinction due to the illegal trading of mature plants (Middleton, et al., 2020).

The irony is that the orchid trade in Sarawak has been a historical tradition since the colonial-era enthusiasm of orchid collectors because known as ‘orchidelirium’. This involved the collecting of unique endemic orchids by orchid explorers who were well-known botanists (Low, 2002; Wallace, 1962; Mjoberg, 1930) or collectors for top nursery owners (Swinson, 1970). However, despite the laws and conferences attended by leaders on OC, in this information age, illegal, unsustainable orchid trading is still going on in Sarawak, conducted by a handful of locals through social media, E-commerce, private business websites, individual websites and telephone apps. For example, WhatsApp has groups of orchids sellers who do not require phytosanitary certificates from the Sarawak authorities, an export license or a CITES permit before being dispatched to buyers at affordable prices (Plate 2-15). It is reported by the UN that 1.1 billion orchids have been illegally traded (Hinsley & Fay, 2018) for scientific research (covering new pharmacological substances and the natural history collections of BGs, which are scientifically important) and commercial trade (Vermeulan, et al., 2014; Fukushima, et al., 2020). However, today in Sarawak, the most common reason for illegal and unsustainable orchids is profitability (Steyn, 2015; Westlake, 2018).

Plate 2-15



Wild Cleisocentron merrillianum, classified as endangered by CITES, which is marketed on one social media outlet at an affordable price. Source: Author, 2019

There is no specific state body, even at a national level, or a CITES significant trade process for orchids. This is in contrast to the processes that are in place for elephant poaching. Monitoring the Illegal Killing of elephants – MIKE (IUCN, 2017) – and its sister programme, the Elephant Trade Information System (ETIS) (CITES, 1997) reduces elephant poaching and identifies trends in the illegal trade of ivory (Hinsley & Fay, 2018), making it more difficult for OS traders to engage in illegal trade. In programmes like MIKE and ETIS, sophisticated technology (ETISONLINE, 2002) is used to detect ivory, no matter how well hidden it is in containers (Plate 2-16). If this was available for orchids, it would control transactions or reduce the frequency of trading in the long term.

In addition, the phenomenon of ‘plant blindness’, where plants are regarded as inferior to animals (Wandersee & Elizabeth, 1999), leads to an absence of funding to address the illegal trade of orchids (Masrgulies, et al., 2019). Thus, the above weaknesses and the high demand for orchids by collectors (Gray, 1999; Hinsley, 2018), either for hybridising, medical or consumption purposes, despite local authorities’ heavy penalties for illegal trade activities (SARGov, 1998; Toyat, 2021), contributes to this illegal trade in developing countries.

Plate 2-16

Left: A scanned image of a container of ‘timber’ showing a secret compartment. Right. Ivory confiscated from the secret compartment. Source: HKCITES Mamnagemnent,2006

2.7.7 Unsustainable Species Orchid Harvesting

The absence of support for an affordable sustainable supply of OS for orchid enthusiasts and the presence of weekend markets in outlying towns selling mature OS (Plate 2-17) at low prices compared to those sold by licensed nurseries have encouraged illegal OS harvesting. In addition, the abundance of accessible forestry throughout Sarawak and the lack of awareness of the importance of OS also encourage poachers to harvest OS from their natural habitat. In addition, villagers who are unaware of the legislation and the values of OS to the ecosystem believe that they are a part of the forest resources which they have been extracting like other resources to meet their day-to-day needs. As long as there is demand and a limited supply, the trade will remain, especially when there is online trade.

Plate 2-17

Mature orchid species being sold at the border town of Tebedu, Serian, Sarawak. Source: Tengku, 2018

That some orchids had recovered only to immediately become extinct, such as the famous case of *Bulbophyllum kubahense* (Vermeulen & Lamb, 2010; Schuitermen, 2017), which shows that illegal trade is ongoing. There may be loopholes in the guidelines for orchid nurseries to obtain a license to conduct business activities in the sale of OS (SWK Gov, 2015). In the UK, OS nurseries have an in vitro orchid propagation lab, with every activity recorded to ensure that seedlings are legally sourced (Plant Heritage, 2020; WSBE, 2020). Currently, there are fewer than five licensed OS nurseries in Sarawak. The main nursery which has monopolised the market and manages the Government Orchid Garden (DBKU, 2018) is Orchidwood Sdn Bhd (Orchidwood, 2020). This state-owned orchid garden does not sell any orchids; however, the caretaker of the Orchid park sells its collection of OS at a very high price, mainly targeted at tourists. With the high level of habitat destruction going on, displaying attractive orchids at gardens without providing any effective conservation message to locals will encourage the unsustainable harvesting of selected OS for profit and gradually lead to the extinction of other OS.

Until Sarawak authorities facilitate and endorse sustainable and accessible methods for the mass propagation of orchid species (OS) and effectively educate the public on OS conservation through awareness (Chapter 5), the persistent issue of unsustainable harvesting is likely to continue unabeted until reaching critical levels as emphasized by (Go, et al., 2020). Drawing lessons from other nations, particularly Great Britain, where in vitro micropropagation is not onlya subject in higher education but also integrated into secondary schools extra curricula (Pumpkin, 2016; WSBE, 2016; Pugh- Jones, 2020), Sarawak could benefit from a similar educational approach. Raising awareness about the threats faced by OS and imparting knowledge on OS habitat, the symbiotic relationships with pollinators and mycorrhiza, and the associated habitat threats and opportunities could inspire school children and indirectly influence the community in their vicinity to actively contribute to the development of a pertinent curriculum (Pugh-Jones, 2020; Pugh- Jones, 2020).

Plate 2-18

Exposing students to OS habitats would help the younger generation understand the importance of sustainable harvesting, habitat preservation and orchid conservation. Source: Sarawak Orchid Society- SARORSO, 2019

Moreover, the absence of orchid societies in Sarawak, in contrast to the situation in the UK, has resulted in missed opportunities for local engagement in orchid-related activities, including educational, horticulture, floriculture could benefit through orchid activities, such as educational and horticultural displays and conservations efforts employing various innovative technologies (EOCCE, 2018; OSGB, 2019). Such activities hold the potential to acquaint the public the aesthetic values which as highlighted by Beaman (Beaman, et al., 2001), remain relatively unfamiliar to the local population. Moreover, these activities serve as a platform to communicate anthropogenic threats and underscore the economic potential associated with orchids. The exposure facilitated by these endeavours is anticipated to stimulate local involvement in the generation of ideas and development of effective policies (AOS, 2018), representing a consequential avenue for addressing unsustainable harvesting. Importantly, gthis avenue extends beyond the purview of scientists or state governance, encompassing active participation within civil society itself (Gao, 2018).

Plate 2-19

Educational displays prepared by a British orchid society, a school with an orchid project, in Bath, the UK, and participants at the Paris Orchid Conference, which was open to the public. Source: Tengku, 2018

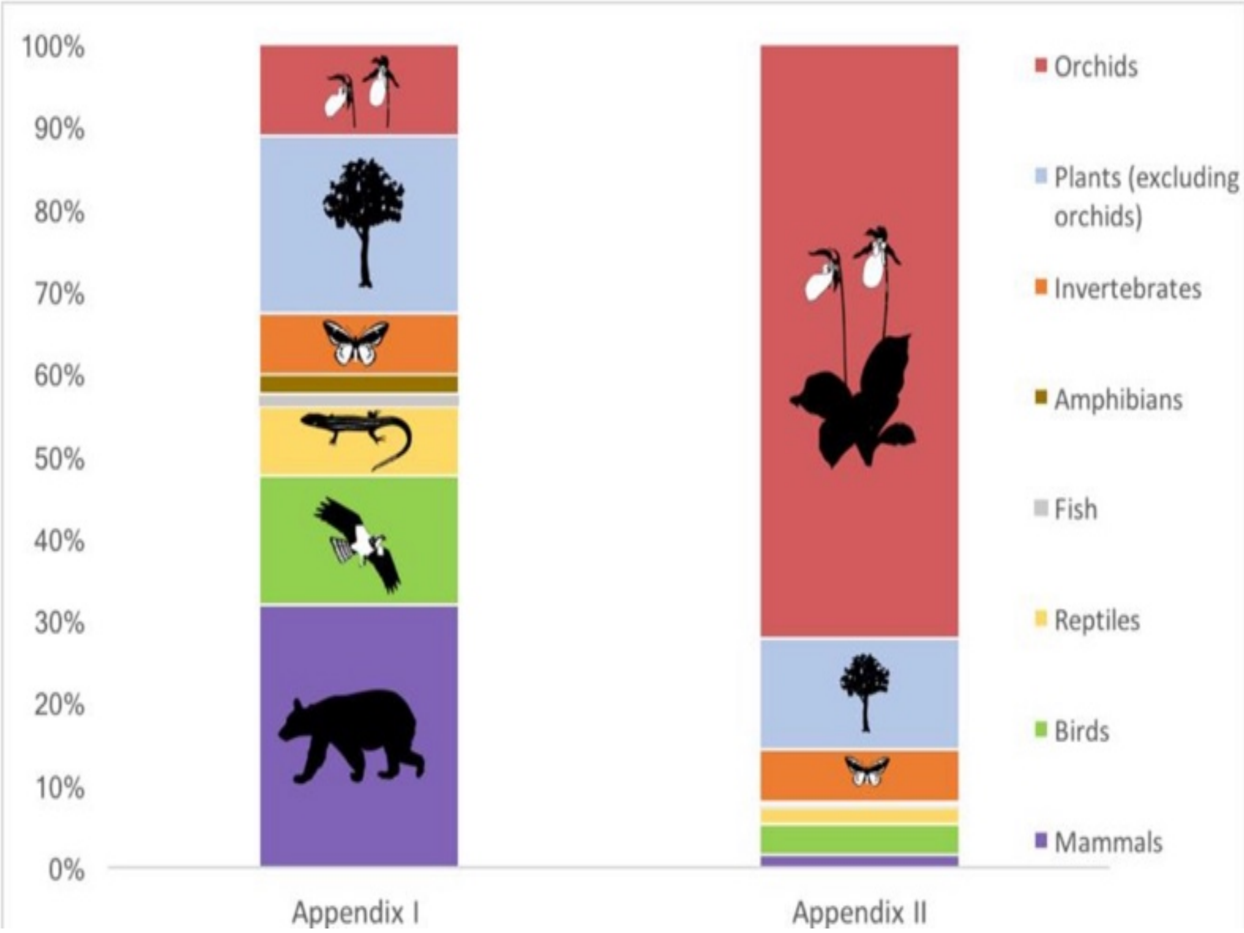
2.7.8 CITES

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), established in 1973 with the participation of 120 countries is multilateral treaty designed to safeguard endangered plants and animals (CITES, 1973). CITES, governing wildlife trade, oversees transactions between participating countries with OS constituting 70%

of the listed wildlife (Figure 2-7. Despite collaborative efforts between CITES the World Customs Organisation (WCO) to monitor online trading particularly concerning OS, effective control remain elusive, evidenced by persistent illegal online trading (CITES, 2020) (Hinsley, et al., 2017; Hinsley, 2018).

Upon species declaration as endangered, there is an augmental allure for illicit black-market trade. However, Dr Ian Chalmers, an Australian orchidologist, contends that CITES' trade agreement primarily aims to prevent wildlife international trade from jeopardising OS's survival rather than directly addressing OC (Chalmers, 2019). Despite the existence of CITES , recent undocumented cases, such as the *Phragmipeding kovachi* case, underscore the continuing impact of illegal international trade on OS populations globally, even in the face of substantial penalties imposed by CITES (Cribb, 2005; Oilson, 2014). Additionally instances

Figure 2-7



Orchids are at the top level of endangered species (prepared by Integration and Application Network, University of Maryland Centre for Environmental Science). Source: Hinsley, 2018

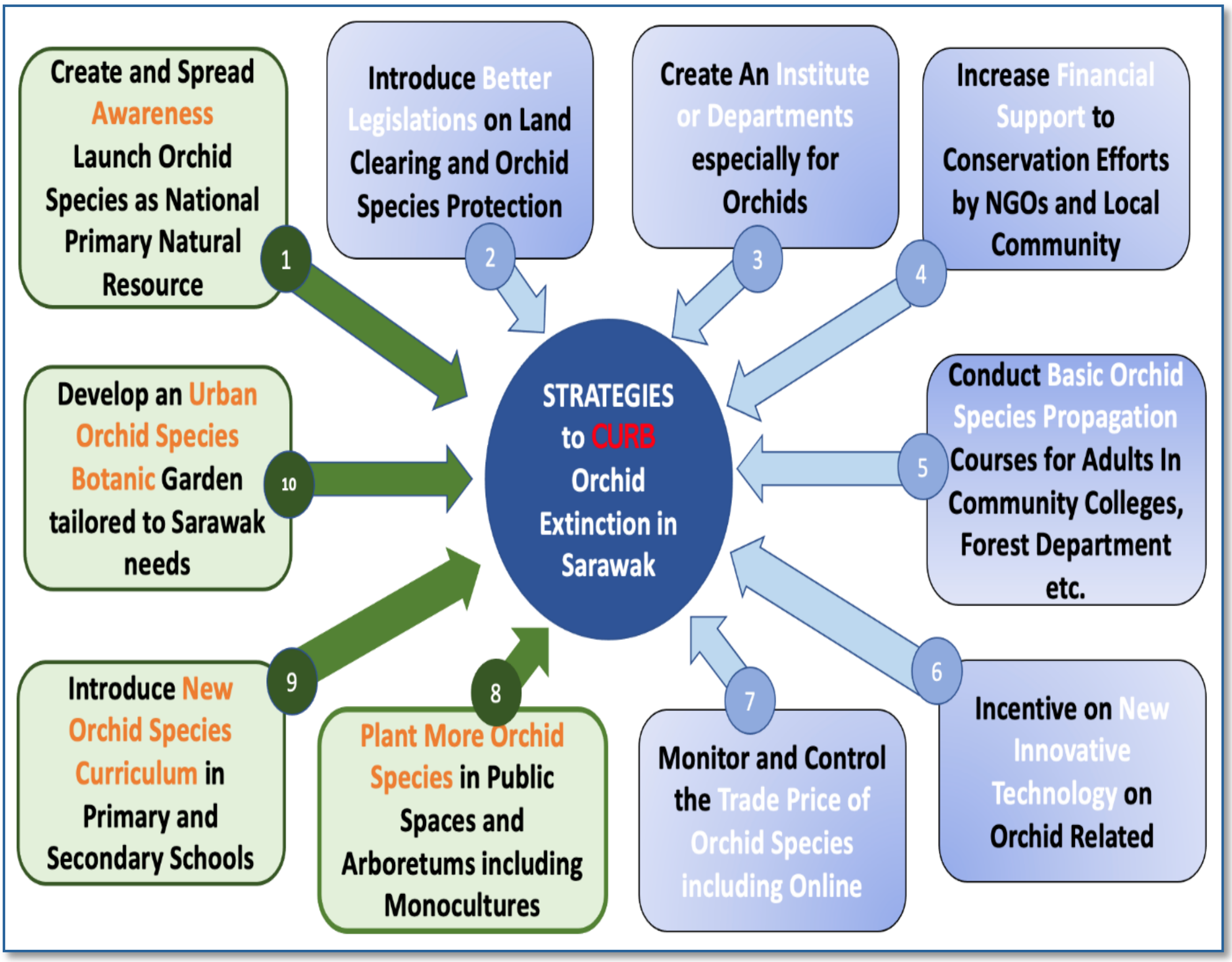
2.8 Sarawak Orchid Conservation Efforts

Keeping the above in mind, it is imperative to understand that there have been many factors that have led to the OEC in this part of the world (Wraith & Pickering, 2018). Official OS conservation efforts essentially do not exist due to the lack of dedicated or specialist organisations focusing on OS. Sarawak does not have a BG nor does the Forest Department have a dedicated working team for OS even though OS comprise the largest species among the wildlife. On the other hand, conservation need not only be considered at the macro level, involving policies, governments and countries but instead can be applied at the micro-level. Whilst changes to laws and cross-border interaction may take time to develop, both ex-situ and in situ conservation can begin in the backyards of households or schools led by their own communities (Pugh- Jones, 2003; Dilley, 2007; Oldfield, 2010). The key lies in the spreading of awareness and knowledge to the masses. This can unlock the desire to practise conservation at a personal level and as a community. In launching a national campaign to introduce OS, the current OEC would help to create awareness among a larger group of people.

Whilst there are laws for the protection of wildlife in general (SARGov, 1998; CoLRSWK, 2008), they are too broad. With the pace Sarawak OS habitats are being cleared in 21st century anthropogenic activities, there is a need for professional guidance from higher authorities to ensure effective OS conservation programmes. With the establishment of Sarawak Orchid society (SARORSO) in February 2018, some positive movement on this ground has occurred, producing promising results. SARORSO seem to be receptive to proposals on OS conservation and has made steps that have led to successful conservation efforts, attracting the involvement of State authorities and the public (Choo, 2019; Cowan, 2019; Darani, 2019; New Sarawak Tribune, 2019; Otsman, 2019; Jee, 2021; RHS, 2021; Sarawakku, 2021)**.** That is, an action-based, broad scale, integrative conservation approach focused on OS which engages the community and seems to have been more effective in addressing the issues and gaps identified in Figure 2-8

If the awareness levels of Sarawakians on the OS population increase, a similar contribution to halt the OEC through education and the latest technologies could be replicated and shared with those interested throughout Sarawak's divisions. This Orchid Cluster Concept (OCC) is based on the Thailand and Taiwan orchid clusters framework. Thailand and Taiwan are leaders in OC, growth and enterprises (Lekawata & IntalakAth, 2016; AgriTT, 2018). In addition, OCC would not only help reduce the pressure of wild orchids in their natural habitat, but it would also help build a competitive sustainable orchid floriculture industry in Sarawak in line with the state's aspiration to have a flourishing floriculture export industry (Borneo Post, 2015; The Star, 2019).

Figure 2-8



Proposed strategies to address the orchid species extinction crisis in Sarawak, Malaysia. Source: Tengku, 2020

2.8.1 Legislation

In Sarawak, it is illegal to export orchids from the jungle (SARGov, 1998; SARGov, 1998; CoLRSWK, 2008; SWK Gov, 2015). The National Forestry Act 19 (SARGov, 1998; CoLRSWK, 2008; CITES, 2014) -amended 1993), the Wildlife Protection Act 1972 of the Wildlife and the National Parks and Nature Reserves Ordinance 1998 (amended 2008) also prohibit the removal of vegetation from wildlife reserves unless it is for cultural purposes (reasonable quantity) or local research. However, despite strict laws, the following OS destruction still takes place:

> "OS are still being poached in Sarawak's forest reserves, as is the case of Bulbophyllum kubahense (Vermeulen & Lamb, 2010).
>
> Massive clearing of forests affecting OS habitats continues without rescuing and relocating the OS by the contractors (Go, et al., 2020). Orchids have been left to dry and perish on the tree trunks.
>
> Illegal trading continues (Hinsley & Roberts, 2017)"

The amendments to the Sarawak Forest Ordinance (SARGovt, 2015) in 2015 and Sarawak's Natural Resources and Environment Ordinance (SARGovt, 2019)in 2019 increased the penalties for violations of the law. Infringements include includes ownership and resettlement of wildlife of identified affected forests before the deforestation process takes place. With the OEC and to strike a balance between development and conservation for a protected environment, a focus on OS as the flagship of plant conservation needs to occur with regards to ownership, rescue and translocation work to an alternative habitat, which is similar to and near their natural habitat (SARGov, 1998; SARGovt, 2019). Heavier penalties than before need to be imposed on contractors, project owners and government officers in charge (to prevent corruption) as their irresponsible act is leading to the mass destruction of the state's valuable natural resources and environment. In addition, there needs to be stricter enforcement of the law for OS nursery owners who sell or export undocumented, highly-priced OS from the wild. Due to the critical OEC, rescued wild OS should not be put on the market but need to be reintroduced to nature reserves, BGs and green spaces owned by the state government or local government and semi-state premises, academic institutions for research or alternative habitats, such as perennial monoculture plantations, to improve biodiversity.

Adopting an effective international law such as the US Endangered Species Act (ESA)1973 (EPA, 1973; FWS, 1998) as a model to focus on punishments and legislation covering the protection of the OS could further improve the overall body of law. On the other hand, international laws introduced under CITES have hardly ensured compliance, with offenders being seldom caught (Lavorgna, et al., 2018). Therefore, legislation in Sarawak needs to play a more important and effective role in managing the state's overall conservation needs in order to create a sustainable environment. The law needs to include preplanning, developing and implementing recovery plans and involve federal, state and local officials (including forest, herbariums, parks and nature reserves), orchidologists, NGOs, academics (from higher institution and schools) and community representatives (village and tribal heads) before awarding any projects and prior to deforestation. Nevertheless, even with the enhancement and empowerment of legislation, the geography of Sarawak will be the real challenge for successful implementation. Therefore, the chances of success would be higher with the participation of the local communities familiar with their own areas if they realise the benefits of participation (Hinsley & Roberts, 2017; Keyles, 2018).

2.8.2 Effective Community Involvement in Sarawak Orchid Conservation

According to Stanford University in the US, Malaysian scientists are among the top 2% of scientists in the world (The NST, 2021; The Star, 2021). In Sarawak, research on OS conservation by organisations such as the Botanical Research Centre (BRC, 2019), Sarawak Biodiversity Centre (SBC, 2009), and University Malaysia Sarawak (UNIMAS, 2018) are highly technical, using sophisticated instrumental techniques They are well supported and respected nationally and internationally, especially with their collaboration with the University of Cambridge under scientific exchange programmes (Sarawak RDC, 2017). However, despite their achievements, there is still a lack of cooperation between local scientists of registered scientific institutions and the community in Sarawak (Hinsley & Fay, 2018; Hinsley, 2018;

Hinsley & Robertds, 2018). Research (Arlettaz & Schaub, 2010) shows that scientific findings and knowledge are not being made known or accessible to the local community due to four factors. Firstly, it is impossible to convert conservation theory to conservation action due to a lack of information; secondly, some conservation research is irrelevant for practical purposes; thirdly, implementation is dependent on economic, social and political support, and finally, there is a lack of commitment by researchers to implement measures, which has resulted in research going nowhere after it has been published (Fitzpatrick, et al., 2020). Taking these four factors into account, awareness of the community of OC issues is inconceivable without the creation of a group of third parties interested in orchids. These would be volunteers acting as a link between scientists, the media and the community, (Jamison, 1996), combining expert knowledge into policy-oriented packages and contributing their experience and knowledge (Keyles, 2018). This is being practised in Taiwan and Thailand through their respective orchid cluster frameworks (AgriTT, 2018).

Sarawak's scientists and botanists from various state governments and semi-government organisations involved in OS conservation have represented, participated in and even organised local and international conferences over the past four decades, yet the level of awareness among the public on OS is still very low (Zizka, et al., 2020). For instance, OS have been removed from city trees and not translocated as it was assumed that they were parasites (Plate 2-20).

Plate 2-20

The staff of Kuching City Council cleared orchid species growing on trees assuming that orchids were parasites. The orchids were rescued by Sarawak Orchid Society (SARORSO) members who happened to be passing by. Source: SARORSO, 2018

Unlike the KMC staff, Singapore Municipal City Council workers put orchids on their city trees to create a fragrant city and as part of their OC programme (Nparks, 2013; Nparks, 2013). They even shared their ex-situ conservation effort on social media and included the benefit of OS to educate, inform and stir interest amongst the public (Plate 2-21). Consequently, this article may have motivated a secondary school student who entered a drawing competition and submitted her entry under the same topic as the article (Plate 2-22). Most importantly, it reached young readers (Ngee Ann, 2017). Therefore, despite Sarawak and Singapore being neighbours and having been colonised by the British, there is a stark difference between their responses to the conservation of OS, with Singapore introducing OS into trees in urban areas whereas

Sarawak removes naturally-occurring OS from trees. Singapore also has a 163-year-old, 203-acre BG, a UNESCO World Heritage Site, a 26-year-old National Orchid Garden (NParks, 1995) and A 94-year-old orchid society (OSSEA, 1928)

Plate 2-21

NEWS FOCUS

New drive to make S'pore a fragrant city

By Francesca Nathan

FRAGRANT city — that's the aim of a new effort to make Singapore not only clean and green, but fragrant as well.

Sweet-smelling orchids have been planted along Orchard Road, Orchard Boulevard and Upper Pickering Street.

The project involves attaching wild orchid plants to the branches of roadside trees — as they would do naturally.

The Parks and Recreation Department started the project three weeks ago, and has already "married" more than 500 such plants with "host" trees in the Orchard Road area.

But vandals struck about one week ago. They ripped out some of the plants from the rubber tubes which held them in place.

So far, the wild Pigeon Orchid, or Dendrobium Crumenatum, is the only flower used in this project. It is one of a few orchids known for its delicately perfumed blooms.

Another feature that makes this orchid suitable for the purpose is that all the plants of this type in a particular area tend to bloom together.

Mr Hardial Singh, the Deputy Commissioner (Maintenance) of the Parks and Recreation Department, said: "Singaporeans walking down a street lined with trees bearing Pigeon Orchids in bloom would get a strong whiff of perfume."

The department picked this programme as a step forward in

The Pigeon Orchid ... In Papua New Guinea, it is believed to be a cure for a sexual disease.

Some 85 trees along Orchard Boulevard now bear more than 320 orchid plants, while trees along Orchard Road are covered with 171 plants.

The project will gradually be extended to other parts of the island.

It is now also planting Pigeon Orchids on trees along Pickering Street, and will move onto

The final phase in the "perfuming of Singapore" will involve trees in various parks.

Another programme currently under way involves the planting of ferns on roadside trees.

The plant used is the stag horn fern, which Mr Hardial Singh described as a "natural" choice for such a project as it is attractive and is found growing

An article in a Singaporean local newspaper on the orchid conservation program showing how its national park staff are putting Dendrobium crumenatum on a city tree. Source: Daily News, 2016

Plate 2-22

An entry submitted by a secondary student in a drawing competition in 2017. Source: Daily News, 2017

In addition, Kuching city has frequently organised international orchid events, the latest being the grand 13th Asia Pacific Orchid Conference (APOC), held in Kuching in 2019, with the objective of achieving international cooperation (DBKU, 2019). Presentations were made by scientists from 15 countries, but the turnout of the public was low due to the reportedly high entrance fee. Nevertheless, the floral display and sales of orchids received overwhelming responses, and it could have been a great opportunity to create public awareness on OS. However, the floral displays were also focused on the aesthetics of hybrid orchids and there was hardly any literature or posters on OE available on site (APOC13, 2019).

There were two booths that attracted many civilians (including the younger generation), leaders and international scientists. These were educational booths set up by the Sarawak Orchid Society (SARORSO) for their SARORSO/Mara Junior Science College (MRSM) Orchid Project, which resulted in it receiving sponsorship (Otsman, 2019; New Sarawak Tribune, 2019; Cowan, 2019; Nani, 2019; TVSarawak, 2019) to expand its OS citizen science (Roy, et al., 2012; Haklay, et al., 2021) projects (defined in the UK Environment Observation Framework as the involvement of volunteers in sciences) to expose other secondary school children as well as the community in the remaining 12 divisions (Haklay, et al., 2018; NG, 1996)

Therefore, as it appears the world faces another mass extinction event (Wilson, 2001; Brannen, 2017; Matjja, 2017), there is a need for citizen science (CZ) to be involved in OS conservation efforts in Sarawak, as OS habitats are depleting at an alarming rate. This is in order to be politically important and effectively address OEC over a short period (NG, 1996; Geoghegan, et al., 2016) (Philips, et al., 2018; CBD, 2021). As highlighted in Chapter 2.7 and Figure 2-5, more than just legislation is required. Scientific research and living specimens for effective OC efforts are required, along with an intermediary party who is passionate about OS and has the ability, finance and time to translate these scientific findings into issues of public concern (Kasperowski & Kullenberg, 2019; Chalmers, 2019). Data suggest that the involvement of CZ produces a better chance of success with relatively low capital rather than leaving it to scientists and conservationists (Pocock, Michael JO; Tweddle, John C, 2017; Gale, et al., 2018). Not only will the participation of CZ among scientists projects (if provided with the right tools) improve CZ literacy (Cronje, et al., 2011; Hecker, et al., 2018), it will give a new perspective, providing greater appreciation, understanding and knowledge of OS and OC, which would then help address OEC for future generations to benefit from (AOS, 1921; fairchildgarden, 2020).

Further, collaboration between the two parties would not achieve wide coverage, promoting new OC findings and ideas, but would have the capacity to influence policy and decision making (Stone, 2014).

Case 1: Sarawak Orchid Society – SARORSO – Citizen Science-based Conservation

Sarawak has never had an orchid society or a BG despite having a close association with Singapore since the James Brookes era (Brooke, 1853; Brooke, 1935; Reece, 1993; Reece, 2004). Therefore, in pursuit of assisting the state authorities in bridging the gap in awareness between scientists and the community on the need for OC in Sarawak, SARORSO was established on February 6, 2018 (Appendix 2.2) by a group of women of differing academic backgrounds who were passionate about orchids. The members were formed from individuals from the 13 divisions of Sarawak, with each division being represented by a committee member who was designated to disseminate information. Since its inception, SARORSO has been committed to preserving OS by addressing the OEC through promoting the involvement of educators from various backgrounds, such as orchidologists, botanists, taxonomists, scientists, and schoolchildren. SARORSO has also:

- Created OS awareness programmes, such as local talks with communities in urban areas and villages (Appendix 2.3).
- Held field trips with its members and students to introduce to them orchid herbariums, (Appendix 2.4).
- Helped deliver scientific knowledge to several orchid micropropagation laboratories belonging to institutions of higher learning, the government, and private institutions (Appendix 2.5).

- Created a database – data obtained includes information on exhibition booths displaying information on OS and the need for OC while raising public awareness through questionnaires for the society's future planning on addressing the OEC effectively (Appendix 2.6).

- Initiated technology transfers and data collection. It built Malaysia's first OS in vitro micropropagation (OSIVM) school laboratory, based on Writhlington School's OSIVM laboratory model, to produce seedlings and collect data through observation. Both situ and ex-situ conservation measures include at future BG, a school compound and the community (parents, teachers, cleaners (Cowan, 2019; Kunjak, 2019)(Appendix 2.7).

- Introduced the concept and role of a BG within a school and got their response; built an OS nursery (living museum), labelled all OS growing wild on trees and planted more Sarawak endangered endemic trees in the school compound. These will also act as future OS hosts (Appendix 2.8).

- Supported biodiversity and conservation projects – assisted in collecting data through observation in the trial for translocating OS into OPE and adopted the trial as a model project for implementation in other OPEs, encouraging local and international youth to respond to the OC (Darani, 2019), (Appendix 2.9).

- Built effective future OS research, presentation, and communication skills – participated in conferences nationally and internationally, exposing members and students to scientific research results, AND meeting others, including leaders within the same field (Appendix 2.10).

- performed in situ conservation – Collecting data and rescuing OS, translocating them to new habitats (Appendix 2.11).

- Understood and engaged with stakeholders on agreeing with the society's goals – meetings and discussions with Sarawak government authorities, among others the Deputy Chief Minister's office, the education minister, the land development minister, the forest department chief executive officer, tourism board authorities, higher institutions' heads of department, Kuching municipal mayors (Appendix 2.12).
- Collaborated with international partners – discussions for improvements which benefit and complement the conservation efforts of all parties (Appendix 2.13).
- Raised funds for community OC projects and cultural efforts – socio-economic opportunities for citizens from the state's natural resources while at the same time promoting conservation efforts (Appendix 2.14).
- Obtained a premises for SARORSO headquarters to hold exhibitions, events and a living museum for members, the community and visitors, as well as a centre for Sarawak OS (Appendix 2.15).

In 2018, SARORSO initiated the effort to develop a questionnaire (Appendix 2.16) to understand the level of awareness the public of Sarawak had about OS and the need for a BG focusing on OS in Kuching. This came up when the committee members could not get obtain data for their future short and long-term goals. Even the members realised that their understanding of Sarawak OS was very low. The questionnaire was distributed at SARORSO events and there was no discrimination around who could complete the questionnaire (appendix 2.16).

The key takeaway from the questionnaire (data up to 2019 due to Covid-19) was that 64% of the public believed that OC was an important subject even though only 34% had heard about OC efforts being carried out before knowing about SARORSO. This indicates that there is a latent appreciation of OS or an understanding that they are under threat; however, there is a lack of outreach. This is further backed up by 87% of the public not understanding what the rescue of OS entails. Had there been sufficient outreach, most of the public would have some awareness of OS, and OC would understand the objective, methods and activities revolving around the issue of the rescuing of OS.

Concurrently, the results (Appendix 2.17) show that 59% of those who completed the questionnaire believe that there is a need for an OS BG in Sarawak. This is understandable as only 34% have heard about OC. From these results, it can also be understood that should there be a botanic garden established. There is already a latent amount of interest even before any active outreach or promotional events took place. This bodes well when considering that community engagement plays a crucial role in raising awareness and if the community in general already has an interest in BGs, it stands to reason that any efforts made will be well received.

As a pioneering orchid society, SARORSO is committed to driving the OC cause with the above programmes that require time and money (Geoghegan, et al., 2016). However, with the Covid-19 pandemic, the Society's physical activities came to a halt for almost two years. Activities were limited to virtual events, which has affected some of the projects. Nevertheless, the Society has carried out effective conservation activities over the past two years. This was recognised, commended, and highlighted in the 13th Asia Pacific Orchid Conference by speaker

Dr Ian Chalmer, from the Australian Orchid Council, Australia, in his presentation (Chalmers, 2019) (Appendix 2.17).

Unlike many other orchid societies which were established in the 18th and 19th centuries by nursery owners and had the objective to collect OS specimens for research and horticultural purposes and for (NEOS, 1897) (OrchidWire, 2018), SARORSO's main objectives in the 21st century are raising awareness and championing OS conservation among the public to assist in addressing the OEC. Additionally, SARORSO is steadily following its goal of showing that through horticulture, conservation projects do not limit progress in socioeconomic development (Hinsley & Roberts, 2017; Martin, 2019) This is reflected in SARORSO's recent project of processing *Dc* and *Ag* into herbal tea with the guidance of the Malaysia Agricultural Research and Development Institute.

Even though SARORSO members have voluntarily carried out a list of ambitious conservation activities over the past two years, attracting community engagement from secondary students to OPE owners, the focus could change with a different leadership in the future. The current stewardship is focused on OS conservation and the setup of a UOBG. The goal of the society may change with new leadership, along with the pressure of authorities and politics. Secondly, SARORSO may lack the scientific finesse when recording data (mainly due to lack of access and mobility during the Covid 19 pandemic). This could lead to data discrepancy and could hinder conservation aims, causing disillusionment in the people involved (Cox, et al., 2012). Under normal circumstances, they would be professionally guided so that data quality observed and recorded would be accurate and validated by qualified scientists from the area. For example, the questionnaires and reports prepared and shared by SARORSO may raise doubts even though they have a resident scientist who is a retired professor at a local institute of higher education unless he manages the validation of data.

Thus, a great responsibility lies with the leader, committee members and those responsible for carrying out plans and projects to create SO awareness and develop related skills and interest through motivation (Geoghegan, et al., 2016; Roy, et al., 2012). Such a society has a significant conservation role to perform. Its success will be measured by whether it will win over the public, scientists, and government authorities. The presence of SARORSO underscores the efficacy of CZ projects in OC, as evidenced by their impact on urban orchid conservation actions and design (Roger & Motion, 2021; Capdevilla & Kirschke, 2020; Gao, 2018; Ballard & Tweddle, 2017; Sforzi, et al., 2018). Therefore, implementing and replicating an enhanced framework of SARORSO CZ projects within both OPE and the secondary school community represents a holistic and comprehensive strategy and expedient approach to addressing orchid extinction in Sarawak.

Case 2: Writhlington School (WSBE) – A Model for OS Conservation Education in Sarawak

WSBE is a British school located in Writhlington village, a suburb of Radstock, six miles north-west of Frome in Bath. The school runs the Writhlington School Orchid Project, led by Dr Simon Pugh-Jones MBE (WSBE, 2016; Pugh-Jones, 2020). The Orchid Project involves Year 7 to Year 13 students and focuses on the conservation of many SO from around the world, including Sarawak OS (WSBE, 2020). Writhlington is the only secondary school in the world known to undertake the OC of up to 800 species, including tropical orchids, initially in a bid to save OS in the wild. But over the years, this project has helped create effective OC education in tropical countries (Pugh- Jones, 2003; Choo, 2019). This would not have happened without the passion, ideas, initiatives and inspiring leadership of the teacher in charge, Dr Simon Pugh-Jones, for the past 30 years (UoBristol, 2019). The project has thrived to the point where members of the project have travelled around the world for OC expeditions, creating awareness and sharing knowledge and skills with secondary school students (Plate 2-23), including Malaysia (WSBE, 2004; WSBE, 2014; WSBE, 2019). With the collaboration with Writhlington, the MRSM Orchid Project students were invited by the 23rd World Orchid Conference held in Taiwan to present a poster (Plate 2-24), which is a first for Malaysia.

Plate 2-23

Writhlington Orchid Project Students in Kuching share their experience, knowledge and skills with MRSM Orchid Project students. Source: Tengku, 2019

Plate 2-24

The MRSM Orchid Project team represents Sarawak, Malaysia. It was the first time Malaysia was represented in such a conference by secondary school students. Source: WOC, 23, 2021

The project encourages students to carry out their own research with tangible, real-world applications, ensuring that students will be developed holistically. Students look at the entrepreneurial element of OC through the sales of laboratory-based orchid tissue culture, which has kept the project sustainable while, at the same time, allowing them to influence children to have the right attitude as entrepreneurs. Through sales, the WSBE project has sufficiently financed students for them to hold OC educational field trips abroad, including to

Malaysia. The enterprising factor of WSBE is another area that makes the OC project realistic, attractive and successful. More often than not, innovative, creative, scientific and inspiring projects fail because the project cannot be transferred to real-life situations. The infusion of science, including presenting papers in conferences, which has won them national and international recognition, enables them to present professional educational and art displays of OS in conferences. This has broadened their knowledge of OEC and OC. Working with the national curriculum has been beneficial to the students themselves, exposing them to non-classroom-based experiences. This is evident through the number of WSBE students who have attended Russell Group universities such as the University of Cambridge, the University of Oxford and the University of Nottingham.

The Orchid Project's Year 8-12 students are knowledgeable, skilled and passionate about their 52 UK-native terrestrial orchids and epiphyte orchids from around the world as compared to school children in Sarawak, who have been surrounded by 2,500 OS all their lives (Coles, 2021; WOP, 2021). This project serves as an eye-opener and an effective model for engaging Sarawak school children in being part of OC and knowing the importance of OS. Introducing OC projects in schools would also increase interest in BGs, as schools have the potential to become mini BGs. Schools are not only in the unique position to influence students' interests and careers by having orchid laboratories and living museums but also help inspire the next generation of orchid conservationists. This is especially true in Sarawak, as students of each division can relate to the natural wonders that surround them, such as Gunung Mulu, Gunung Api and Guung Benarat, and also the historical Gunung Santubong, which have virgin rainforests rich with OS.

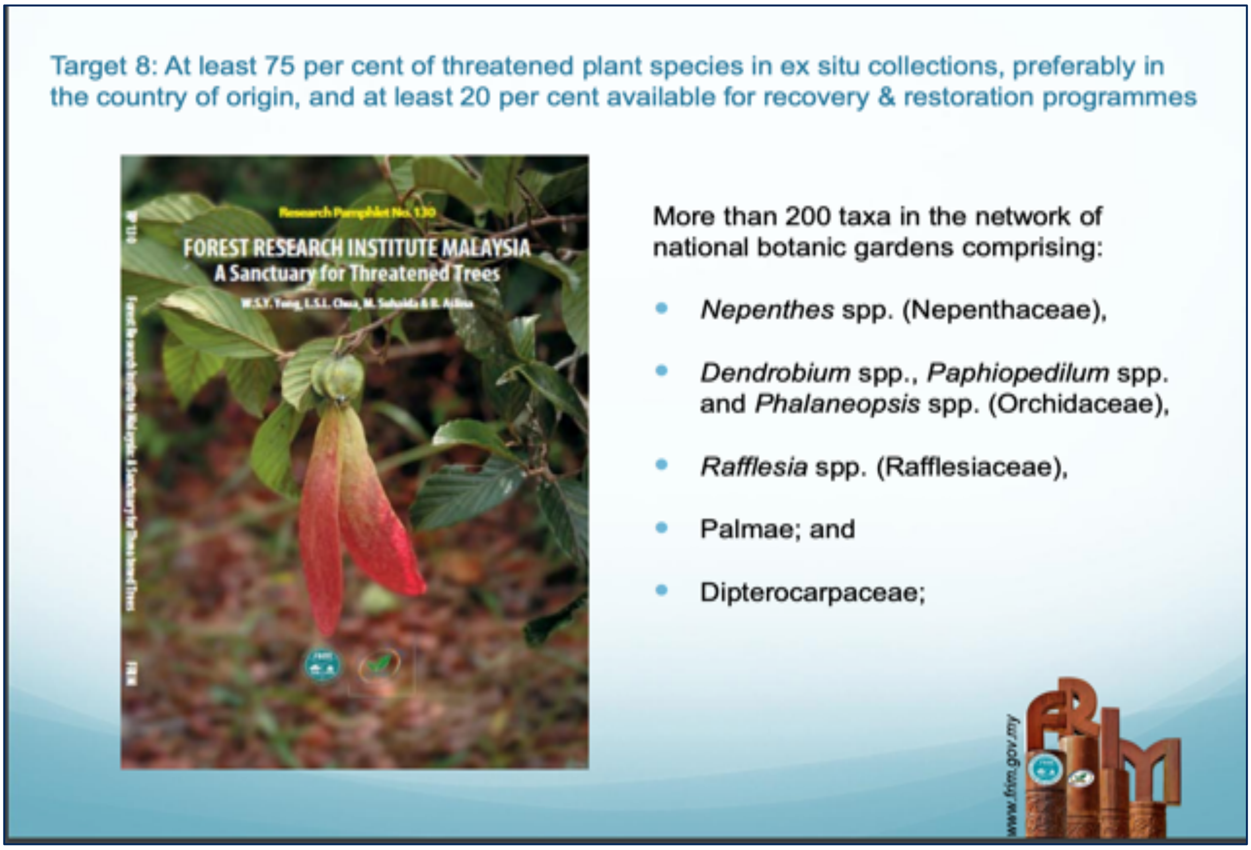
2.9 Botanic Gardens (BG) and Orchid Conservation (OC)

Today, BG, representing the world's 'single largest biological institutional capacity' for the purpose of scientific research, horticulture, the conservation of rare and threatened plants, displays, and education in compliance with international policies and sustainability and ethical initiatives (Swarts & Dixon, 2009; BGCI, 2018), are being questioned (Donnell & Sharrock, 2017; Smith, 2018; Breman, et al., 2021). This is especially so as Target 8 of the GSPC, which calls for 75% of threatened plant species to be present in ex-situ collections in the country of origin, with at least 20% percent available for recovery and for restoration programmes to be launched by 2020, has generally not been met. This is especially so in non-developed countries with high plant biodiversity (CBD, 2019; CBD.int, 2020). Visitors (non-scientists) need to be able to experience the above whereby, as they enter a BG, they can automatically understand the role of BG so that it inspires developing countries to spend their revenues on an iconic BG. These expensive glass conservatories are not needed in tropical countries to address OEC (Smith, 2018).

The earliest record of the origin of BGs is the gardens of monasteries, where herbalists grew plants for their medicinal properties and the gardens attached to the medical schools of universities for the purpose of scientific research by medical students. This version of a BG seems to be more relevant to public understanding as the evidence of scientific effort and relevance of plants is clear to visitors. It stimulates and educates them, and appears to be relevant rather than being just a display of horticulture with minimal and unclear communication (Primark, et al., 2021). According to the director of Edinburgh's Botanic Garden, David Rae, 'the 21st century BG "must" be all things to all people not "can" in order to be effective in delivering it' (Swift, 2014). Different countries have their own histories, which has led to the development of their own BGs. They have been tailored to their needs over time. The challenge is that they have to maintain it over time. As for Sarawak, a BG has yet to be developed despite discussions continuing since 2013 and an allocation of funds amounting to RM10 million (Danell, 2013; Recoda, 2016). This gave Sarawak the opportunity to develop a BG that would meet the plant conservation requirements of Sarawak, as outlined by BGCI (BGCI, 2016; BGCI, 2018). However, in this context, the BG would specialise in OS. The investigation of recommended features to meet the concept of an urban orchid botanic garden's needs based on a study of selected successful BGs is discussed in Chapter 4.

The main purpose of GSPC is to halt the continuing loss of plant diversity through human activities, with Target 1 of GSPC being to increase the level of awareness to 100% by 2020. OC in Sarawak is low (Swee, 2020), where OS diversity is currently being lost at an unprecedented anthropogenic rate. Thus, there is a growing recognition and concern by local scientists of the acute biodiversity conservation challenges to be overcome, such as the disappearance of mangroves, which destroys valuable biological diversity, obsolete legislation, which prevents progress, weak land management, which leads to ecosystem destruction, poorly updated statistics and tools for identifying and understanding the value of biodiversity, the lack of funding and coordination among departments, which requires more effort in creating awareness among the public, and the need for greater studies at state government level on the 'development of ex-situ collections' to meet GSPC Target 8 (Go, 2016; Swee, 2020; Go, et al., 2020; Amir, 2021). At the national level, only three genera of OS, Dendrobium spp, Paphiopedilum spp and Phalaeniopsis spp, have been listed as documented in ex situ collections (Plate 2-25), as reported by the Forest Research Institute of Malaysia (FRIM). In Sarawak, there are at least 120 genera, of which 80% are epiphytes (Wood & Cribb, 1994; Beaman, et al., 2001; Sarawak Forest Corporation, 2019).

Plate 2-25



GSPC (Progress on the Implementation of the Global Strategy for Plant Conservation) 2020. As seen here only three genera of Orchidaceae were documented against 120 genera (Sarawak, 2011). The status of biodiverse systems by safeguarding ecosystems, species and genetic diversity needs to be enhanced. Source: FRIM, 2020.

This alarmingly poor rate of documentation since the establishment of GSPC in 2002, adopted 20 years ago by the Conference of the Parties (COP-6) to the Convention on Biological Diversity (CBD) at its sixth meeting (CBD, 2002), will inevitably mean that the remaining 117 orchids could be extinct before being properly documented at the national level as habitats are being destroyed for development reasons.

Figure 2-9

GSPC – Target 2. Malaysia's overall progress on the assessment of the conservation status of all known plant species is minimal. Implementation through planning, knowledge management and capacity building needs to be improved.

One cannot compare the achievements of developed countries, for example, the UK, which has the best documentation for flora in the world (Plantlife, 2020), with about 6,000 orchids listed, of which 52 are OS (Sarawak has 10,000 flora of which 2,500 are OS) mapped and monitored. Sarawak could have done much better if a BG had been developed since it was last discussed 8 years ago. In line with GSPC target 1, a BG's goal is to promote the diffusion of knowledge and understanding through awareness of plant diversity by undertaking various educational initiatives aimed at promoting OC awareness, especially in young citizens who are potential decision-makers (Gao, 2018).

2.10 Conclusion

The alarming rise of the OEC has been attributed to a range of threatening processes, including habitat loss, a lack of awareness of the importance of a body to monitor the range of conservation roles and legislation to reduce misaligned SO jurisdictional borders, and the lack of public awareness of the cultural and socio-economic values of OC. Despite Sarawak Forest Corporation's (SFC) significant effort and investment in programmes protecting the orchid taxa through habitat rehabilitation designed to assist the recovery of biodiversity (SFC, 2018), OS are on the verge of extinction.

As Sarawak heads towards the future, it is faced with numerous challenges and opportunities for conserving orchid biodiversity. Whilst great advances have been made in understanding the ecological and evolutionary processes of Sarawak OS by its local scientists and orchidologists, the region is still faced with significant knowledge gaps for ensuring best practice conservation and the restoration of orchid biodiversity, as reported in the review of Malaysia's progress towards 2020. More community involvement, especially amongst the younger generation, in OC through schools needs to be promoted and highlighted, and this is expanded on in Chapter 5. The same goes for maximising alternative habitats through the translocation of OS, which, at the same time, could improve biodiversity and ecosystems. Further investigations have been conducted in chapters 5 and 6 as part of the features of the proposed concept of UOBG.

This study investigates the holistic approach of addressing OEC through a sustainable UOBG, with features that carry significant OC messages and actions which can be clearly understood by all, especially non-scientists. The features proposed will need to complement both OC and the development of the progress of Sarawak. The concept of a sustainable UOBG (SUOBG) is the amalgamation of three stakeholders, firstly the buy-in and participation of the public, including the younger generation, the state government and scientists, who will address the OEC effectively and improve the environment. Following that, the proposed SUOBG should also serve as a platform to encourage both OC and the improvement of biodiversity in monoculture plantations. The arboretum would display the potential of orchid translocation and the effect it has on the ecosystem. Lastly, the proposed SUOBG needs to demonstrate the effect of a concerted effort on OC of development, and its potential for creating additional sources of income and socioeconomic growth (Tallis & Polasky, 2020). Today, it is not enough to look at conservation and development independently, especially in developing countries. Society has a responsibility to both itself and the environment.

Therefore, the case studies in chapters 4, 5 and 6 investigate whether an investment in a UOBG with the proposed concept in Chapter 7 can quickly and effectively address the knowledge gaps regarding critical OEC, that is, increasing public awareness and through education and communication. Secondly, a high-capital, long-term investment in this Sarawak resource for an OS establishment (Seaton, et al., 2010), and its scientific OC activities and features, would encourage the community to participate in OS biocultural diversity conservation and consequently address the OEC. Finally, the scientific activities in the proposed UOBG would contribute to a broader space and an accurate collection of data for SO (BGs are known for having strong research programmes) in filling the gaps to halt OEC (Mounce, et al., 2017; Perez, et al., 2018).

3 Chapter 3 – Methodology

3.1 Introduction

This chapter covers the ideologies and concepts that guided the progress and development of the subsequent chapters. The detailed breakdown of methods that were carried out can be found in their respective chapters.

This chapter aims to introduce the methodological framework employed in this research to address the literature review, research questions, and overarching aims of the thesis, which focuses on assessing the potential of the proposed SUOBG as both a conservation economic, scientific, learning centre and a recreational hub. The research rationale is discussed herein. The study adopts a methodological stance rooted in participant observation, emphasizing active engagement 'with' rather than 'on' the object of research. Participant observation along with action research as defined by Tegan (Tegan, 2023), serves as the cornerstone of this research endeavour, enabling a comprehensive understanding of situated phenomena within specific contexts and capturing subtle nuances that may be overlooked from a distance.

Moreover, the study involves observing real-life scenarios through visits to selected frequently visited international BGs and relevant institutions, as detailed in chapter 4 section 4.3.1, to raise awareness and facilitate learning. Additionally, the research integrates action research with active participation and engagement in trials and experiments as discussed in chapters 5 and 6, pushing the boundaries of knowledge to develop a comprehensive understanding of how the envisioned SUOBG could in interact with various stakeholders and beneficiaries. Ethical considerations and time constraints necessitated due to personal circumstances and the pandemic necessitated the adoption of case studies or pre-existing questionnaires provided by organizations such as the SARORSO, a detailed discussion in chapter 2 ,section 2.8.1 of the literature review (pages 105-11I), to obtain providing detailed context and understanding of SARORSO which is an important vehicle in obtaining comprehensive data through the various innovative activities which were carried out with commitment. This approach aligns with calls for generating new knowledge through action-oriented research methods, bridging the gap between theoretical insights and practical implementation.

Furthermore, a comparative methodology focusing on case comparisons was employed to ensure diversity and obtain comprehensive data, acknowledging its limitations in dealing with complex information (Hantrais, 2009). While the historical context of BGs and conservation of SO remains pertinent, scientific, learning, and economic perspectives are also crucial to create interest among beneficiaries as discussed in various journals (Chaminade, 2020; Polasky, 2019).

Chapter 3 also outlines the methodology employed for conducting a vulnerability analysis and establishing a strategic framework for the sustainability of SLEO through a SUOBG, aligning these methodologies with the research objectives and data collection methods .

3.1.1 Methods for Chapter 4

Chapter 4 employed a qualitative analysis approach, initially utilizing questionnaires administered by SARORSO, along with observational studies of case studies involving Malaysian expatriates and visitors to RBGK to assess their knowledge of SO and BGs. Additionally, personal visits were conducted by the researcher to six selected international BGs and local parks in 2018, as referenced in section 3.1. This methodological choice aimed to gain a comprehensive understanding of the necessity for a Sarawak Sustainable URBAN Species Orchid Botanic Garden and its features that align with the contemporary role of BGs (Dodd & Jones, 2010; Centenaro, 2023). These roles encompass conservation of endemic plant diversity to address global change, facilitating scientific research, serving as educational centres, and effectively disseminating knowledge to the public to bridge gaps between scientific understanding and practical application, as highlighted in existing literature (Fay, 2018; Wraith & Pickering, 2020).

Moreover, the observational studies aimed to identify the strengths and weaknesses of various selected international BGs and sites in successfully attracting visitors and fulfilling their intended historical roles. Through site comparisons, the study sought to discern best practices contributing to SDGs (Smith, 2018) and pinpoint potential areas for improvement in botanical garden management. Notably, attention was paid to the financial sustainability aspect, particularly concerning the number of paying visitors necessary to support maintenance costs. This approach aimed to inform the development of the proposed SUOBG with a USP, enhancing its viability and sustainability in alignment with literature on sustainable design and management practices (Atelier ten, 2013; Medway, 2022).

Justification for Methodology

Overall, the methodology is justified as it allows for a comprehensive exploration of the need for and features of the proposed SOUBG, informed by stakeholder perspectives, best practices from existing BGs, and considerations for financial sustainability. The qualitative analysis of case studies was chosen for Chapter 4 because it allows for an in-depth exploration of the unique characteristics of each site. By examining factors such as plant conservation efforts, research work, history, and industry involvement, the study aimed to identify patterns and trends that could inform the development of the first SUOBG in Sarawak.

It is therefore justified based on the following reasons:-

1. Comprehensive Understanding: The qualitative analysis approach, including questionnaires, observational studies, and personal visits to selected sites, allows for a holistic understanding of the need for a Sarawak SUOBG and its features. This multi-faceted approach enables the exploration of various perspectives and aspects related to the proposed SUOBG.
2. Knowledge Assessment: By administering questionnaires and conducting observational studies, the research can assess the knowledge levels of different stakeholder groups, such as Malaysian expatriates and visitors (who are highly educated), regarding SO and BGs. Understanding the existing knowledge base is crucial for designing educational programs and informational materials for the proposed SOUBG.
3. Identification of Best Practices: Through personal visits to international BGs and local parks, the study aims to identify strengths and weaknesses in visitor attraction and BG management. By comparing different sites, the research can identify best practices that contribute to achieving SDGs and effective BG management.
4. Financial Sustainability: The focus on the number of paying visitors and its role in funding maintenance costs addresses a critical aspect of BG sustainability. By understanding the financial dynamics of BG management, the research can propose strategies to ensure the financial viability of the proposed SOUBG, such as developing USP to attract paying visitors.

5. Literature Alignment: The chosen methodology is supported by existing literature on BG management, sustainable design practices, and the role of BGs in conservation, economics, and education. By aligning with established literature, the methodology gains credibility and relevance within the broader academic discourse

Expected Outcomes

The anticipated outcome of the research methodology is the creation of an exceptional BG that captivates visitors with its interactive and relatable features, fostering repeat visits. Through stakeholder assessments and best practice observations, the SUOBG aims to offer an immersive experience highlighting orchids' diverse roles in horticulture, medicine, art, and more. By emphasizing orchids' practical and cultural significance, the SOUBG seeks to attract a broad audience, promoting engagement and appreciation while serving as a hub for both international and local community interaction, engagement, and education.

3.1.2 Methodology for Chapter 5

The methodology adopts an experimental structured research approach, inspired by the successful the Writhlington School Orchid Project (WSOP) and adapted to suit Sarawak environmental conditions:

i. **Inspiration from WSOP**: Emphasizes experimental research within horticulture and botany, students from year 5-7 (Writhlington, 2017; APOC13, 2019), ensuring accessibility and potential for replication by adhering to strict aseptic guidelines.
ii. **Environmental Considerations**: Acknowledges Sarawak's unique environmental conditions, characterised by high humidity and temperature, impacting

contamination control during IVOM (Qiu & Zhou, 2022; Fritsche & Pinheiro, 2022)

iii. **Ex Situ Conservation Trials:** Conduct hands-on trial to evaluate the feasibility of IVOM of *Dendrobium anosmum (Da)* using various seed types under controlled conditions, following rigorous aseptic procedures similar to those in institutions like RBGK (WSOP, 2022).

iv. **Interactive Learning**: Incorporates fun challenges and field trip rewards to OBG-related sites, enhancing student engagement and understanding of orchid conservation economics (OCE).

v. **Entrepreneurship Training**: Provides students with hands-on entrepreneurship training, preparing them for critical thinking, problem-solving, and teamwork, essential for governing an OBG or conducting OCE.

vi. **Field Trip Incentives**: Incentivises students with field trips to BGs allowing them observe SO in their natural habitats, conservatories, interact with botanists, and gain firsthand experience in OCE.

vii. **Applied Approach to Conservation Biology**: Translocates developed seedlings to phorophytes, including Elaeis guineensis (*Eg*), within the school compound, preparing students for ex situ conservation practices and laying the groundwork for the development of the first school OBG within the school premises..

viii. **Educational Benefits**: Engaging in the establishment of the school OBGs provides students with practical experience in biodiversity conservation enhancing their ecological literacy and fostering environmental stewardship. (Qiu, 2022; Fritsche & Pinheiro, 2022)

Moreover, this methodology allows for scalability across schools in Sarawak, enabling each school to specialize in endemic SO, fostering a sustainable and legal supply of SO and develop their respective OBG. Schools can propagate orchid seedlings for sale and contribute to the SUOBG, engaging YG in OCE efforts.

Justification for Methodology

This methodology, tailored to suit Sarawak's environmental conditions, ensures rigorous aseptic procedures are followed during ex situ conservation trials.

Incorporating interactive learning components, such as challenges and field trips, enhances student engagement and understanding of orchid conservation principles. Furthermore, the experiment's progression to translocate seedlings to phorophytes within the school compound signifies a practical application of ex situ OC practices.

This methodology aligns closely with the study's objectives, offering a comprehensive approach to investigating IVOM and promoting OC awareness among students. Through a combination of experimental research, environmental adaptation, and practical application, the study aims to contribute meaningfully to orchid conservation economics efforts in Sarawak.

The hands-on entrepreneurship training approach prepares students for critical thinking, problem-solving, funding acquisition, risk-taking, and teamwork—essential aspects of governing a botanic garden or conducting ex situ orchid conservation.

Expected Outcomes

The proposed methodology anticipates several impactful outcomes:

1. **Addressing a Historical Gap:** Despite decades of adult-focused awareness campaigns since 1992, orchid conservation remains a challenge. This initiative recognizes that adults may be preoccupied with immediate concerns, such as livelihoods, potentially overlooking conservation efforts.

2. **Empowering Future Leaders**: By introducing conservation skills to students, the project aims to cultivate a new generation of environmentally conscious leaders. These individuals will possess the necessary knowledge and passion to prioritize conservation efforts throughout their lives.

3. **Enhancing Environmental Literacy**: Through hands-on activities and interactive learning experiences, students will develop a profound understanding of orchid conservation's significance. This methodology nurtures a more profound affinity with the natural world and encourages conscientious environmental guardianship. Notably, students from MRSM achieved recognition, securing the **Junior Research Award at the 23rd World Orchid Conference in Tainan, Taiwan, 2024 .(refer to Figure 61, page 426)** Their poster titled 'Developing Effective Interpretation for a School Orchid Botanical Garden in Sarawak' exemplifies their dedication and contribution to the field.

4. **Bridging Generational Divides**: The project bridges the gap between past conservation efforts and future endeavours by empowering young minds to take an active role in biodiversity preservation. This generational shift is crucial for sustaining long-term conservation efforts.

5. Aligned with SDGs: The initiative aligns with SDG 4 (Quality Education) and 15 (Life on Land), promoting inclusive education and biodiversity conservation as integral components of sustainable development.

6. **Scalability and Widespread Adoption**: The project's scalability enables widespread adoption across Sarawak's schools, fostering OCE and empowering communities to become active participants in biodiversity preservation.

7. **Establishment of School BGs**: Each school's establishment of OBGs nurtures a sense of ownership and stewardship among students and faculty members. These gardens serve as educational hubs and contribute to the larger network of the SUOBG, ensuring sustained engagement of YG in OCE initiatives.

8. **Commercial Sustainability**: The project's commercial aspect provides schools with a sustainable income source, which can be reinvested into educational and conservation efforts. This holistic approach addresses immediate conservation needs and sets the stage for a self-sustaining ecosystem of orchid conservation and education throughout Sarawak.

3.1.3 Methodology for Chapter 6

The methodology employed in Chapter 6 aimed to provide a systematic and rigorous evaluation of OC strategies. By combining quantitative and qualitative analysis approaches, the study sought to contribute valuable insights into effective approaches for OC and biodiversity preservation. This encompassed careful specimen selection, meticulous preparation, and thorough monitoring to evaluate the success of the translocation project and its long-term conservation implications.

Experimental trials were conducted to explore different approaches to OC, including translocation programs and artificial propagation. The trials aimed to assess the success of these methods in preserving SO and enhancing biodiversity of OPE.

The Quantitative analysis involved calculation using statistical methods, such as chi-square tests (McHugh, 2013), were used to compare observed and expected frequencies of categorical data as mentioned in Chapter 6. The Qualitative analysis focused on assessing community engagement and perceptions through observational notes and participant feedback. This provided insights into the social aspects of OC efforts.

Evaluation parameters included survival rates, specimen health, flowering patterns, seed pod viability, new seedling growth, host plant productivity, and monitoring frequency. These parameters were assessed annually, with a particular emphasis on comparing project outcomes to those observed in natural populations.

Justification for Methodology

The chosen methodology was driven by the need for a comprehensive evaluation of OC strategies within the context of biodiversity preservation. Several key factors underpinned this choice:

Systematic Evaluation Requirement: Given the complexity of OC efforts, it was essential to adopt a systematic approach to evaluate the effectiveness of different strategies. The selected methodology enabled a structured assessment of translocation programs and artificial propagation techniques, providing valuable insights into their success and potential limitations.

Integration of Quantitative and Qualitative Analysis: The combination of quantitative and qualitative analysis approaches was crucial for gaining a holistic understanding of the outcomes of OC initiatives.

Ensuring Long-term Conservation Implications: By emphasizing meticulous specimen selection, preparation, and monitoring, the chosen methodology aimed to assess not only short-term outcomes but also the long-term implications of translocation projects. This forward-looking perspective was essential for determining the sustainability and effectiveness of OC strategies over time.

Alignment with Research Objectives: The methodology was tailored to align closely with the research objectives of Chapter 6, which sought to evaluate the feasibility and viability of OC strategies within known range habitats. By focusing on experimental trials and evaluation parameters relevant to these objectives, the chosen approach ensured the collection of pertinent data for analysis and interpretation.

Expected Outcomes

The methodological approach undertaken in this study is expected to yield impactful results, including the potential success of translocating rescued SO from their habitats, which are currently under threat of clearance, to nearby OPE. This offers scientists and botanists a unique opportunity to evaluate the viability of SO survival in alternative environments. Historically, the task of rescuing SO from endangered habitats has been hindered by the large number of specimens and the lack of suitable relocation sites. However, OPE emerge as a promising solution, providing a conducive environment for vegetative propagation. Furthermore, this initiative holds the potential to restore biodiversity within OPE, as SO are known bioindicators of ecosystem health. The transformation of these OPE into arboretums, adorned with SO, not only enhances their aesthetic appeal but also serves as a tangible demonstration of the prospects for orchid floriculture industry and tourism in such environments. Implementation of this model stands to showcase the economic opportunities inherent in horticulture and floriculture for local communities. Through rigorous analysis of experimental trials, this study endeavors to discern practical solutions for the challenges confronting SO conservation and OPE in Sarawak, while also emphasizing the economic advantages it offers to society.

3.1.4 Methodology for Chapter 7

Overall, the analysis approach for creating the proposed concept for the SUOBG combines rigorous research, expert consultation, strategic planning on introduction and reintroduction, restoration, reacclimatisation, naturalisation of plants translocation as highlighted by Gorbunov and BGCI guidelines in developing BGs (Gorbunov & ADzybov, 2008; Anon., 2016), and community engagement to address orchid extinction challenges effectively and sustainably. It also employs the findings from chapter 4,5, and 6 to assess the level of community engagement ,to evaluate the integration of historical narratives and cultural elements combining into the SUOBG design mixed-methods approach, combining with documented observations and data collected from community interactions , questionnaire surveys to gather data on public awareness and perception of orchids and conservation efforts.

Qualitative analysis techniques such as thematic analysis can be used to identify recurring themes, patterns, and trends in the qualitative data collected throughout the methodology which involves coding, categorizing, and interpreting qualitative data to uncover underlying meanings, cultural nuances, and community perspectives related to the SUOBG project.

Thematic analysis provides a systematic approach to analysing qualitative data and generating insights that inform decision-making and project refinement.

Justification for Methodology

The methodology in Chapter 7 employs qualitative analysis and participatory design to comprehensively explore the SUOBG concept. Qualitative methods capture diverse perspectives and contextual nuances, fostering inclusivity and collaboration among stakeholders. Participatory design ensures stakeholder engagement and translates theoretical concepts into actionable interventions. This pragmatic approach bridges theory and practice, promoting meaningful insights and collaborative solutions to the orchid extinction crisis. Overall, the methodology facilitates a nuanced understanding of the SUOBG project, advancing knowledge and fostering sustainable development.

Expected Outcomes

The anticipated outcomes of the methodology encompass a deeper understanding of the SUOBG's efficacy in fostering public awareness, engagement towards OC. Through meticulous analysis of observational, interaction, and survey data, the study endeavours to unveil actionable strategies for amplifying public involvement in OC initiatives in the SUOBG encouraging repeated visits and participation in the SUOBG. In addition, the expected outcomes of the methodology extend to nurturing sustained engagement and participation in SUOBG programs. By fostering a USP, SUOBG aims to cultivate a sense of ownership and patriotism among locals of diverse backgrounds and age groups. Furthermore, through captivating experiences, foreign visitors are anticipated to make return visits, ultimately elevating SUOBG to an iconic status in orchid conservation and botanical tourism.

3.1.5 Summary

There is no one approach to the overall study; instead, each chapter, depending on its topic and fundamental objectives, has its own methods. The integration of methodologies allows for a more complete and synergistic utilisation of data than applying a single methodology. Each chapter comprises different aspects of the study before amalgamating with the main objective. The research methodology combines qualitative and quantitative methods, such as observations from experiments, public questionnaires, case studies and third-party interviews. This approach allows for a deeper understanding of the BG being an effective and active OC site and provides a way to develop theories and trends from the data obtained in order to understand how it would work in the long-term.

3.2 Data Collection Approach and Methodology

This section outlines the methodology employed for data collection across all chapters of the thesis. It explains the specific methodology applied and the rationale guiding the selection. The data for the case studies were gathered from various sources including field trip observations, herbarium specimens, literature from books, journals, articles, reliable experiments and trials, reports, conference proceedings and articles, weekly courses organised by Kew Garden at the Jodrell Laboratory, orchid society monthly meetings, conferences on orchids and botanical gardens and online resources. Supplementary visual data about sites and experiments collected are included in the appendixes. Additionally, questionnaires, a prevalent tool for assessing public knowledge and perception of natural hazards were administered through SARORSO, and their findings were integrated into the main content of the study across, chapters 1, 2, 4, 5, 6, and 7 or the appendices.

In operationalizing the above theoretical framework, data collection involved observation, Rubric analysis (Assaf, et al., 2012; UEN, 2020) and insights from relevant literature (Xiang Ci, et al., 2015), informal discussions, field notes, document collection, and third-party public surveys, mainly from SARORSO, using pre-designed questionnaires, were conducted. Subsequently, several case studies involving six established international BGs and local parks were investigated, employing a comparative study approach to identify their distinct features, strengths, and weaknesses in visitor attraction. Furthermore, recent ex situ trials and experiments, as mentioned in chapter 6, were conducted to integrate scientific disciplines with practical horticulture. These sites were selected based on criteria such as their focus on plant conservation, research activities, historical significance, and involvement in the orchid industry. Furthermore, recent ex-situ trials and experiments were conducted to integrate scientific disciplines with practical horticulture, including an investigation into the potential of OPE as sites for OC through translocation programs in chapter 6 and the viability of in-vitro techniques for educational awareness program among the YG as well as for Sarawak SO sustainable supply and replenishment as discussed in chapter 5.

3.2.1 Data Collection Process

The data collection process involved a systematic approach tailored to each chapter's objectives. For Chapter 4, data was gathered through qualitative analysis of case studies, allowing for an in-depth exploration of BG features. Chapter 5 involved a comparative methodology to analyse ex-situ trials and experiments, while Chapter 6 focused on experimental trials to evaluate conservation techniques. Chapter 7 utilised a mixed-methods approach, combining observations, interviews, and surveys to gauge public awareness.

3.2.2 Research as a Continual Process

Throughout the data collection process, research was viewed as a continual process of learning and discovery. Insights gained from initial data collection informed subsequent data collection strategies, allowing for ongoing refinement and adaptation.

3.2.3 Interviews

The support of organisations such as SARORSO was instrumental in facilitating interviews and accessing relevant data.

3.2.4 Transcription and Analysis

Data collected from observations, surveys and interviews conducted by SARORSO were transcribed and analysed using thematic analysis techniques. This involved identifying patterns and themes within the data to uncover key insights and findings.

3.2.5 Reflexivity

While reflexivity may not be directly relevant to this study, it is worth noting the importance of reflecting on the research process. Researcher should consider their own biases, assumptions, and perspectives, acknowledging how these factors may influence data collection and interpretation.

3.2.6 Positionality

Similarly, while positionality may not be a primary focus of this study, researchers should recognize their own position within the research process. Acknowledging personal perspectives and experiences can enhance transparency and credibility in the research findings.

3.3 Elaboration on Specific Methods

3.3.1 Interviews and Surveys

The initial data generated from interviews and questionnaires conducted by SARORSO on public knowledge, the perception of SO and the threats they are facing is a powerful scientific research tool (Oladeji, 2012) to support the need for the development of a SUOBG. However, the questionnaire could be challenged as constituting a biased sampling for eliciting desired information from society (Dome, et al., 2019). Chapter 1.4.2.1 analyses the results of the questionnaire. Interviews played a crucial role in gathering insights from key stakeholders involved in OEC and BG management. The selection of interviewees by SARORSO was based on their expertise and involvement in relevant areas such as municipal governance, environmental conservation, education, and botanical societies. Semi-structured interviews were conducted to allow for flexibility in exploring diverse perspectives and experiences. Questions were designed to elicit detailed responses regarding the challenges, opportunities, and best practices in orchid conservation and botanical garden development. Interviews were recorded with the consent of participants and transcribed verbatim for analysis. Thematic analysis was then employed to identify recurring themes and patterns across interviews, providing valuable insights into the research questions.

3.3.2 Observations

Observations were conducted during field trips to botanical gardens, parks, and nature reserves, both locally and internationally. These observations provided firsthand insights into the features, management practices, and visitor experiences of different botanical sites. Detailed field notes were taken to document observations, including plant collections, infrastructure, signage, educational programs, and visitor demographics. Visual data, such as photographs and videos, were also collected to supplement written observations. By immersing oneself in the environment and engaging with botanical garden staff and visitors, valuable insights were gained into the functioning and impact of botanical gardens on conservation and public awareness.

3.4 Challenges Faced- Research Limitation

3.4.1 Initial Stage:

- Extracting information from stakeholders via websites or publications is challenging and may yield inaccurate data.
- Balancing the role of researcher and friend to stakeholders poses difficulties due to pre-existing relationships.
- Outdated legislation restricts actionable measures based on legal frameworks.
- Orchid experts, whether academic or industry-based, exhibit reserved behaviour.
- While public interest in species orchids is high, awareness and contribution to their history and uses remain limited.
- Scarce reference materials on in-situ and ex-situ orchid conservation for Southeast Asia, particularly Sarawak.

3.4.2 Second Stage – Case Studies

i. Field Trips:

- Language barriers hinder primary data collection in Korea, Japan, and Thailand, necessitating reliance on observation and translated services and non-verbal communication
- Limited contact with UK industry players until attending an orchid conference in Paris, 2018, as advised by Ms. Sandra Nicholson.

ii. Oil Palm Project:

- Geographic distance poses challenges in accessing project areas and stakeholders, impacting information gathering.
- Limited experimentation on two species of epiphytic orchids demonstrates successful flowering and growth but highlights the need for further trials on additional 700 species.
- Pollinator specialization and other variables require comprehensive experimentation for conclusive results, hindered by logistical constraints.
- Reliance on third parties for data collection and interruption due to the COVID-19 pandemic impede research progress.

iii. MRSM Orchid Project:

- Limited scientific equipment restricts participant selection to academically inclined students, potentially biasing sample representation.
- Change of Principal and Teacher-in-Charge

3.4.3 The COVID-19 :

- outbreak disrupted research activities, necessitating alternative methods such as virtual, limiting data collection, SARORSO's surveys limited to online
- Destroy protocorms due to laboratory left unattended.

3.4.4 Ethical Issues:

- Research conducted adheres to University of Essex ethics committee guidelines, with data collection based on voluntary participation and prior consent from relevant organizations.

Access to Stakeholders:

- Limited access to key stakeholders, particularly internationally, was overcome through persistent efforts and professional networking.

3.5 Summary

In summary, this chapter provides an in-depth exploration of specific data collection methods employed in the research, including interviews, observations, and challenges faced. By utilising a combination of qualitative and quantitative approaches, the study aims to generate comprehensive insights into the potential of BGs as conservation and recreational centres for orchids in Sarawak. Despite encountering challenges such as limited access to stakeholders, language barriers, and the COVID-19 pandemic, the research endeavours to contribute valuable knowledge to the field of OC and BG management.

3.6 Significance of the Research Approach

The methodology employed in this study is significant for several reasons. Firstly, it allowed for a comprehensive exploration of the potential of botanical gardens as conservation and recreational centres for orchids in Sarawak. By employing a range of data collection methods, including interviews, observations, and surveys, the study was able to capture diverse perspectives and insights from stakeholders.

Secondly, the research approach facilitated the generation of valuable insights and recommendations for botanical garden management and orchid conservation practices. By analysing case studies, comparing methodologies, and synthesising findings, the study aimed to inform evidence-based decision-making and best practices in botanical garden development.

Finally, the methodology adopted in this study contributes to the broader field of orchid conservation and botanical garden management. By documenting research methods, challenges faced, and lessons learned, the study provides a valuable resource for researchers, practitioners, and policymakers working in the field.

3.7 Conclusion

The chapter began with an overview of the research framework, outlining the structure of the methodology and its alignment with the research objectives. It then delved into specific methods used for each chapter of the thesis, including qualitative analysis, case studies, comparative methodologies, and mixed methods approaches. The rationale behind each method was discussed, emphasising its relevance and suitability for addressing the research questions.

The approach to data collection was elaborated upon, highlighting the systematic process of gathering data through interviews, observations, surveys, and document analysis. The importance of research as a continual process was emphasised, underscoring the iterative nature of data collection and analysis.

Challenges faced during the research process were addressed, including limited access to stakeholders, language barriers, and the impact of the COVID-19 pandemic. Despite these challenges, efforts were made to adapt and overcome obstacles, ensuring the integrity and rigour of the research.

3.8 Role as a Researcher

Having concluded her tenure as a vice-president within a commercial bank in Malaysia two decades prior, the researcher transitioned into a role as a business advisory consultant serving two governmental ministries. In addition, the researcher actively participated in the formulation of Malaysia's national occupational skill standards. With a firm belief in the potential impact of her PhD research endeavours, the researcher aims to enhance the socioeconomic landscape of Malaysia, particularly in Sarawak, and other neighboring countries confronting similar challenges.

Motivated by a commitment to environmental advocacy, the researcher's chosen research topic aligns closely with the pressing needs of Sarawak State in the realm of OC, as well as global environmental concerns. Through this pursuit, the reseracher aspires to contribute meaningfully to addressing these critical issues and fostering sustainable development within the region.

CHAPTER 4

4 Case Studies- Optimising Botanical Gardens: Leveraging Models for Sustainable Orchid Species Conservation at the Proposed SUOBG

4.1 Introduction

Efforts are currently being made to develop this botanical garden as a 'living' museum (RBG, 2019), which would serve as a scientific-educational institution (Heyd, 2006; Zoe, 2013), an economic horticultural research centre (Parker, et al., 2013; SGNPB, 2020) and a conservation establishment (UNESCO, 2003; Maunder, et al., 2001; Zelenika, et al., 2018) in order to become a visitor attraction (Williams, et al., 2015; Kolanowska, 2019) and facilitate in-depth learning and engagement (Turrini & Aletta, 2018). According to the Botanic Garden Conservation International (BGCI), BGs have the capacity to attract an estimated 60,000 to 250,000 visitors annually (Ballantyne, et al., 2008; BGCI, 2019). This potential impact on citizen science from visiting BGs is vital at this eleventh hour, as 80% of our forests are being cleared and species orchids are becoming susceptible to extinction (Roy, et al., 2012; Theobald, et al., 2015).

The next challenge is to create economic value for the proposed UOBG to obtain the approval of relevant authorities, create public demand and ensure long-term sustainability (OxfordEcons, 2019) (Wraith & Pickering, 2020). Since Kuching city is still at a stage of active development as per income per caog (DOSM, 2018), and with the Covid-19 pandemic in Malaysia (MdShah, et al., 2020; World Bank, 2020), critical issues that were being deal withh (Bernama, 2020; Alamgir, et al., 2020) such as housing, infrastructure, jobs, healthcare costs, education and service tax (GST) have become primary areas of focus, meaning a proposed UOBG is not a priority (Kong, 2013; Recoda, 2016).

Policymakers and authorities may challenge the proposal to convert a part of the green lung (Gunn, 2007; Bradley, 2019), situated within a prime green space, into an effective, sustainable UOBG (LRSwk, 2008; Norton, et al., 2016) even though healthy ecosystems are needed to purify the environment (Burkhard, Muller, & Lill, 2008; Sandifera, Sutton- Grier, Wardc, & P., 2015; Kruse, 2019). Thus, public education and garden displays, citizen science projects conducted by NGOs, volunteers from community members and interested secondary school children as researchers to assist in monitoring and controlling conservation areas strengthen the concept of a UOBG. Using a citizen science programme would promote awareness, knowledge and behavioural changes in local communities regarding conservation and climate changes (Chen & Sun, 2018). The proposed UOBG could contribute to the Sarawak tourism industry through economic and social benefits means that it would satisfy a vital component of sustainability (RBGKew, 2019; Nparks, 2020).

Therefore, the proposed UOBG must involve an interplay vision and culture to ensure visitors develop an emotional attachment to it (Berthon, et al., 1999; Morgan, et al., 2011; RBG, 2019). The UOBG requires a brand that educates to achieve differentiation that would benefit the community socially (BGCI, 2010), the stakeholders economically (Barnard, 2016) and the project sustainably (BGCI, 2018) in line with the updated Global Strategy of Plant Conservation 2010-2020 (CBDrGPSC, 2020). This would convince the views of authorities and other stakeholders (MUDeNR, 2020) about the creation of an UOBG over other profitable proposals for use of prime land. Its unique feature is the introduction of SLEOs into a protected area to recreate a historical landscape (Low, 1968; Mjoberg, 1939; Harrison, 1959; Russan & Boyle, 1893; Whitmore, 1975; Keppel, 1847), closely aligns with the structures of BGs. In addition, the inclusion of contemporary landscapes involving monoculture forests (Hughes, 2018; Salcra, 2020) is a part of Sarawak's green cover. A coherent conservation message would differentiate this UOBG from other BGs. Simultaneously, it would not detract from economic growth potential. It could exist in parallel with the need for economic development (Ballantyne, et al., 2008; BGCI, 2010).

Research Definition

This section of the research studies the impact of the identified physical features and characteristics (elaborated in Section 4.3.1) of selected iconic and popular international BGs and relevant institutions. The findings identify the relevant and effective characteristics of BGs which could be adopted and implemented so that the role of the new proposed UOBG, the needs, and its importance as a scientific institution of orchid conservation, would address the unmet GSPC objectives after its implementation (Ballantyne, et al., 2008; BGCI, 2018; IUCN, 2020; CBD.int, 2020)

4.1.1 Objective of Case Study

The primary objective was to analyse the potential features and characteristics to be incorporated into the proposed UOBG. This was carried out by conducting a comparative study on six selected UBGs, which have retained the ability to keep their identity despite years of change to their roles, ranging from the academic study of medicinal plants in the 16th century to conserving plants and educating the public (Powledge, 2011; Chen & Sun, 2018; BGCI, 2019). The selected UBGs effectively stand out from other BGs through their unique personality, incorporating fundamental elements of the natural world. Their grandeur has been achieved through the principles of the famous Lancelot (Capability) Brown (Rutherford, 2016) and André Le Nôtre (Mariage, 2010).

However, despite their iconography and success in pulling crowds, the Global Strategy for Plant Conservation (GSPC) has been declared not to have been met (CBD.int, 2020), with 40% of plants, including orchids, now facing extinction (Pvid, 2020). As such, a tour of different BGs and gardens in Malaysia and other regions with similar climates, such as Singapore – Singapore Botanic Garden (Nparks, 2020) – and Thailand – Queen Sirikit Botanic Garden, Royal Park Rajapruek (QSBG, 2018; HRDI, 2018; HRDI, 2018) – was undertaken. Additionally, BGs in South Korea – Nam San Botanic Garden (Parks,Seoul, 2020) – Japan (ENVjp, 2018) and the United Kingdom – Royal Botanic Garden, Kew (RBGKew, 2020) and Chelsea Physic Garden (Chelseaphysic, 2020) – were also visited.

The comparative study also includes a secondary school (WSBE, 2019) – Writhlington School – which performs in vitro orchid propagation on tropical epiphytic orchids. The Writhlington School Orchid Project (WSOP) has involved ex-situ conservation of orchids by micropropagating 800 OS using seeds in their laboratory for the past 30 years (Pugh-Jones, 2003; WSBE, 2021). WSOP may not be applicable to all secondary schools in the UK, as it has only 53 species (one is extinct) of terrestrial orchids (Pritchard, 1989; Leif, 2017) but WSOP's effort and achievements have motivated secondary schools and orchid societies in Sarawak to work with them. WSBE could be a role model for all secondary schools in Sarawak (WSBE, 2019; Choo, 2019) in becoming orchid conservation institutions, thereby encouraging citizen science (Ballantyne, et al., 2008; Oldfiled, 2010; Turrini & Aletta, 2018). In addition, two other local orchid gardens, the 3-acre Gunung Jerai Botanical Garden (GnJerai, 2018; Lucas, Manuel, 2018), Peninsular Malaysia, and the 15-acre DBKU Orchid garden (DBKU, 2021) specialise in species and hybrid orchids. These were also included in the study.

The presence, use and accessibility of the resources available to BG visitors (specifically to those with little prior engagement and knowledge of plant conservation) have evolved in accordance with 21st-century requirements and demands (Hill, 1915; Heyd, 2006; Swarts & Dixon, 2009; CBD, 2000; BGCI, 2010; CBD, 2020; CBDrGPSC, 2020; IUCN, 2020). In order to create awareness, deliver education and disseminate invaluable plant conservation knowledge and skills to visitors (BGCI, 2010; Dhandra, et al., 2019), BGs must evolve. This study will look at each in the context of:

2 Education

2.3 interactive communication of information on the importance of BG to visitors upon arrival.

2.4 representation of culturally designed themes.

2.5 library – availability, accessibility and quality.

2.6 Botanical educational academy – availability, accessibility and quality.

3 Conservation

3.3 scientific institute – availability, accessibility to public and quality.

3.4 collection museum – availability, accessibility to public and quality.

3.5 conservation organisation – availability, accessibility and quality.

3.6 Socio-economic value (Golding, et al., 2010; Perez, et al., 2018).

3.7 Citizen Science – involvement of volunteers (Roy, et al., 2012, pp. 10 - 14).

4 Recreation

4.3 shop – availability, accessibility and quality.

4.4 café – availability, accessibility and quality.

4.5 gallery – availability, accessibility and quality.

4.6 theme park – availability, accessibility and quality.

4.7 pleasure garden – availability, accessibility and quality.

4.8 location – urban or suburban.

4.9 opening hours (Desmond, 1995).

4.10 entrance fees charged (RBGKew, 2019; SGB, 2020).

4.11 transportation – accessibility of public transport and convenience (Golding, et al., 2010; Perez, et al., 2018).

4.12 Children's Garden (RBGKew, 2020).

5 Sustainable management of natural resources

5.3 herbarium – availability, accessibility and quality.

To ascertain:

3 If efforts made on branding initiate an identity for the establishment (Blain, et al., 2005; Anholt, et al., 2011; Fiveash & Kim, 2018).

4 If the branding of the BG is engaging and encourages repeated visits (Golding, et al., 2010; Perez, et al., 2018).

5 If the BG's layout is aimed at the public and is inclusive of all ages and backgrounds (BGCI, 2010; BGCIRoots, 2017; BGCI, 2019).

6 If the branding used by these six establishments has been successful in creating awareness and disseminates invaluable information on plant conservation and its importance to the ecosystem in line with the Global Strategy for Plant Conservation- GSPC (CBD, 2000; Dhandra, et al., 2019; CBD, 2020; CBDrGPSC, 2020).

7 If the roles and functions of BGs have evolved (Hill, 1915; Heyd, 2006; Swarts & Dixon, 2009) in accordance with 21st-century requirements (BGTS, 2019), where they display social and environmental responsibility.

8 If the establishments deliver the message to their visitors (especially those with minimal engagement and knowledge of plant conservation) regarding the importance of a sustainable UOBG and if this has resulted in community participation at home (Theobald, et al., 2015; Chen & Sun, 2018; Turrini & Aletta, 2018).

This research intends to outline what an UOBG would look like which encourages the public and the community to engage in both in situ and ex situ orchid conservation (Maxted, 2013; Turrini & Aletta, 2018) through citizen science as well as prevent the biodiversity of the green lung, which is part of a green belt running through the city, from being lost to intensive development. The confidential findings and conclusions may provide guidance to both tendering parties for a successful proposal and the approval body in Sarawak for further research and future decisions to preserve the land through development as an effective and sustainable UOBG.

All observations made are from the researcher's visit to the six institutions during the first year of research in order to obtain first-hand experience and information which the researcher could not get from the literature. The researcher had been to these BGs before as a tourist.

4.1.2 Gap in Research Knowledge

The absence of a BG in Sarawak highlights that a knowledge gap exists among the authorities concerning the potential impact of developing and marketing an economically viable and sustainable UOBG (Blain, et al., 2005; BGCI, 2015) as a solution to the orchid extinction crisis. This is a critical environmental and biodiversity issue (CBDrGPSC, 2020). It is also to address gaps in knowledge on conserving SLEO on a piece of land located in the green belt of Kuching City (Kong, 2013). This would lead to effectively engaging citizens, as in the case of citizen participation, in preserving *Centaurea iconiensis*, Nezahat Gokyigit Botanic Garden, Turkey (Oldfiled, 2010, pp. 77-78). In addition, the proposed UOBG, whilst displaying potential socio-economic value, would maximise local resources sustainably, as in the famous case of *Papilionanthe Miss Joaquin*, Singapore Botanic Gardens and promote national benefits (Oldfiled, 2010; BGCI, 2019).

The branding strategy of the proposed UBG is of paramount importance (Liu et al., 2016) for effective positioning, differentiation and impact (Chen and Phou, 2013; Murphy et al., 2007) to be able to become self-funding and sustainable. This is especially so to justify the use of prime land (Norton, et al., 2016) and participation from the public (Dodd & Jones, 2011; Blaszak, et al., 2019). Hence, in order for a UBG to engage the public (Chen & Sun, 2018; Turrini & Aletta, 2018), planners need to do more research on understanding the needs, expectations, perceptions and satisfaction rates of today's visitors as a foundation (Hosany, et al., 2007, pp. 62-81; Kotsi & Pike, 2020) and a catalyst for preventing UBGs from becoming a white elephant (Heywood, 2016). To be self- sustainable, this proposed UOBG would need to become a functional nation-branded product, inherently adopting the destination's personality and image (Usakli and Baloglu, 2011; Chen and Phou, 2013; Kaplan et al., 2010; Pereira et al., 2014).

4.1.3 Research Justification for Selected Case Study

A significant critical review of the strengths and weaknesses of existing famous UBGs allows for the identification of the current distinctive characteristics of a functional, effective and sustainable 21st-century UOBG (BGCI, 2010; BGCI, 2015). The BGCI (BGCI, 2019) has outlined various aspects to be considered in developing a UBG. Exploring other notable UBGs could generate new ideas, which could be further investigated and tested using other methods by future researchers.

Some BGs still maintain plant exploration activities following the introduction of new ornamental, foreign species (Heywood, 2017) to visitors as one of many significant features and attractions seen in RBGK, UK (RBGKew, 2019; RBGKew, 2020), including Singapore BGs (SBg, 2020), which is supported by an integrated suite of sophisticated technological tools (Yuen, 2019). There are also UBGs that have been transformed considerably and now have distinct national identities due to sustainability, the growing awareness of ecology and the environmentalism around improving local conservation outcomes. In addition, citizen science has been introduced to Durban's BG, the oldest in South Africa (Phillips & Jodi, 2017; DBG, 2020) and Cadi Jam Ora, Sydney Royal Botanic Garden, Australia (Rbgsyd, 2019). These UBGs embrace floral diversity and have worked within a budget since the 1960s (BGCI, 2010). On the other hand, based on research (Kuitert, 2002; Oldfiled, 2007; Lane, 2020) and recent visits to Korean (Oldfiled, 2007, pp. 80-81; Parks,Seoul, 2020), Japanese (Oldfield, 2007, pp. 79-80; ENVjp, 2018) and Thai BGs (HRDI, 2018; QSBG, 2018), which are rooted in their national heritage, it was found that their approach is more thoughtful and sensitive towards nature, and is focused strongly on their unique native vegetation, culture, and landscape characteristics (Toquin, 2004; Turner, 2010; Lane, 2020). This in turn has made these BGs sustainable and able to evolve smoothly (with minimal renovation)m adapting to the current need of visitors, engaging local communities and foreign visitors to be appreciative, and being knowledgeable of their local natural heritage.

Thus, using the case studies as models feeding into the planning, development and branding of the new proposed UOBG, would assist in meeting the urgent challenges facing SLEO such as habitat extinction, the loss of biological and cultural fabric of communities within the State and its ecosystem due to rampant development. With this process, the proposed UOBG has the potential to effectively reach millions of people (Dodd & Jones, 2011; BGTS, 2019; CBD.int, 2020) which would not only address societal issues that extend beyond the conservation issues but will lead to both positive impacts and actions within communities as well as reassure authorities, corporate donors and external patrons on the potential of the proposed UOBG (Ballantyne, et al., 2008; BGCI, 2019).

4.2 Background

4.2.1 Effectiveness of Existing Botanic Gardens in Orchid/Plant Extinction Awareness

Today, there are approximately 3,693 botanical gardens in the world (Golding, et al., 2010; BGC!, 2020), attracting approximately 500 million (BGCI, 2010; BGCI, 2019) domestic and international visitors (Connel, 2004). The roles of BGs have evolved to serve world demand and goals as well as to justify their social relevance in order to be self-sustainable (Powledge, 2011; BGCI, 2019). Today, BGs are being forced to adjust their roles (Connell & Meyer, 2010) to address global environmental issues (Miller-Rushing, et al., 2006 ; Primark & Miller-Rushing, 2009; UN, 2015) and social-economic changes (Zimm, et al., 2018). Missions to fight extinction and the loss of biological diversity have become the essential roles of BGs, with actions plans, objectives and targets set in meeting SDG to combat climate change's impact (CBD, 2020; CBD.int, 2020). In the context of this research, the success of BGs in creating awareness to address SLEO extinction is being evaluated.

The failure to meet the GSPC targets (CBDrGPSC, 2020; CBD.int, 2020) since 2000 shows that the plant extinction crisis, in general, is still poorly understood by citizens (Swarts & Dixon, 2009 ; Hinsley, et al., 2018; Wraith & Pickering, 2020). Despite the conservation efforts of scientists through BGs (living museums, herbariums and seed banking) to halt orchid extinction, in megadiverse countries, in particular (Iberdrola, 2021), such as Malaysia, illegal extraction (Plate 4-1) and trading from the wild by locals continue (UOL, 2017; Bale, 2017). Anthropogenic-driven activities such as clearing of forests without initially rescuing the orchids (IUCN, 2020, pp. 119,124; Vince, 2020) and limited educational conservation programmes on OS aimed at the public or the younger generations (Masuwai, 2016; Wraith, et al., 2020), as mentioned in Chapter 2, are endangering natural resources, which contributes to the acceleration of the sixth extinction (Wilson, 2001).

Plate 4-1

Illegal extraction of SLEO by locals, conducted as part of their income. These are sold at a weekend market in Tebedu village. Source: Tengku Auvaroza, 2018.

4.2.2 Evaluating BGs' Effectiveness in Creating Awareness, Educating the Public on Plant Conservation Issues and Engaging Citizens

Insights from the eleven case study sites investigated in this research are described in Appendix 5. These establishments were chosen due to their strong contribution to plant conservation and, specifically in the case of a few, towards orchid conservation. In addition, they were selected because of some of the characteristics tabled, which could be considered for and adapted into the proposed UOBG. These establishments were also selected due to their significant popularity and relevance to identifying what contributes to a UBG that effectively conveys the plant conservation message to their visitors and the public (Garrod, et al., 1993; Mwebaze & Bennett, 2011; Oxford, 2016) and what can be learned, improved upon and incorporated in the structuring of an innovative and creative approach to the proposed UOBG. This justifies the UOBG's efforts at halting the extinction of orchids. Calls have been made to combat this issue more than two decades ago (CBD, 2000; BGCI, 2018). The glaring gap in the BGs' role in promoting, educating and knowledge distribution on the importance of plant biocultural diversity conservation has to be addressed (CBDrGPSC, 2020). This includes the message of what the public could contribute towards the betterment of plant/orchid conservation and climate change (Chen & Sun, 2018; Smith, 2019).

4.3 Methodology: Case Study Approach

The study carefully records the challenges being faced by UBGs and communities from the perspectives of the gardens, as well as relevant parties such as local governments. The UBGs chosen for the case studies above (details in Appendix 5) were selected based on variables such as their geographic location, their reputation for having different purposes, their size and capacity and their involvement in sustainable community development activities. This was to ensure an adequate cross-section of the types of UBGs that can be represented in the construction of model approaches.

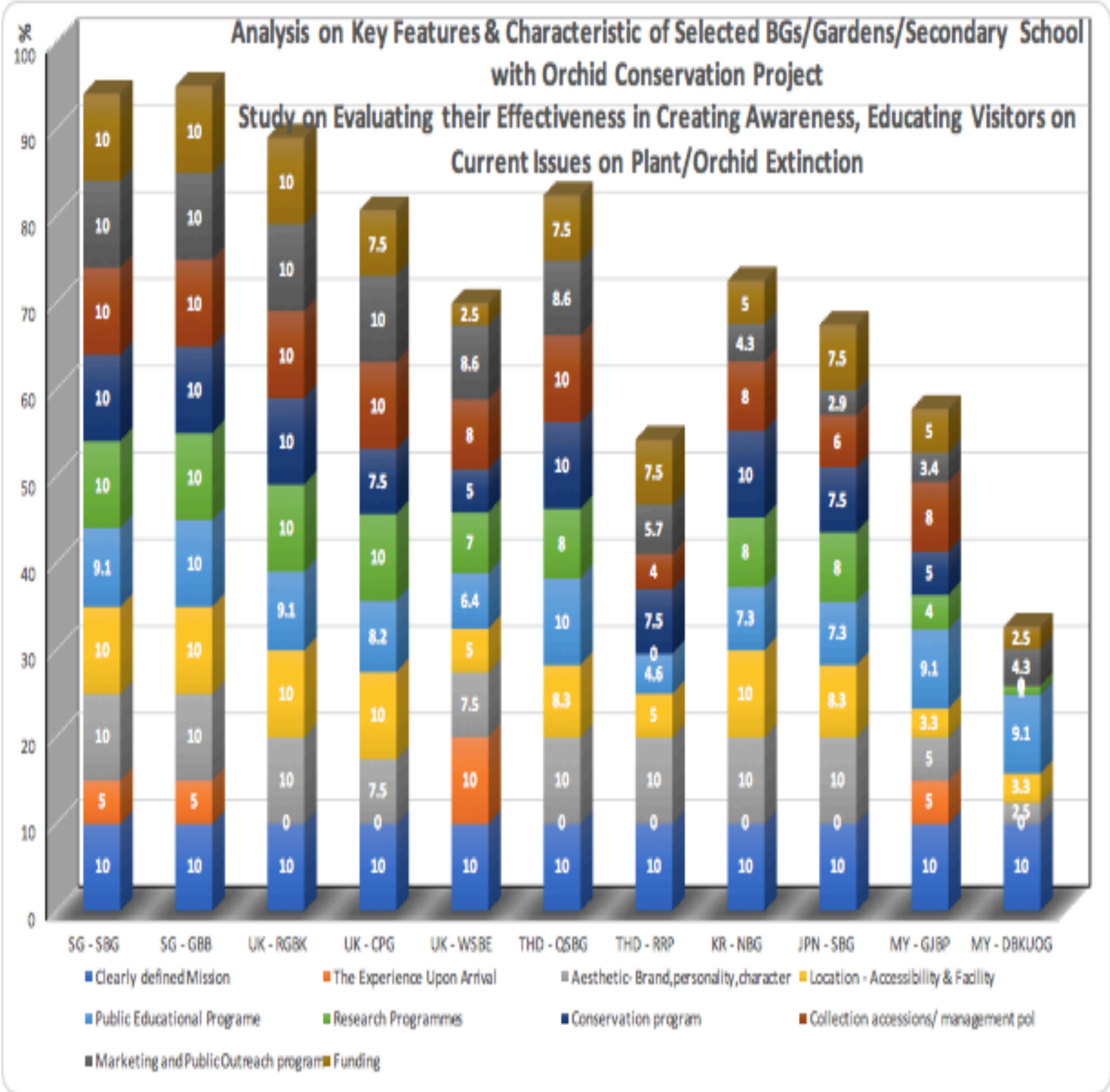
Prior to the scheduling and traveling to the selected public gardens, research conducted on the internet resulted in the assembling of comprehensive profiles of each garden and the community in which they are located. However, there were no formal interviews conducted as the visits were done at a preliminary stage of the project and there was a language barrier, especially with regards to Thailand, Korea and Japan. Discussions revolved around issues such as challenges and the responses to these challenges in leading community outreach programmes and the important partnerships that make these initiatives successful. In addition, document analysis was conducted using documents provided by gardens or community partners relating to publications. Throughout the case study process, in the Malaysian gardens, a close partnership was maintained with the Gunung Jerai Principal Officer, the officers of Kuching City North Hall Landscape Advisory Board, and Sarawak Orchid Society's patron and committee members to ensure a quality research process. The feedback received during these meetings helped to ensure the validity of the findings presented here.

4.3.1 Data Collection and Analysis of Data

A detailed investigation must be carried out on BGs which focuses on aesthetics, taxonomy, habitat, horticulture, education and conservation (Neves, 2019; CBD.int, 2020). The data collected is based on audited financial statements (CPGC, 2018; NParksSGB, 2020; RBGK, 2020), as well as the researcher's visits to these BGs, which have revealed key insights, as detailed in Table 4-1, and which are further discussed and elaborated below.

The key areas being highlighted and evaluated are based on the BCGI Manual on Planning, Development and Managing New BGs (BGCI, 2019), conservation efforts in newly developed BGs in China (Cannon & Chai-Shian, 2017), botanic garden books (Oldfield, 2007; Oldfiled, 2010) and journals (Hill, 1915; Stephen, 2017; Chen & Sun, 2018). The detailed analysis of Table 4-1 and Figure 4-1 below reveal key insights related to plant conservation and the infrastructural context in the selected establishments. The analysis used the best combination of a well-designed, well-monitored, well-managed scientific system (including both ex-situ and in situ conservation, living collections, cryogenic seed banks (Walters, 2020) for preservation and natural history museums.

Figure 4-1



Rubric analysis of comprehensive grading of selected botanical gardens (UEN, 2020). Source: TATA, 2020

The above-selected establishments, comprising BGs and NBGs, were assessed against the criteria gathered from the BCGI Manual on Planning, Developing and managing BGs (BGCI, 2019), books (Oldfield, 2007; Oldfiled, 2010; Lane, 2020) and journals (Chen & Sun, 2018; BGCI, 2020). Each establishment was marked so as to satisfy (Y) or not to satisfy (N) each criterion. For example, a 10/10 score does not rate efficiency or the success of a BG or NBG in executing the respective criteria but instead means that they fully complied with the pre-established criteria.

Table 4-1

Rubric Analysis of selected international BGs and a secondary school in UK case studies. Source (Assaf, et al., 2012; UEN, 2020)

Refer to Appendix 6 for Calculation of Scoring

Rubric Analysis of the characteristics of selected international BGs and a secondary school in the UK

Study evaluating BGs' effectiveness in creating awareness and educating visitors on plant conservation Issues in their respective areas

	Criteria compiled from consultation of various sources (BCGI manual, books and journals)	SGP		U.K			THD		KR	JPN	Malaysia		AV
		SBG	GBB	RGBK	CPG	WSBE	QSBG	RRP	NBG	SBG	GJBG	DbOG	
A	**Clearly defined Mission (out of 10)**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	10
B	**The Experience Upon Arrival * Sub total (Out of 10)**	**5**	**5**	**0**	**0**	**10**	**0**	**0**	**0**	**0**	**5**	**0**	0.8
2	Virtual /Audio/Verbal-Presentation- Pre Discover What To Expect From Visit (Climate Change /Conservation)*	Y	Y	N	N	Y	N	N	N	N	N	N	
3	Interaction with BG Representative	N	N	N	N	Y	N	N	N	N	Y	N	
C	**Aesthetic - Brand, personality, character–Sub Total (out of 10)**	**10**	**10**	**10**	**10**	**7.5**	**10**	**10**	**10**	**10**	**5**	**5**	10
4	Architecture landscape-Identity/Branding	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
5	Landscape-Frequently changed-promotion of horticultural strength	Y	Y	Y	Y	N	Y	Y	y	y	N	N	
6	Theme/Image/Logo	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	

7	Conservatories/Living Museum	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
D	**LOCATION/ Accessibility & Facilities** **Sub Total (out of 10)**	**10**	**10**	**10**	**10**	**5**	**8.3**	**5**	**10**	**8.3**	**3.3**	**3.3**	**9.4**
8	Urban	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	
9	Transportation	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
10	Herbarium, library	Y	Y	Y	Y	N	Y	N	Y	Y	N	N	
11	Laboratory	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	
12	IT facilities – WiFi	Y	Y	Y	Y	N	N	N	Y	N	N	N	
13	Disabled	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	
E	**Public Educational Programme**	**9.1**	**10**	**9.1**	**8.1**	**6.4**	**10**	**4.5**	**7.3**	**7.3**	**9.1**	**9.1**	**8.5**
14	Interactive technology display	N	Y	N	N	Y	N	N	N	N	N	N	
15	Labelled plants	Y	y	Y	Y	Y	Y	Y	Y	Y	Y	N	
16	Garden brochures or interpretative panels	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	
17	Ongoing Short/Long Exhibits	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	
18	Community programme	Y	Y	Y	Y	Y	Y	N	N	N	N	N	
19	Collaboration with Schools programmes	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	
20	Youth camps	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	
21	Undergraduate/graduate education	Y	Y	Y	Y	N	Y	N	Y	Y	N	N	
22	Internships	Y	Y	Y	Y	N	Y	N	Y	Y	N	N	

23	Agriculture extension resources	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N	
24	Professional training courses	Y	Y	Y	Y	Y	Y	N	N	N	N	N	
F	**Research Programmes**	**10**	**10**	**10**	**10**	**7**	**8**	**0**	**8**	**8**	**4**	**1**	**9**
25	Twinning with Local Universities	Y	Y	Y	Y	Y	Y	N	N	N	N	N	
26	Horticulture techniques/ethnobotany	Y	Y	Y	Y	Y	N	N	Y	Y	N	N	
27	Propagation	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	
28	Botany: taxonomy, systematic and evolution	Y	y	y	Y	Y	Y	N	Y	Y	Y	N	
29	Conservation and/or ecological restoration	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	
30	Education & Visitor Service	Y	Y	Y	Y	N	Y	N	N	N	Y	N	
31	Invasive Species Control	Y	Y	Y	Y	N	N	N	Y	Y	N	N	
32	Pollinators	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	
33	Fungi	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	
34	Ethnobotany	y	Y	Y	Y	N	Y	N	Y	Y	N	N	
G	**Conservation program** **Sub Total out of 10**	**10**	**10**	**10**	**7.5**	**5**	**10**	**7.5**	**10**	**7.5**	**5**	**0**	**9.2**
35	Biological (ex-situ)	Y	Y	`Y	Y	Y	Y	Y	Y	Y	Y	N	
36	Ecological Conservation/restoration (in situ)	Y	Y	Y	N	N	Y	N	Y	Y	Y	N	
37	Ethnobotanical, local cultural knowledge	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N	

38	Agronomic/horticultural activities	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	
H	**Collection accessions/ management Sub total (Out of 10)**	**10**	**10**	**10**	**10**	**8**	**10**	**4**	**8**	**6**	**8**	**0**	**9**
39	Focus on local/regional	Y	Y	Y	Y	y	Y	Y	Y	Y	Y	N	
40	Focus on rare /endangered plants	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	
41	Collected data on province	Y	Y	Y	Y	Y	Y	N	Y	N	Y	N	
42	Invasive species assessment/deaccession programme	Y	Y	Y	Y	N	Y	N	N	N	N	N	
43	Priority taxa clearly articulated	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	
I	**Marketing and Public Outreach program- Sub total (out of 10)**	**10**	**10**	**10**	**10**	**8.6**	**8.6**	**5.7**	**4.3**	**2.9**	**1.4**	**4.3**	**7.6**
44	Use of social media & regular websites updates	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	
45	Use of traditional media and advertisements	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	
46	Local community patronage outreach	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	
47	Domestic International collaborations i.e. Schoolchildren through schools	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	
48	ii. Adults through Societies	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	
49	Domestic/International collaborations association membership	Y	Y	Y	Y	N	N	N	N	N	N	N	
50	Gift shops (Physical and online)	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	

J	**Funding – Sub Total (out of 10)**	**10**	**10**	**10**	**7.5**	**2.5**	**7.5**	**7.5**	**5**	**7.5**	**5**	**2.5**	**7.9**
51	Government	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	
52	Private	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N	
53	Patrons contribution – Charitable acts	Y	Y	y	Y	N	Y	Y	Y	Y	N	N	
54	Self funding – Education/Membership/Entrance	Y	Y	y	Y	N	N	N	N	y	N	N	
	Total Scores (out of 100)	**94.1**	**95**	**89.1**	**80.6**	**70**	**82.4**	**54.2**	**72.6**	**67.5**	**55.8**	**35.2**	**81.1**
	%Percentage Scores	**94.09**	**95**	**89.09**	**80.68**	**69.9**	**82.4**	**54.26**	**72.56**	**67.46**	**55.8**	**35.2**	**81%**
		SBG	GBB	RGBK	CPG	WSBE	QSBG	RRP	NBG	SBG	GJBG	DBOG	

(Assaf, et al., 2012; UEN, 2020)

Botanic Garden

Non-Botanical Gardens

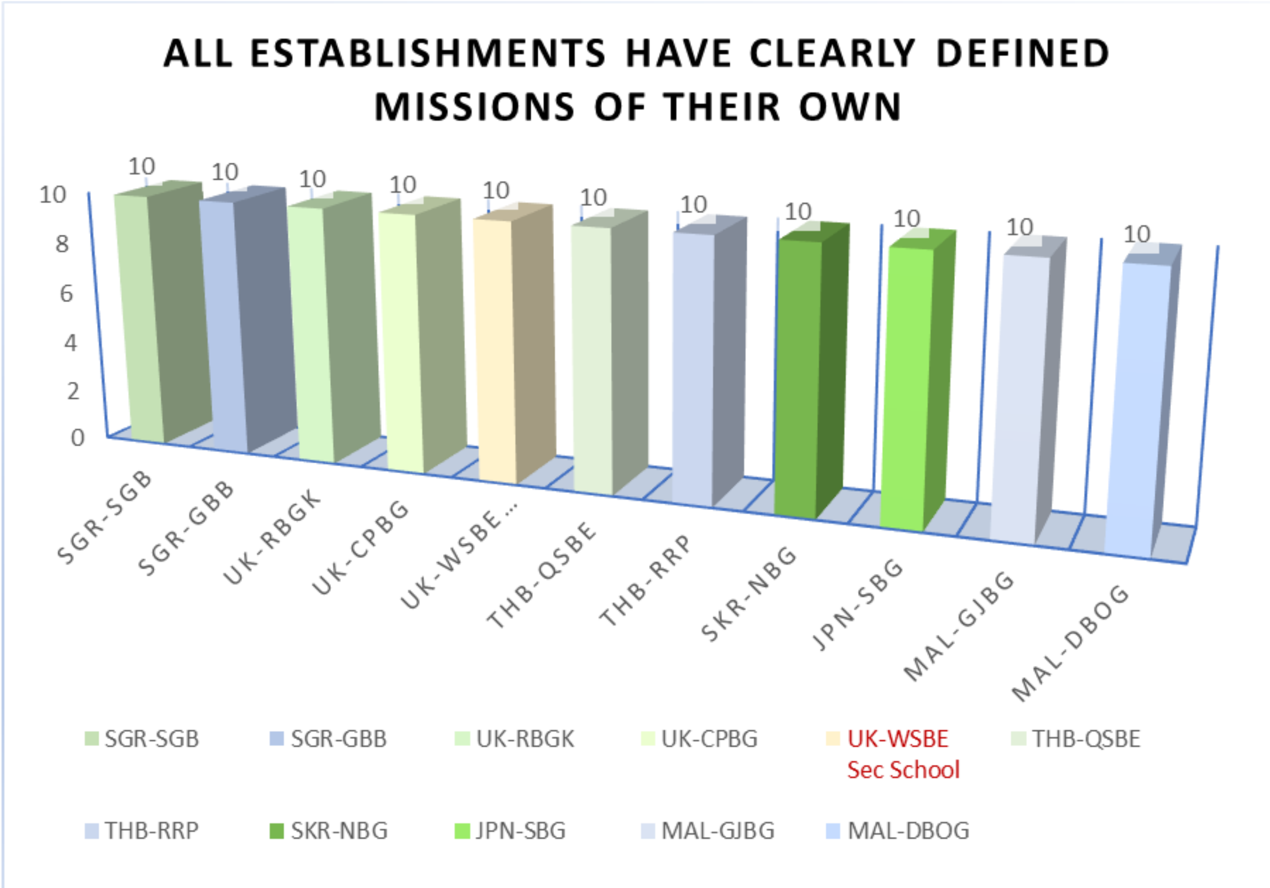
The scoring is based on the rubric analysis method with a maximum score of 10 for every sub-criterion, a Y is given. If the criterion is absent it will be an N. The score for the particular criterion is given by adding the total number of Y and dividing by the total number of sub-criteria, that is, the total Y+N multiply by 10 (Assaf, et al., 2012; UEN, 2020)

4.3.2 Data Evaluation and Observation of Botanic Garden and Plant-Based Organisations

4.3.2.1 Clearly Defined Mission

A clearly defined mission statement acts as an effective tool in communicating the goals of an institution. This is essential for a superior performance result (Bart, 2001; Algre, et al., 2018). Thus, a powerful mission statement by BGs should articulate activities that they are performing, should be performing or are planning to perform (Heyd, 2006; Dodd & Jones, 2011; Spenser & Cross, 2014; NBGW, 2020), which is in line with the plant needs of today: creating awareness, promoting education and conservation, engaging in research and widening public appeal (Wraith, et al., 2020).

Figure 4-2



The selected botanical gardens and non-botanical gardens have their own specific missions. Source: Tengku Auvaroza, 2018

The six BGs assessed, as shown in Figure 4-2, are members of BGCI (BGCI, 2018; BGCI, 2019) and have a clearly defined mission. Their mission statements and visions are set out in their websites as a comprehensive BG in accordance with BGCI's definition and guidelines (BGCI, 2016; BGCI, 2018; BGCI, 2019). Additionally, they have also expressed concern for the conservation of plants (including orchids) in line with efforts by the Convention on Biological Diversity (CBD, 2000; CBDrGPSC, 2020) and the action plans of the IUCN SSC Orchid Specialist Group (IUCN, 2020). These are shown in Appendix 3 and 4 respectively.

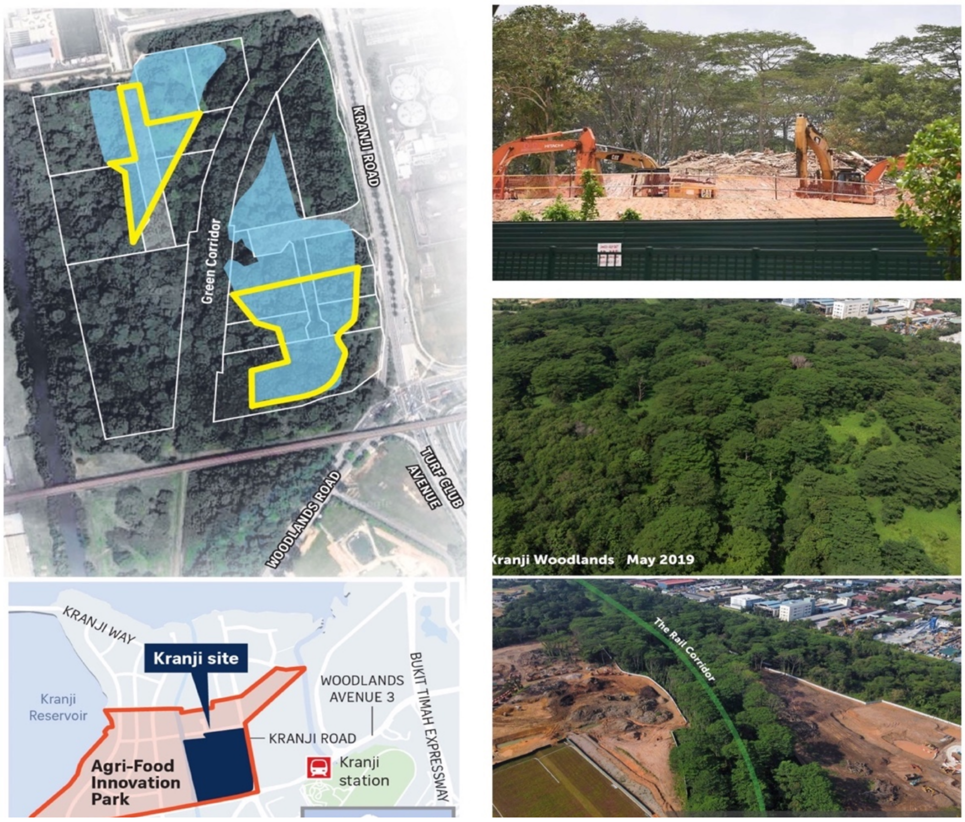
Similarly, the other five NBGs (of which three organisations focus purely on orchids) have clear missions, which are to explore, conserve and explain the world of plants/orchids and human dependence on plants and fungi, as well as their pollinators. These missions are clearly stated on their websites (GBB, 2020; WSBE, 2020; HRDI, 2020; Lucas, Manuel, 2018; DBKU, 2020).

Therefore, while world-leading BGs have defined missions that address the challenges and threats faced by plants today, large-scale development activities such as the clearing of valuable forest lands still take place in 2022. Could it be that the mission statements are poorly researched theoretically and need a new approach to readdress the development of a workable mission statement for BGs to engage in conservation (Bart, et al., 2001)?

Plate 4-2

High-speed 2 Mega Project, United Kingdom – woodland has been cleared to make way for developing the HS2. Source BBC, 2021.

Plate 4-3



The railway project – clearing of Kranji woodland. Source: News Strait Times, 2021.

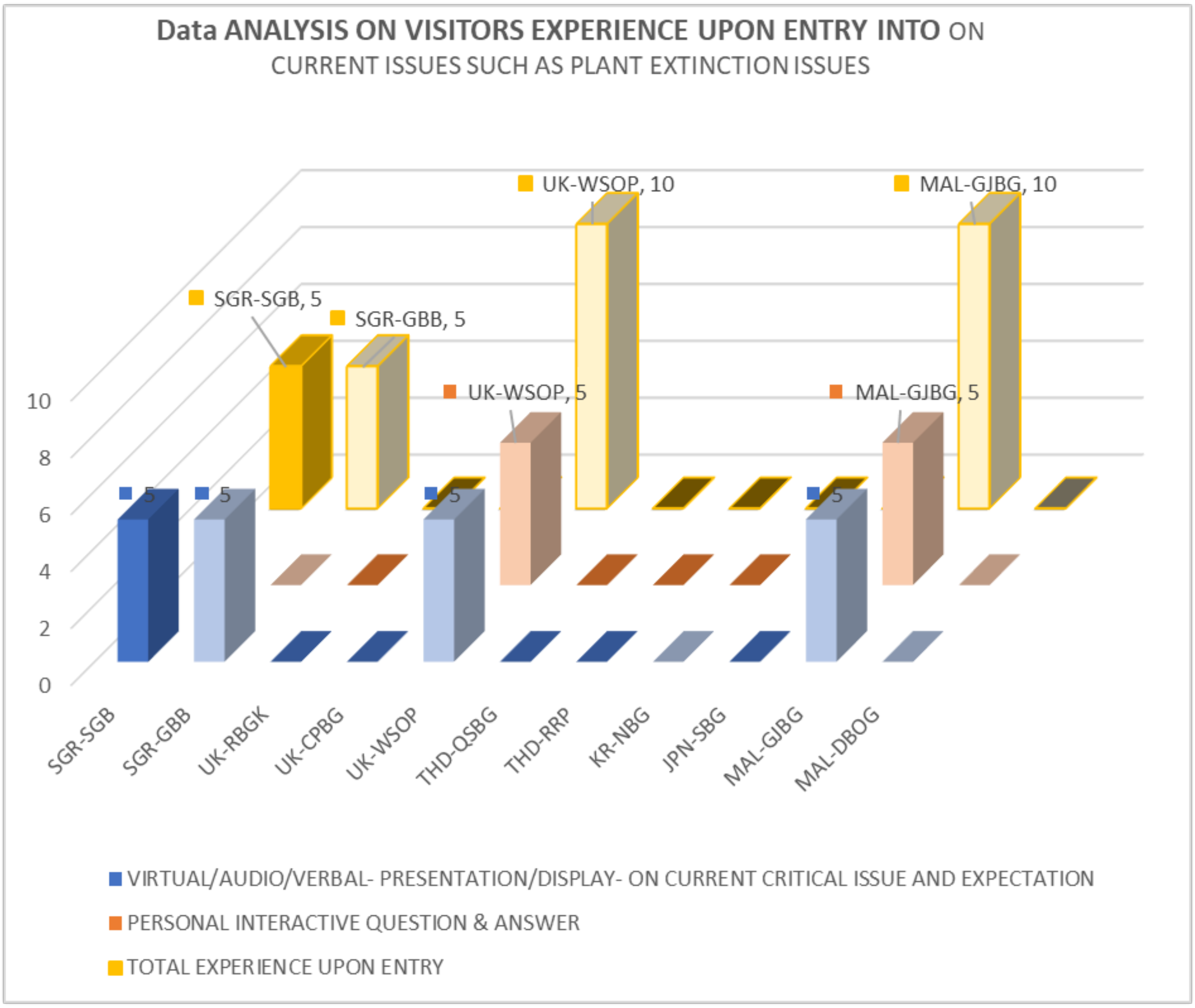
Plate 4-4

The oil palm phenomenon in Sarawak: replacing ancient forests of Borneo in the name of development? Source: Tengku Auvaroza, 2018.

4.3.2.2 The Experience around BGs addressing the Plant/Orchid Extinction Crisis

Since 2000, BGs' role in plant/orchid conservation has expanded greatly (CBD, 2020). However, the results and effects of this have been slow in coming as GPSC Target 14 has not been met since its launch in 2000 (CBDrGPSC, 2020) whilst forests and nature reserves are still being cleared in both developed and developing nations, devastating the natural habitats of wild species for development purposes (Plate 4-1&Plate 4-2), as mentioned in Chapter 4.3.2.1.

Figure 4-3



Analysis of 'Experience Upon Entry into BG'. The objective mainly is to inform visitors of critical plant/orchid issues and the assistance needed from visitors. Source: Tengku Auvaroza.

The 'Experience Upon Arrival' criterion can be further broken down into sub-criteria:

a. A virtual/audio/visual presentation upon arrival, which briefs the visitors on what they may expect from the visit, highlighting the BGs current focus (climate change and plant extinction) which requires visitors' attention.
b. A personal interactive question-and-answer system encouraging feedback, opening pathways for visitors to be involved and to get to know the organisation.

This criterion is specific to the experience visitors have the moment they set foot ON the establishment after passing the ticketing counter. This first impression is especially important (Human, et al., 2013) as a BG should be able to convey their mission, goal and activities around addressing conservation, advocating efforts to combat climate change and plant/orchid conservation (Monkhouse, 2019). At its core, this criterion seeks for staff in the organisation to personally address BGs, creating and raising awareness regarding the critical issues and enabling visitors to act upon what has been learned from the visit and to share it with others (Hesketh, 2010; Sheane, 2012).

With the exception of SBG, the BGs did not include a 'presentation/briefing' before visitors commenced their tour. It appears that being an established BG with a large footfall does not directly correlate with a BG's commitment to prepare a briefing for their visitors upon entry, regardless of whether it addresses conservation, other current issues, or the workings of the BG. Despite Singapore being a tech-savvy country, SBG did not leverage this in preparing an effective visual display for visitors as soon as they entered the premises. Instead, it opted for a traditional display on the importance of plant diversity and the plant extinction crisis. Similarly, GBB, a recreational park in Singapore, prepared a conventional display of informative posters.

On the other hand, despite not being a BG, WSBE, a secondary school with an orchid conservation project in the UK, understood the importance of needing to supply visitors with information or a context upon arrival through a variety of presentations – from display boards to verbal, audio and poster presentations.

Plate 4-5

The main entrance of RBG, Kew, after the ticketing counter. Displays on critical plant issues at this point would be very effective. It would be a great opportunity for the BG representatives to meet visitors at this point provide a briefing on what RBGK is currently doing to address these critical issues and what visitors could do for their part. A group of stakeholder officials from Sarawak visited RBGK. Source: Tengku Auvaroza 2019.

A BG representative welcoming the visitors to the garden was only practised by two establishments, both of which were NBGs. Again, WSBE was one of those which engaged in this practice, which shows how impressive their establishment is in addressing and understanding that disseminating information and providing a context to visitors upon entry is just as important as the actual experience within. GJBG, in Kedah, West Malaysia, was the other NBG that included this sub-criterion in their establishment. The manager of the park regularly briefed visitors on the importance of the garden for conserving orchids and preventing them from going extinct.

The average score for this criterion is less than 5, with only four establishments applying at least one of the sub-criteria. This means that a significant majority of the selected BGs in the case study took the opportunity to establish a positive visitor experience upon entry by creating awareness, educating and inspiring visitors at the point of entry, at a time when plant/orchid conservation is a critical issue (Corlett, 2016).

Plate 4-6

The Writhlington School Orchid Project – the Orchid Project Laboratory. Explaining to the visitors their project is the objective at the entrance of the exhibition. It IS interactive, educational, inspiring, action-oriented and fulfilling for the visitors. Source: Tengku Auaroza, 2018.

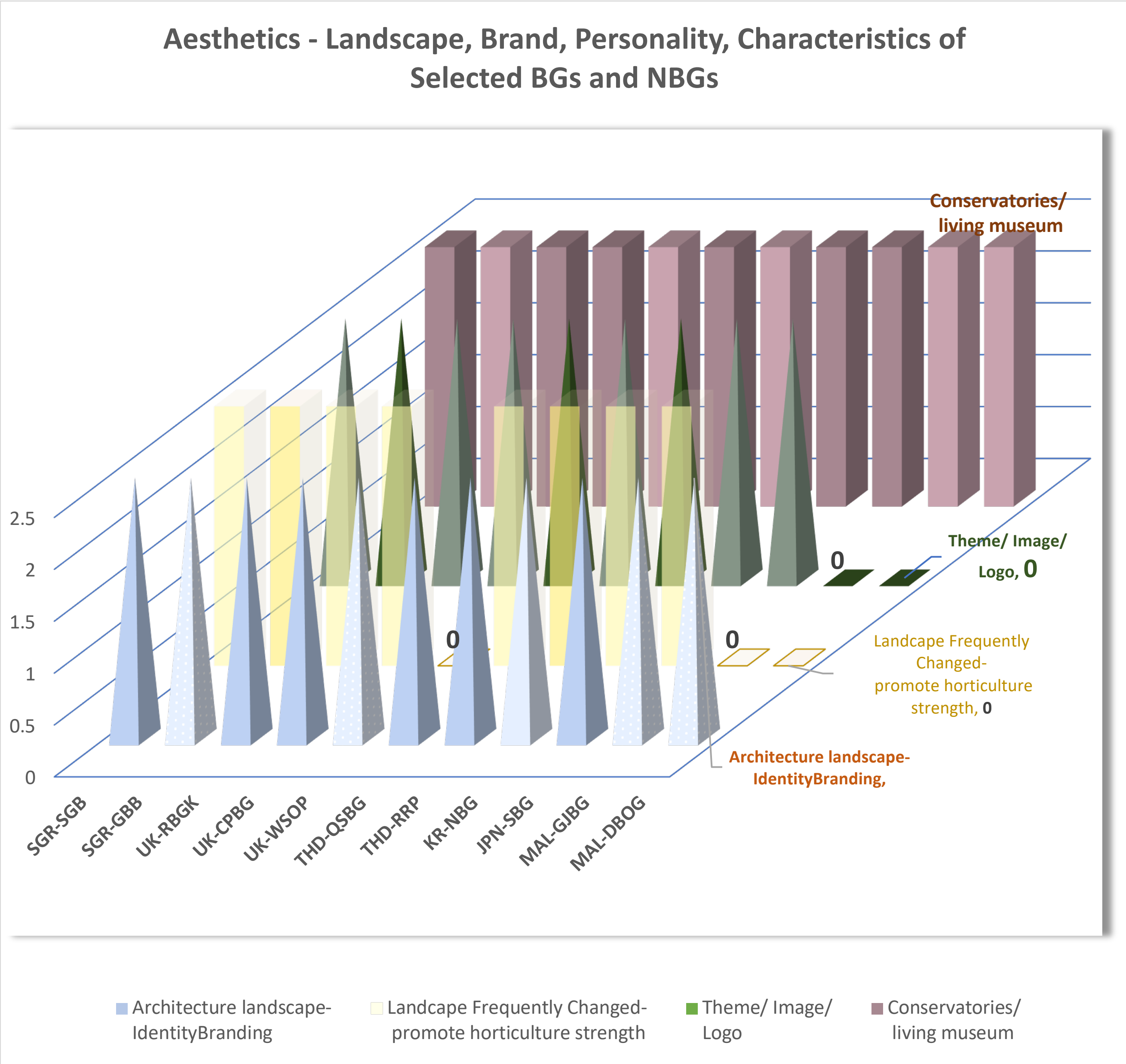
Plate 4-7

Gunung Jerai Botanical Garden. The curator and manager of the garden briefs his visitors about his orchid conservation project, which creates awareness, educates, inspires and motivates. Source: Tengku Auvaroza, 2018.

4.3.2.3 Aesthetics – Creating Brand, Personality and Character

Taken at face value, BGs are still predominantly aesthetically driven, which may or may not reflect any efforts made towards conservation that takes place behind the scenes in laboratories. However, in a period when plant conservation is becoming a prevalent issue, is an aesthetically driven BG sufficient to address the need for conservation?

Figure 4-4



The chart shows the four major components that make up the third criterion, in which the aesthetic element, which features landscape, brand, personality and character, differentiates the identity of each of the establishments from one another.

Source: Tengku Auvaroza, 2021.

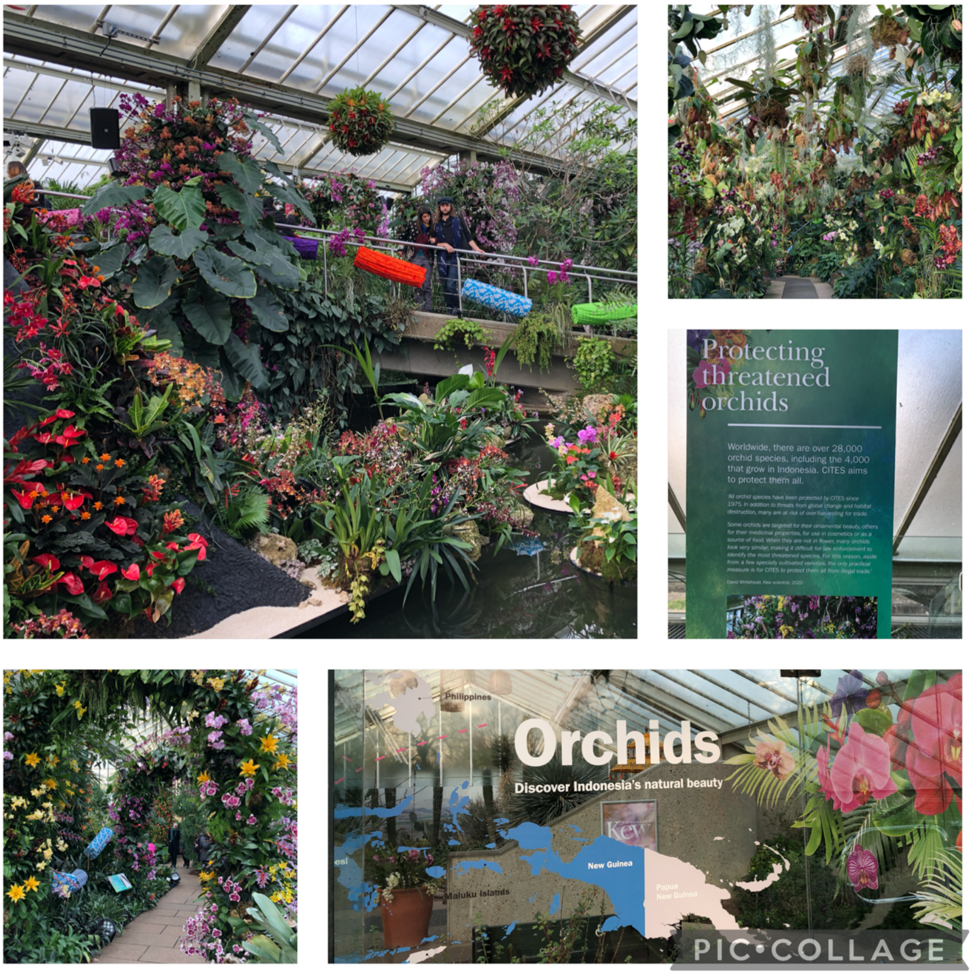
Referring to Figure 4-4, each establishment among the BGs and NBGs had a distinctive identity, telling a story and representing their native and other collections of plants, culture and history (Oldfield, 2007; Oldfield, 2010; Eckbo, 2019). When mentioned, each BG through their landscape architecture generates a snappy mental image and have names synonymous with a strong corporate identity. This influences individuals to visit (Pike, 2007) and experience their magical touch. Many BGs have been inspired by individuals such as the famous and influential Englishman, Lancelot Brown (Brown & Williamson, 2016), a pioneer of the natural, whose landscape architecture designs reached Far Eastern countries such as Japan (Lane, 2020, pp. 227-233), and the famous twentieth-century architect, Kobori Enshu (Cambert, 2005).

Plate 4-8

Shinjuku Botanical Garden, now known as the National Garden. The landscape architects of Japanese BGs vividly reflect the importance of nature representing the history and culture of the country and have a tourism function or a public amenity rather than a major research role. After the Meiji Era (1868-1912), Japanese BGs received a Western influence, which can be seen in this BG. Unlike European BGs, the majority of Japanese BGs are relatively small. Source: Tengku Auvaroza, 2018.

As shown in Figure 4-4, a majority of the establishments have integrated landscape aesthetics, with seven of the establishments displaying horticultural strength through changing displays of plants during different seasons, either in the garden or in their conservatories. For example. Kew's expert horticultural team successfully transformed their conservatory into an entrancing tropical forest display, evoking some of the sights, smells and sounds of winter and defying the original habitat and temperature requirements of the tropical state (Plate 4-9).

Plate 4-9



Horticultural expertise: The Princess of Wales Conservatory has been transformed into a rainforest filled with breathtaking flowering Indonesian orchids in different sections of the glass compartments, imitating the tropical orchids in their natural habitat when the temperature was outside is 8-11 degrees. Source: Tengku Auvaroza, 2020.

All BGs met the sub-criterion of having a discernible theme or image be it through their logo, philosophy, culture, native plants or their latent aesthetics (Oldfiled, 2007; Oldfiled, 2010; Anderson & Yamashita, 2020). Though each BG inadvertently has similarities because of a common infrastructure and facilities, as defined in BGCI (BGCI, 2019), they have individual characteristics that visitors can unmistakeably recognise. Three of the NBGs had a distinctive theme or image, portrayed through their plant collections and set up. The purpose of each of these NBGs is reflected in their theme so as to be easily identifiable.

Plate 4-10

Korea Nam San Botanical Garden and its other BGs focus on an arboretum devoted to conservation and applying its ancient farming traditions to create a holistic recycling method, such as using rice straw processed after the harvest as ground/tree cover and crop protection to prevent the growth of weeds. The covers retain soil moisture during droughts and cold during *winter. This traditional Korean landscape management technique gives Korean BGs a strong unique visual element. Economy-wise, Nam San Botanical Garden invested in research and development on Korean Red Pine products and promoted their visitor numbers. Source: Tengku Auvaroza, 2018.*

In European countries, elegant and sophisticated glass houses (Minter, 1990; Stein & Virts, 2020) were built with the function of protecting plants from the harsh winter weather. This later became an icon for BGs to emulate, with continuously changing garden displays put on according to the seasons, such as those in Japan and South Korea, drawing millions of visitors. Unsurprisingly, all 11 establishments incorporate conservatories or the concept of a living museum as this is a key feature. The key difference across the 11 establishments is that BGs or NBGs in non-temperate countries such as Malaysia and Singapore have no need for conservatories or glass houses, as there is no need to regulate temperatures in a tropical climate for the purpose of conservation (Minter, 1990). On the other hand, instead of heating a glass house, GBB comprises two cool conservatories to generate the ideal growing conditions for their temperate flora, mainly for display purposes (GBB, 2020). It is clear that glasshouses in temperate countries inspired Singapore, a tropical country, to incorporate cool conservatories in GBB, (Inhabitant, 2013; Bahrami, 2018) the world's largest climate-controlled greenhouse (GA, 2020), which leaves no carbon footprint (Syed, 2012). Consequently, GBB has been dubbed a modern-day Hanging Gardens of Babylon, a successful garden attraction drawing in 12.5 million visitors annually as of 2018 (GBB, 2019).

Plate 4-11

Garden by the Bay – the iconic living museum provides incredible visuals, attracting the most visitors of all BGs. There is great potential to spread awareness of current plant issues. Source: Tengku Auvaroza, 2018.

On the face of it, the above case studies show that the BGs are aesthetic-centric and there is no denying that aesthetic elements play an important role in attracting millions of visitors (BGCI, 2015), which in turn may help address the cost maintenance. However, if not well collaborated by other factors, it may lead to the foregoing of clear conservation measures and climate change messages as a priority to visitors who are not aware of the current plant extinction issue. Facilities and infrastructure that have had educational and conservation purposes behind them may be overshadowed by design elements, existing as merely check boxes to be filled or icons to be integrated into an establishment (Krishnan, et al., 2019).

On the other hand, the highlighted NBGs which have not fulfilled the predetermined sub-criteria, each with unique functional attractions (except for DBKUOG) that draw in visitors (though not as many as UBGs do) into the plant extinction issues, provide information about conservation and consequently receive support from the public (Lucas, Manuel, 2018; WSBE, 2020; DBKU, 2020). However, it seems that not enough importance has been given to the aesthetic environments for attracting more visitors and being more sustainable (Lucas, 1991; FC, 1994). For example, despite GJBG embracing the ‘natural’ aesthetic of Jerai forest and incorporating trees with rare OS that grow and flower profusely as features, GJBG lacks a landscape shaped by an architect/designer to enhance the forest aesthetic (Vanderoot, 2018) appeal of the natural environment which would turn it into an attractive and safe forestry BG.

Plate 4-12

Gunung Jerai Botanical Park is rich with 10,000 living anchored to its trees. However, It lacks aesthetic elements for attracting more visitors from all walks of life. Human beings have an intimate capacity to appreciate the aesthetic rather than other elements, as highlighted by Edward O. Wilson. Source: Tengku Auvaroza, 2018.

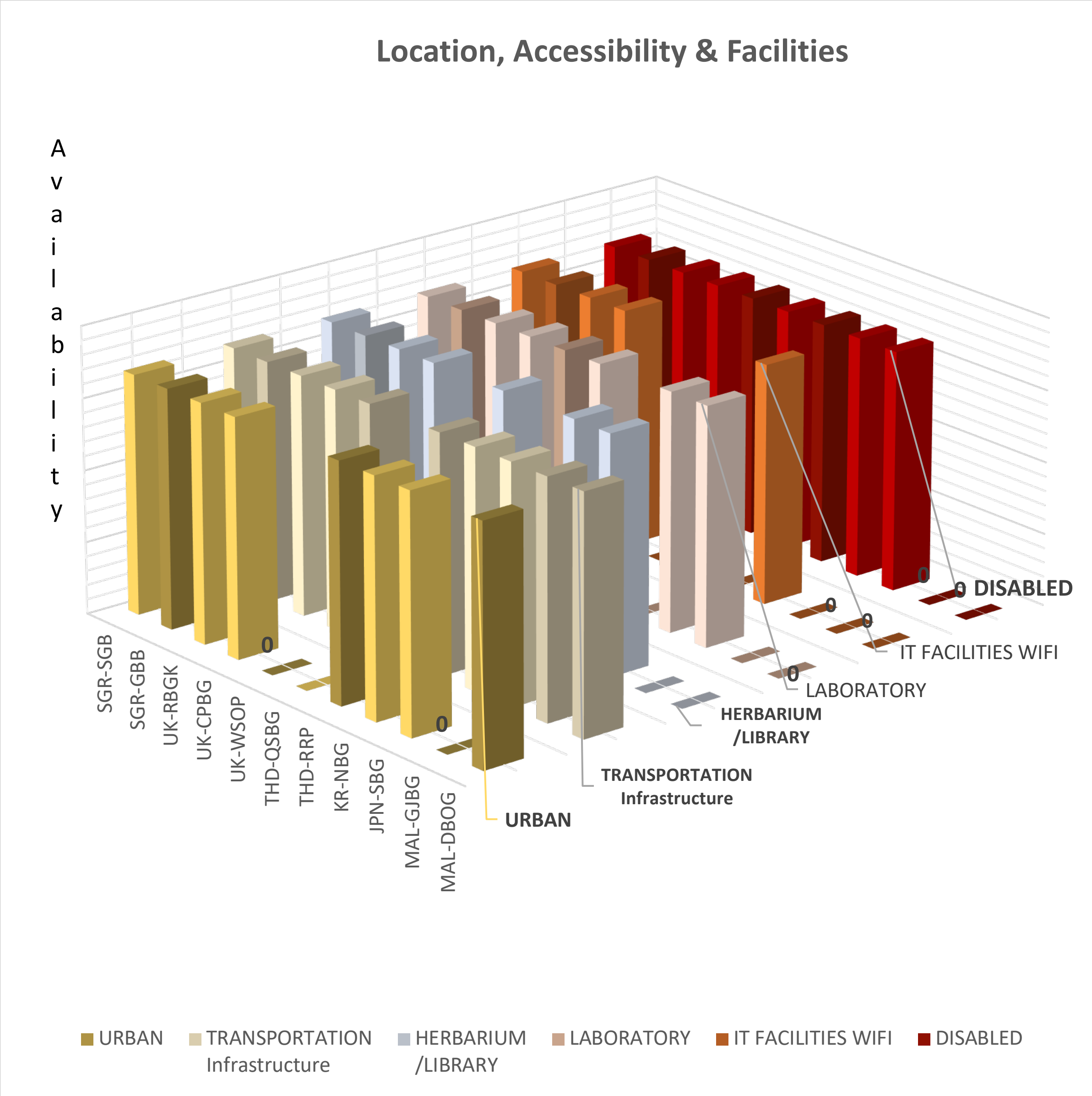
Plate 4-13

Orchids Species of Gunung Jerai Orchid Botanical Garden: There is educated labelling of plants, proper documentation of the collections and other specifications defined by BGCI. However, it is lacking the aesthetic elements required to reach out to more visitors so as to help in solving the current orchid extinction issue through public engagement. Source Tengku Auvaroza, 2018.

4.3.2.4 Location, Accessibility & Facility

Globally, 55% of the population lives in urban areas (UN, 2019). Location is considered a critical factor that contributes to the effectiveness of a BG in attracting visitors (Moutinho & Paton, 2015; Yang & Dong Li, 2017) locally and internationally and also in making full use of any retail allotments within the UBG. Location and accessibility are also key to enabling wider coverage for creating awareness of plant conservation and environmental issues (Shoari, et al., 2020). In addition, goo facilities help further develop the relationship between BGs and local communities, encouraging their participation (Westwood, et al., 2020).

Figure 4-5



The chart shows the six major components that make up the fourth criterion, as mentioned above, comprising urban aspects, an efficient system, affordable transportation, and accessible facilities to the public, including facilities for the disabled. The columns with darker shades are non-BGs. The columns represent either a Yes or a No. For instance, the BGs and NBGs ae located in urban areas (Yellow) except for WSBE and GJBG. Source: Tengku Auvaroza

As per Figure 4-5, only three out of eleven of the selected establishments are not located in urban areas. The BGs are located in cities, except for QSB which is located at the outer side of Chieng Mai and 686 km from the main city of Bangkok.

With the advent of climate change, the increase in temperature in urban areas affects plants such as orchids; high levels of pollution and concentrated gas emissions mean that the presence of UBG could play an important role in mitigating these issues (Primark & Miller-Rushing, 2009; Chen & Sun, 2018) whilst also becoming a great avenue for UBG to educate others on climate-related research (Ballantyne, et al., 2008; Primark & Miller-Rushing, 2009; Cavendar & Kate, 2019). Thus, UBGs' roles regarding climate change and conservation techniques are now at the forefront of many research programmes (Schulman & Lehvävirta, 2011; Cavender, et al., 2019).

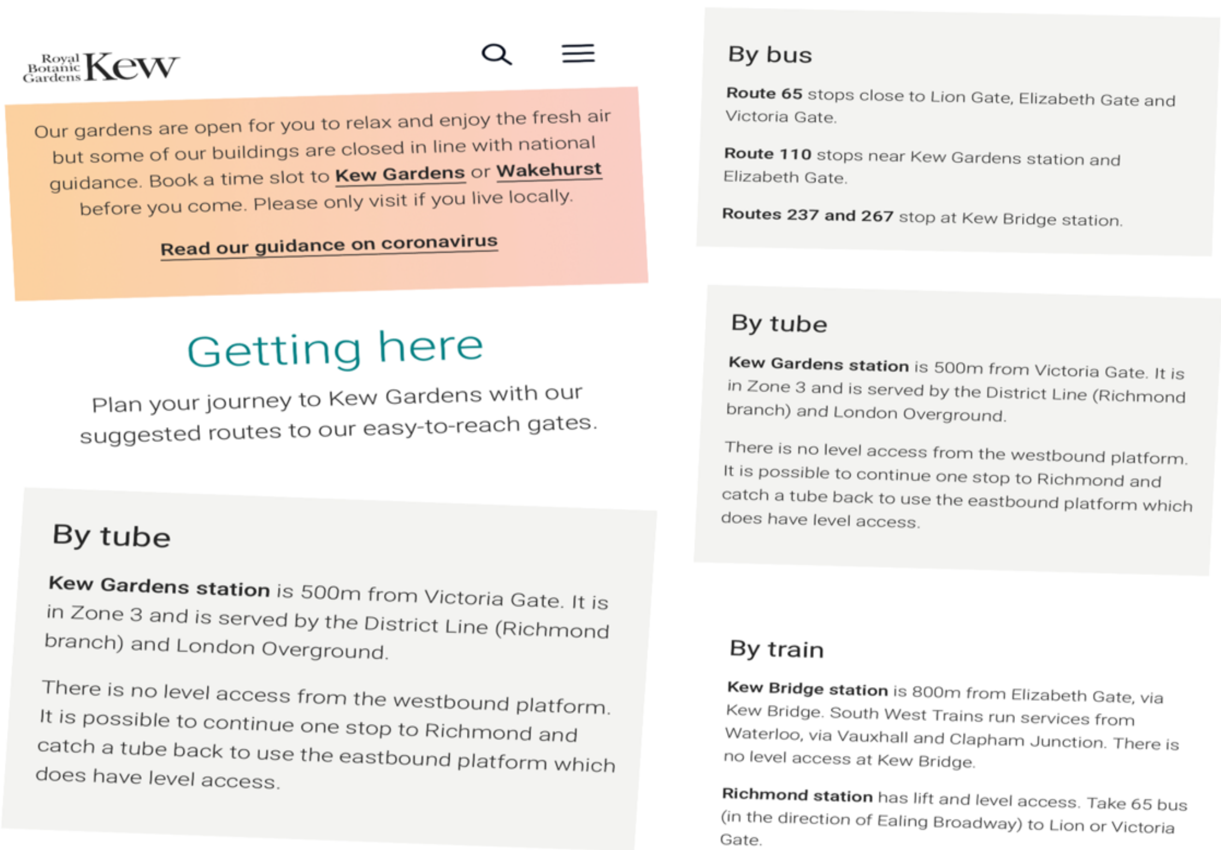
The urban environment provides opportunities to maximise the UBG's functions to connect to the community enabling them to learn and to be educated indirectly without incurring additional costs. For example, the technology of utilising recycled rainwater in GBB (GBB, 2020) to address technical issues can also be used to help educate and energise the community to proactively support urban conservation. At the same time, the existence of UBGs addresses the pollution of cities and other environmental problems through citizen science and community support, which strengthens stewardship. For instance, in Singapore, the issue of the 'urban heat island effect' (when urban areas experience an isolated increase in temperature in comparison with the surrounding suburbs) was addressed and also has research potential as its BG is situated in the urban core itself (Han, 2018). Research on environmental awareness relating to perceptions, motives and interests has also been conducted to evaluate the public's use and perception of botanical gardens (Othman, et al., 2010; Ward, et al., 2010). According to the research, the public often takes the functions that botanical gardens provide, such as ecology, social, health, and aesthetics, for granted. A factor that may affect the level of appreciation could be the location of the botanical garden (Cavendar & Kate, 2019).

Transportation Infrastructure

Mode of transportation is one of the most important components of a BG (Page & Connell, 2014; Hall, et al., 2017). Firstly, public transportation attracts visitors (Le-Klahn, et al., 2014; Liu, et al., 2017) and, secondly, it can transport plant materials as well as related supplies efficiently and safely (Lukinskiy & Pletneva, 2018; Halaszovich & Kinra, 2020). The role of transportation for BGs has a big impact on the BG's ability to effectively carry out their roles and objectives (Truonga & Shimizu, 2016). The efficiency of transportation to and from the BG will influence the visitor's impression of it, contributing to the decision of whether travel to the BG is convenient or will prove to be value for the money and time well spent. Other than that, transportation for the procurement of chemicals and other supplies can be quite difficult and expensive when the BG is located away from major modes of transportation, especially in developing countries like Sarawak, where transportation infrastructure still faces challenges in rural areas. This not only increases costs but also CO_2 emissions and carbon footprints (Sperling & Sarah, 2002; EnTumi, 2010; Heininen & Junnila, 2011).

In this regard, except for QSBG, the BGs in the case studies have methods of public transportation as a means of access but each will have a varying degree of adequacy for attracting the numbers of visitors in order to create awareness. In the case of the 1000ha QSBG, the transportation infrastructure is complex, coverage was poor and transportation was costly, which would not be encouraging to visitors, especially coupled with the potential of communication breakdowns (Tripadvisor, 2017; Tripadvisor, 2021). This could be one of the factors that affect the visitor's decision-making process, resulting in the BG having untapped resources. In the case of NBGs, such as WSBE and GJBG, the amalgamation of a lack of knowledge of the establishment, distance, location and transportation may be the contributing reason towards a low number of visitors despite them having some of the best conservation facilities and displays (Shahrin, et al., 2014). Nevertheless for WSOP, since it is a school, transportation and location may not be the only factors contributing to the limited number of visitors, as it is also subject to statutory guidance for schools and colleges (DOE, 2020): Attracting visitors can only be done on school days (mnrjournal, 2012; WSBE, 2018).

Plate 4-14



Flyer showing the accessibility to Kew Gardens via public transportation. Despite being 10 miles from central London, Kew among all the selected establishments has proper, efficient, safe and cheap public transportation for people to travel easily and conveniently at their leisure, apart from during the coronavirus pandemic. Source: RBGK,2021

Facilities

Facilities such as libraries and herbariums are only effective and relevant in addressing GSPC and IUCN/SSC (appendices 1 and 2) targets and action plans (Greve, et al., 2016; BGTS, 2019) if they are made easily accessible (in person and online) and affordable to the public. However, in the case of BGs such as RBGK, SGB and QSBG, which have such a diverse and historical range of documents, dry collections and books (RBGK, 2021), these treasures are hidden away from the main gate, not being strategically located, meaning visitors would easily miss them (Cheney, et al., 2000; Greve, et al., 2016). On top of that, the establishments' websites do not promote these facilities. With many front-liners and officers of the facilities being reserved, changes need to be made to ensure that relevant enquiries are addressed promptly and not left unanswered.

Plate 4-15

The top natural museum of Queen Sirikit Botanic Garden, which is very educational and an eye-opener. Bottom: Kew Herbaria and Library. In this era of conservation-oriented botanical gardens, herbariums, plant museums and libraries ideally are easily accessed by the public. Improved landscapes around the areas create other attractions to woo visitors in. Source: Tengku Auvaroza, 2018.

Among the BGs discussed, RBGK is excellent in drawing children in to observe nature. It has child-friendly facilities, such as the Children's Garden (Kew, 2020). On the other hand, NBG WSBE has functional, student-friendly and state-of-art facilities, such as an orchid propagation laboratory and a high-tech 240m^2 greenhouse (Capture, 2020) for 1000 different species of orchids. It utilises recycled rain water. Between seven and thirteen students are allowed access and can be involved in projects on open days (by appointment on days it is closed) (WSBE, 2020). The Writhlington orchid project students are very knowledgeable, skilled and internationally exposed to conservation, especially on species orchid conservation. Their living collection has been growing alongside their data collection, which is priceless. The selected establishments have a form of herbarium/library and laboratory, with the exception of RRP, GBB, GJBG and DBOG. WSBE only has s state-of-the-art laboratory and a 30-year-old living museum which are accessible. WSBE, QSBG and RRP do not have a public-accessible Wi-Fi network. The correlation between the availability of facilities and numbers of visitors is clear to see when analysing GJBG and DBOG, – both of which do not have disabled facilities or IT services.

Plate 4-16

Writhlington School Orchid Project. It has a state-of-the-art nursery (a living museum with 1000 specimens, an orchid propagation laboratory and a grow room manned by students, creating awareness and educating the younger generation effectively on orchid conservation. Source: Tengku Auvaroza, 2018

4.3.2.5 Public Education Programme

This criterion refers to the varying approaches of engaging people who visit BGs (BGCIRoots, 2017; BGCI-QSBG, 2020). This includes labelled plants, brochures, short and long-term exhibits and programmes to explain plant conservation (BGCI, 2019). These involve organising citizen science projects which engage the public. Informational components such as interactive panels as well as active learning components – school programmes, youth camps, undergraduate and/or graduate education (BGCI, 2019), agricultural extension assistance programmes, community programmes and professional training courses related to plant conservation – needs to be a top priority (BGCI, 2019). Currently, UBGs collaborate with tertiary educational institutions (e.g. RGBK with the University of Brighton or Roehampton University), with the objective of providing outdoor education (Vergou, 2006; Vergou, 2010; BGCIRoots, 2017) whereby practical learning can take place within the UBGs. However, collaborations with the relevant establishments should also include the aim of raising awareness of the younger generation regarding environmental protection, plant diversity, conservation, urban horticulture and invasive species (Krishnan, et al., 2019). This is critical as these people will be future leaders. So far RBGK (KEW, 2020), SBG (SBG, 2020), SGE, CPG (ChelseaPS, 2020) and QSBG (BGCI-QSBG, 2020) are among the BGs that offer programmes for children within an UBG, which attracts the participation of students and children, establishing early involvement with conservation efforts.

In addition, RBGK has organised weekly courses for the community under the Kew Mutual Improvement Society lecture series (KMIS, 2021), which creates awareness of plants and fungi for a minimal fee of £5 (£3 online during the pandemic). WSBE offers similar programs to the UBGs mentioned, with the difference that the students have direct access and hands-on exposure to a conservation programme at school daily (WSBE, 2020) whilst under the guidance of their teachers. In addition, these children are exposed to participation at 'high-level' international conservation conferences, presenting papers and posters to international attendees (IOCC, 2019), and winning international conservation accolades for educational exhibitions (Forsyth, 2018). At the same time, they have taught fellow students internationally, inspiring other students across the globe (Rowanda, Africa and Sarawak, Malaysia) whilst sharing their knowledge and skills on conservation (Choo, 2019; Cowan, 2019).

Plate 4-17

The Writhlington School Orchid Project team collaborated with Sarawak Orchid Society by flying to Kuching, Sarawak, in July and October 2019 to share their skills and knowledge with MRSM secondary school students on orchid micropropagation techniques as part of their Conservation Educational Programme. Source: Tengku Auvaroza, 2019.

4.3.2.6 Coordinated Research Programme

In order to support the mission of the institution as well raise standards and best practice in all other aspects of their establishments, RBGK, SBG and SGY conduct research and internal review protocols for diverse disciplines, such as horticulture techniques, breeding and propagation, botany (taxonomy and evolution), conservation and ecological restoration, invasive species control and ethnobotany (Hulme, 2015; BGCI, 2019). These UBGs have doctoral training partnerships with various institutions, providing research, and professional, technical and personal development training in a multi-disciplinary environment (Lindsay & Middleton, 2018; Imperial, 2019).

On the other hand, despite not being a BG, students involved in the Writhlington School Orchid Project have the opportunity to work with higher education institutions connected to BGs, such as the Eden Project, Bristol University Botanic Gardens, Cambridge University Botanic Gardens and Jodrell Laboratory in Kew, exposing them to research, experiments and internships, which could be applied to their school projects (Pugh-Jones, 2021). This is in line with the aims of the Convention on Biological Diversity (CBD, 2020; CBDrGPSC, 2020).

4.3.2.7 Conservation Programme

With the plant extinction crisis (CBD, 2020) the world is facing, ex-situ and in situ conservation, management, and the restoration of biological, cultural, and ecological diversity, focusing on local flora and ecosystems, needs to be a priority, especially for the 17 mega-diverse countries (Westwood, et al., 2020). Unlike SGE and NBG, which have always focused on their local flora, GBB and SGB have included living specimens from other countries as their main attractions as part of their conservation effort. However, historically, the success of SGBs has always been in the area of externally sourced plants including the famous national orchid, which is a hybrid orchid cultivar (NHB, 2018). The parent of Singapore's national orchid, which made history as *Papillionanthe Miss Joaquim (a.k.a. Vanda Miss Joaquim)* (Khew & Chia, 2011), is a cross between the Burmese *Vanda teres Papillionanthe teres* and Malayan *Papilionanthe hookeriana* from Sarawak. RBGK, housing the largest historical scientific living museum in the world, has always been at the centre of ex situ conservation for various types of plants from different parts of the world through four of its main conservatories: Palm House, the Princess of Wales Conservatory, Waterlily house and David Alpine Conservatory (RBGKew, 2020). Nevertheless, recently the Kew director of science, Prof Alexandre Antonelli, has said that it was time for RBGK to decolonize its living botanical collection (Roy, 2018; Antonelli, 2020). The actions of RBGK being a leader of the industry would certainly carry weight and could influence other BGs in the future. GJBG (Lucas, Manuel, 2018) focuses mainly on local flora, employing in situ and ex-situ approaches in natural surroundings, whereas WSBE's strategy is to pursue ex situ conservation.

4.3.2.8 Collection Accessions and Management Policy

In line with their institutional mission, these BGs' recently defined priorities are clearly articulated, with a focus on local and endangered flora (Dunn, 2018), collecting data on provenance and maintenance, and pursuing protocols for monitoring and deaccessioning invasive species (BGCI, 2019). However, in this context, the role of RBGK is valued as the pre-eminent provider of public education related to plants and fungal science, conservation and horticulture. RGBK not only focuses on local flora but also has a department researching the taxa of orchids from all over the world despite the UK not having naturally occurring epiphytic orchids and having only 52 species of terrestrial orchids. Since orchids and fungi from rich mega-diverse areas would be the most critically endangered if this is not addressed (Jin, et al., 2018), the most efficient method for any BGs would be for each country to conserve their own endangered flora, as this would encourage sustainability and maintenance costs, and reduce environmental problems (Westwood, et al., 2020).

4.3.2.9 Marketing and Outreach Programme

As observed, the marketing of BGs to visitors is more about the aesthetical and horticultural aspects of the BGs and not so much about conservation (Funsten, et al., 2020). These selected BGs, also known as tourists gardens, are well known for their history and automatically generate visitors, which motivates them to manage their resources attractively and efficiently, as in the case of RBGK and SBG, because they are accountable to national and international bodies (RBGK, 2020; NParksSGB, 2020). A coordinated, intentional and professional marketing and public outreach programme, including advertising in traditional media, use of social media and regular website updates, patronage support and outreach within the local community, as well as domestic and international collaboration and memberships with societies, would effectively build networks and forge collaborations with fellow gardens, researchers, universities and stakeholders. It would also have a huge impact on local communities and within the larger scientific and conservation communities (BGCI, 2015). Proactive and consistent marketing using the latest technology also assists UBGs in boosting their value.

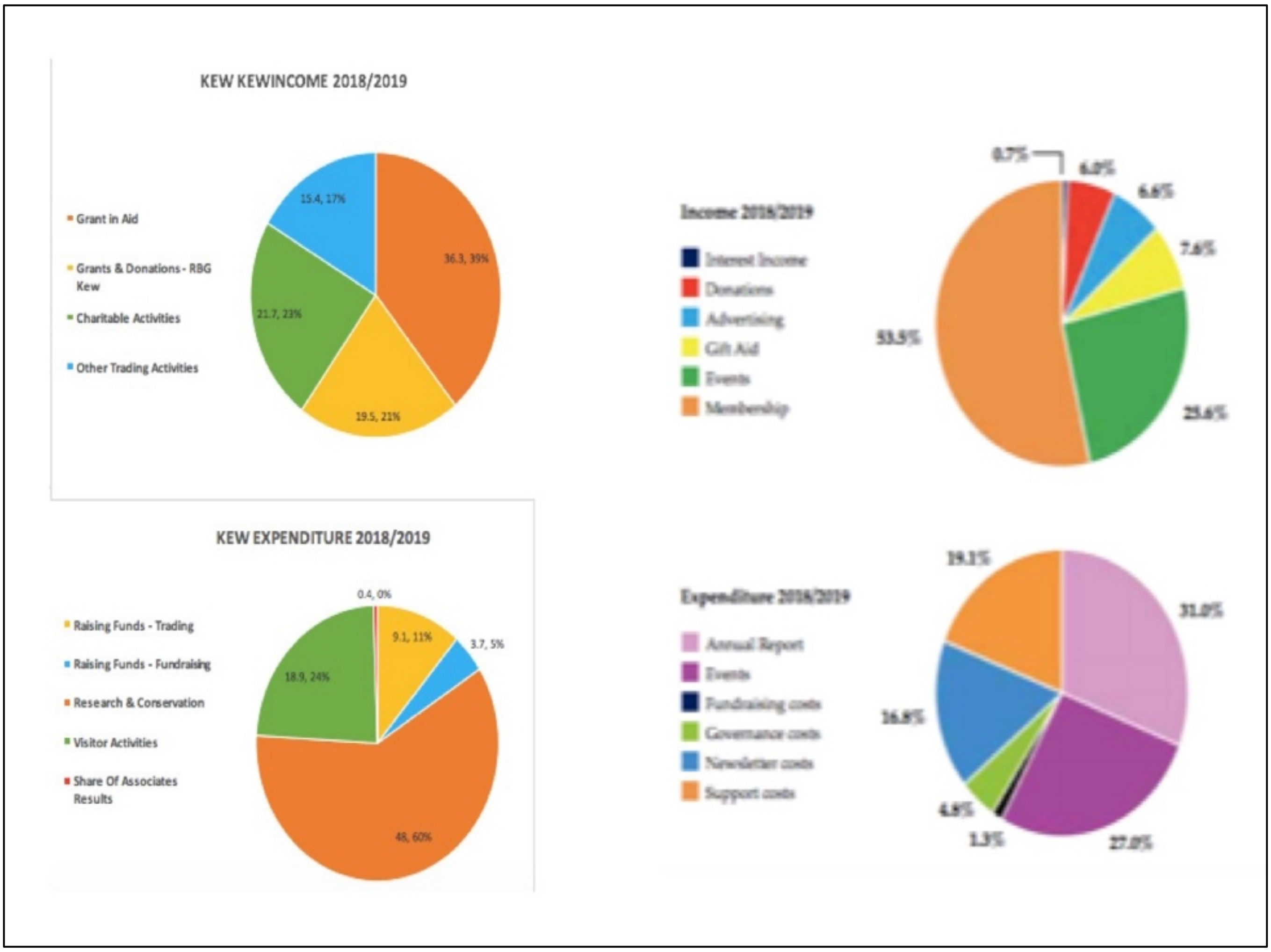
In addition, utilising the current advanced virtual reality technology available at SBG and GBB (Nparks, 2020) would allow them to relay the roles that the public could play in order to mitigate plant extinction issues. Marketing and promoting conservation programmes using the latest technologies could be an effective method for creating awareness in line with the revised GPSC (CBDrGPSC, 2020). Simultaneously, it would educate visitors on understanding the magnitude of the challenge the future generation would face (Tannenbaum, et al., 2015; Frammuseum, 2019) if the recommended actions are not taken.

WSOP, a conservation champion, led by a teacher who has the awareness, knowledge and drive to take action (Mirenda, 2011), runs a community science project with students in resource-rich developing countries, such as Malaysia, and Rwanda, on orchid conservation projects (WSBE, 2014; Cowan, 2019)

4.3.2.10 Funding

BGs are at the vanguard of global action to combat the plant crisis through research, world-class facilities and technologies which require substantial funding. Most of the establishments highlighted are being funded by their government (CPG, 2018; GBB, 2020; NParksSGB, 2020; RBGK, 2020), with the exception of CPBG, WSBE and GJBG.

Figure 4-6



Income and expenditure of RBGK (left) and CPG (right). The main funding for RBGK comes from the government whereas Chelsea Physic Garden's funding comes from activities within the BG itself. The 348-year-old, 3.5 acre BG is more practical and relatable to the current BG conservation concept, which needs to be self-funded, small in size but relatively productive in creating awareness and educating the community on plant/orchid conservation. Source: RBGK and CPBG, 2018.

However, BGs which are not fully funded by a sponsor (such as CPBG) maintain their operations and self-sustainability through various fees and donations (Orton, 2019). With the exception of WSBE, GJBG and DBOP, the establishments are charitable bodies, as stated on their respective websites and their latest audited annual returns (NParksSGB, 2020; GBB, 2020; RBGK, 2020; CPG, 2018). Aside from CPBG (CPG, 2018), these charitable UBGs are funded by their respective governments, either fully or partially, as in the case of RBGK, whereby the UK government provides 50% of its income (SWLondner, 2016; RBGK, 2020), with the rest of the expenses being borne by reserves, a charitable trustee, fund-raising activities, foundations and fees collected from visitors (RBGK, 2020). Comparatively, CPG, which has a 3.5-acre site, is funded by private trustees, income collected from visitors, courses/trainings/workshops and private donations (CPG, 2018).

GJBG (Lucas, Manuel, 2018) is privately managed by a private entity. It was initially funded with funds from the local state government for necessary developments, such as paths, labelling and procurement of seedlings. Since then, operational expenses are managed by a private entity through the collection of fees. WSBE's operational cost is also managed and funded by the project itself through sales of seedlings at exhibitions, online and on open days, private sponsors, the rental of orchids and exhibition winnings (WSBR, 2019). From the audited accounts of the four most notable UBGs, these Noah Arks for threatened plants will not be able to sustain themselves financially without receiving grant aid.

4.4 Discussion

4.4.1 Clearly Defined Mission

As identified, a clearly defined mission is crucial in providing purpose, standing and visitor engagement (Recupero, et al., 2019) for the BGs. Whilst all the UBGs studied understand the importance of having a mission-driven company (Craig, 2018), as each of them has clearly defined missions, more often than not, these missions are not visible and require active searching, be it through websites or documentation. However, a mission is rendered ineffective when it is not exposed to the BG visitors (Monteith, 2018), as it is typically generated to provide a commitment and solution to problems. UBGs can fulfil their role of creating awareness and visitor participation in conservation efforts through the expression of their mission to their visitors, uniting their brand and culture with a clear and visible goal. Missions should be explicit to visitors upon entry to a BG, as this will frame a narrative for the entire UBG experience (Sean & Gentry, 2016).

Equally, a visible mission is also ineffective if not relatable to the masses. With the extension of the GSPC Targets beyond 2020 (CBDrGPSC, 2020), it is clear that efforts made to promote conservation although substantial have largely been unproductive. Much of this can surely be attributed to them being irrelevant to visitors or, at the very least, there being a lack of guidance on how a layman can practise some form of conservation in their daily lives. Even if the consequences of extinction are shown, it needs to be supplemented with information and methods on how solutions can be integrated into one's routine (McDonald, 2019).

Therefore, for the new proposed UBG, there is a need to produce several missions, with specific plans and actions and investment in attractive prominent digital displays (Straker & Wrigley, 2018) visible for all stakeholders including employees and visitors, to see, understand and respond to the intended message upon entering (Lynch, 2015; Algre, et al., 2018).

4.4.2 Experience Upon Arrival

A visitor's experience upon arrival at a BG is crucial for the creation of awareness amongst the community of their role in affecting environmental change and what they can do to mitigate plant extinction (BGCI, 2018). The initial impression of a BG can and should be leveraged in providing context and a narrative to the entire visitor BG experience. Without context, visitors' experience of a BG will be purely aesthetic, with there being no difference to visiting a general contemporary art garden that is not viewed from a true BG perspective (Funsten, et al., 2020). With advancements of technology, there are many methods of creatively incorporating information upon entry to a BG, from prominently showing interactive digital displays (Straker

& Wrigley, 2018) and immersive video presentations or augmented reality displays which complement the BGs and effectively promote awareness and the conservation of plant species (Chen & Sun, 2018).

On this, BGs can take inspiration from the healthcare industry approach (Everett & Bryant, 2011) or the entertainment industry in the form of various themed amusement parks and exhibits. In the example of Warner Bros Studio in London, which presents an exhibit on the Harry Potter franchise (HPSWBros, 2021), advantage has been taken of entry queues and time spent in the lobby to provide information and context to the experience via a video presentation and audio cues. This could be emulated by BGs playing video presentations of the definition of plant conservation, climate change, the consequences of the lack thereof and what the visitors can do in order to aid conservation efforts. A closer example is the Writhlington School Orchid Project. They do not use sophisticated technology, but the posters and exhibits displayed at the entrance to premises give visitors a clear overview of their goals, inspiring visitors, promoting active learning and participation, and instilling a desire to know more (Mimeo, 2021).

Second, the introduction of personnel during the early moments of the BG experience should also be a point of consideration (Hansen & Mossber, 2016; Nejmeddin, 2020). Not only would it be beneficial, but it also addresses the issue that the BG experience can be impersonal (Asminia, 2010; Blaszak, et al., 2019). The introduction of greeting personnel provides a contact point for visitors in the event of queries and creates a face/persona that can be related to the BG.

4.4.3 Aesthetics – Brand, Personality, Character

The selected BGs have fulfilled the aesthetic criterion to varying degrees – each displaying their plant collections in different landscapes representing their identity. This comes as no surprise, particularly as BGs are predominantly aesthetic establishments in the eyes of the public and aesthetics are what have typically drawn visitors since the mid-1800s (Oldfiled, 2007; Oldfiled, 2010; Woods, 2018). This generates income to fund operations. Following this, a lesson that can be applied to what sets GJBG and WSBE apart from other successful BGs is that they integrate communication and the presentation of information with aesthetics. The quality of aesthetics in BGs has not been in doubt, with the high numbers of visitors they draw in each year, BGs need to evolve beyond attractive aesthetics and use their attractions to convey the message that 20% of the world's plants are at risk due to Anthropocene activities, which also threaten the climate and the environment.

Each BG also had its very own unique arboretums, a scientific treasure representing each of the respective country's endemic trees. This is something that the community can relate to and may try to imitate in their homes. Similarly, the green cover in Sarawak comprises its natural forests. In addition, monoculture oil palm plantations cover 12% of the land, having replaced the virgin forest.

As well as bamboo forest, red pine forest and ancient oak trees, Sarawak os also home to epiphytic plants, including Orchidaceae (SFDM,FRIM,SWFDM, 1994; Dixon, et al., 2003). Orchids need alternative hosts and habitats, particularly as in situ conservation is very challenging. The introduction of Sarawak lowland endangered orchids (SLEO) to oil palm trees, representing 80% of Sarawak orchids, addresses the loss of biodiversity. In addition, their inclusion into the proposed UBG would make them relatable to local visitors, especially those who are oil palm operators or are aware of the industry. Further explanations on what could be done and the potential economic benefit of 'value-added' products – such as sustainable orchid floriculture through the oil palm plantation community – would serve as an eye-opener.

It must be acknowledged that oil palm trees were introduced as a result of RBGK (Hartley, 1977, p. 16) to meet the demand for food and provide a better standard of living for the rising population over the past two centuries (Tilman, et al., 2001; Godfray, et al., 2010; Bonhommeau, et al., 2013). Sarawak enjoyed revenue of MYR 2.97bn in 2019 (Hirsschman, 2021) There are ecologically sound ways to manage oil palm trees (Paterson & Lima, 2018). Including them as a feature in the UBOG would make it relatable to the oil palm community, showing a way to continuously improve it by inviting researchers from all over the world to participate. Engagement with stakeholders and the public could be done by displaying the positive and negative impacts of their cultivation on the ecosystem through the 'living museum" and an interactive technological display.

4.4.4 Location, Accessibility and Facilities

Besides UBG playing a role in greening urban areas, combatting city pollution, urban heat, and flooding (Lashley, 2012; Cavendar & Kate, 2019; Cavender & Donnelly, 2019), researchers found that visitor numbers to BGs outside of cities is smaller than to BGs located within a city (Wassenberg & Soule, 2015; Razak, et al., 2016). The location affects the number of visitors due to the additional costs incurred by tourists for transportation and other logistical necessities, such as accommodation (Truonga & Shimizu, 2016). Being in an urban area means BGs can enjoy the benefit of connectivity and the convenience of mobility, which leads to financial growth, allowing the BG to expand and provide more facilities and ensuring that each visit provides value for money (Page & Connel, 2014). Additionally, being in an urban area allows BGs to contribute to urban forestry, biodiversity and urban agriculture (Cavender, et al., 2019). In the case of developing countries, there are more educated academic individuals living in urban areas applying for jobs in UBGs, which is beneficial since many BG staff are highly educated academics, (Maarseveen, 2020). Unlike UBGs with large, highly educated populations in close proximity, which present opportunities for large volunteer programmes, such as the annual Orchid Festival organised by RBGK (RBGKew, 2019), BGs in rural or less developed areas are less likely to receive volunteers to facilitate such events (data.ncvo, 2019).

UBGs can provide insights into ecological changes (Perez, et al., 2018), providing new opportunities for BGs to rediscover new applications in conservation and preservation (Cannon & Chai-Shian, 2017), as in the case of the new proposed UBOG with the Oil Palm Trees Arboretum. This could be shared with visitors from other South-eastern Asian countries. It could be further accomplished through the implementation of BG functions in a common urban setting (Carrus, et al., 2017). While still focusing on the core framework, UBGs still undergo and apply research, education and horticulture through the use of new designs and solutions. These UBGs have become an attraction for city dwellers and communities from rural areas, along with international visitors, which is timely as there is a need to appeal to a wider audience to create awareness in line with the plant extinction issue (Perez, et al., 2018). Successful BGs such as RBGK, SBG, SGY, NBG and CPG have maintained this success during the current economic hardship and have stood out to a wide variety of people, as compared to QSBG, which is located outside the city centre, where accessibility is limited, discouraging communities who are not involved in plant conservation or see the relevance of BG activities to their daily lives (Barnett, 2015).

The issue of accessibility can be compounded by the facilities in a BG. This includes herbariums, libraries, laboratories and other amenities. Facilities such as the herbarium of RGBK and the orchid library need to be readily accessible to visitors of the BG and also need to be advised of the presence of such facilities within a BG (NBGK, 2019).

Furthermore, whilst the availability of a Wi-Fi network is now a necessity in any public area, BGs need to understand that connectivity is crucial in this day and age. With the current pandemic, Wi-Fi in RBGK has been improved. Staff can use the Wi-Fi facility to share real-time updates on their websites for visitors (LAN3 , 2020). Not only that, with Wi-Fi, visitors can use their plant recognition app to learn more about the plants. BGs should now use barcodes on their labels so that more information can be retrieved and shared when visitors enter. Though not necessarily a public area, BGs are and will continue to be a point of attraction and, as such, should be able to provide for the latest basic amenities. In the 21st century, this undoubtedly includes Wi-Fi connectivity, which also contributes to safety.

This also relates to how BGs can address inclusivity and diversity. Although most successful and popular BGs do well in this area, they need to be mindful of providing access and egress for disabled visitors besides providing ramps, widening doorways, providing accessible toilet facilities, light switches and door handles. These include special parking bays, entrances, emergency evacuation chairs, and stations to charge powered wheelchairs.

4.4.5 Public Education, Research and Conservation Programmes

Based on the case studies conducted, it is clear that modern-day BGs are more than just pretty attractions (Oldfield, 2007; Faggi, 2012; McDonald, 2019; Perez, et al., 2018). Behind the scenes, they conducted a plethora of programmes, from researching an assortment of plants to collaborating with educational establishments. Whilst the efficiency of these programmes is not in question, the availability and awareness of them are (RBGK, 2021; SBG, 2020). More often than not, visitors to BGs are unaware of the programmes that are on offer, and this is surely a contributing factor as to why the deadline for the GSPC targets has yet again been delayed. This information may be available in the form of online articles or garden brochures, but unless visitors already have an active interest in these programmes, the information is not readily available. BGs need to do more to put advertise their programmes. Not only does this information need to be available, it should also be interactive so as to allow for interest to grow. If individuals can understand the impact and necessity for these programmes, as well as have their queries answered when they are raised, then surely exposure and awareness to conservation will rise accordingly.

WSOP, a non-BG, is a champion in this aspect because of its orchid conservation programme, which has been ongoing for 30 years, exposing students to the world outside the school walls. Besides instilling conservation values in the students at a young age, the orchid project educates and provides skills training to their students at school from year seven, and encourages them to participate and compete in exhibitions, displaying their skills and knowledge on orchid conservation as well as the orchids they propagate. WSOP's team operates outside the box; it motivates others, as they give the impression to visitors that orchid conservation is doable even by Year 7 students. Their participation in international exhibitions has resulted in opportunities to meet representatives from developing countries where orchids are threatened with extinction and the public has limited knowledge or conservation. This allows for a direct exchange of knowledge and experience and the sharing of new technology and perspectives with students from countries that suffer most acutely from deforestation and which have yet to be involved in the conservation activities and research that WSOP carries out. If all BGs were to adopt the same concept as WSOP – sharing information and skills with the younger generation at schools as part of their programmes instead of students visiting BGs –there would be a process of continuity and not just one-off visits from local schools to BG. The students could develop their wn basic laboratory skills and create develop living museums in their school gardens, building herbarium sections and honing skills to preserve plants and flowers. Mini-botanical garden similar to those of BGs in universities could be encouraged, such as the 400-year-old Oxford Botanic Garden and Arboretum (OBGA, 2019) and the Cambridge University Botanic Garden (CUBG, 2019). There are only six universities in Sarawak, of which three are government-owned and three are private universities. However, there are 132 government secondary schools and 45 non-government secondary schools, all of which are potential mini-BGs that could specialise in conserving orchids in their respective areas. As school establishments are more permanent, they could be educational green spaces, opening up opportunities by displaying different architecture, unique orchids and the plants found only in their area. Other, more far-reaching opportunities and innovations would favour the preservation of the earth. This would allow local universities to work together with the schools on various conservation issues. This section is further discussed in Chapter 5. If these activities were implemented in schools, then school visits to BGs would be just the icing on the cake.

Additionally, BGs should take a bigger step forward and integrate IT into the BG experience as a form of public education. As mentioned, IT can be used through interactive displays, but, at the same time, can be adopted for displaying information at specific locations of the BG via mobile phones or through augmented reality devices. The options to utilise and integrate are boundless, and it is the onus of BGs to evolve and adapt with the changing times, reaching wider audiences. Presentations and activity sessions could be held among pensioners or during non-working hours. Additionally, these could be recorded and made available to be watched or accessed outside office hours. BGs also need to grow and adapt to fulfil their roles, not only internally but through cultivating others to do the same.

During the pandemic, WSOP held a Zoom session with MRSM students and SARORSO members, relating the hands-on challenges and experiences that they'd had in the laboratory and nursery. The time difference between the two countries did not prevent the younger generation from communicating and inspiring each other. The success of such programmes could be duplicated by the word-of-mouth of the students themselves. These students could easily influence their parents on conservation. Before this programme, none of the students in MRSM knew about SLEO and its status. Afterwards, they made a presentation at a World Orchid Conference in Taiwan in April 2021, sharing their experiences and knowledge, and adding to the number of children who have become aware and are taking action in helping to address the orchid extinction crisis. These children could be future ambassadors for BGs by encouraging more youngsters to be sensitive in addressing plant extinction and climate change issues.

At this critical stage, WSOP and SARORSO have become effective models. By joining forces with BGs, they could do even better with the combined resources and expertise they have, seizing new opportunities presented not for the aggrandisement of their own positions, but for the benefit of the younger generation.

4.4.6 Collection Accessions/Management

The new UOBG would involve the collaboration of various stakeholders, such as Sarawak Forestry, UBGs such as RBGK (which have Sarawak orchid seedlings in their nursery); GJBG (which has vast experience in introducing OS to hosts) and WSOP (which has a large selection of tropical orchids found in Sarawak), the Kuching Municipal Landscape Architecture department, the Sarawak Orchid Society, and Sarawak Oil Palm Organisation, to sustainably collect native endangered and extinct species for the garden. This includes managing the garden to address the critical orchid conservation message.

4.4.7 Marketing and Public Outreach

The necessity to engage the public in order to aid conservation efforts has been mentioned multiple times throughout this chapter. Similarly, the issue of BGs being successful in their operations while still lacking effectiveness in combatting plant extinction and furthering the conservation agenda has also been identified. This can be taken to mean that the marketing and engagement of UBGs in relation to their role within conservation has been poor and requires reorganisation. For some time, BGs and horticulture have been widely regarded as aesthetic in nature and increasingly becoming entertainment forms for the younger generations. However, it is now imperative that BGs change this perception in order to expedite the process of conserving plants. UBGs need to engage the younger generations *en masse* (BGCI, 2015), drawing interest and cultivating the desire to safeguard the future through the protection of the ecosystem, as further explained in Chapter 5. It is no longer sufficient that UBGs market themselves as typical attractions where visitors can experience the aesthetic beauty of a variety of plants but instead need to actively appeal to youth for effective short and long-term measures.

4.4.8 Funding

The funding structure for many BGs has been established throughout their time in operation. It is clear that for BGs to be sustainable, some form of external support is required – often this is through government stimulus (RBGK, 2020; NParksSGB, 2020). This is understandable as operational costs are substantial and, without donations or patronage, entry fees and concessions will not be able to cover a significant proportion of these operational costs. However, if the UBGs are kept small as in Japan (Oldfield, 2010) and CPG (CPG, 2018), increase their role actively in conservation and get involved in intensive species recovery projects, the cost of maintaining glass houses could be managed (Oldfiled, 2010) and, at the same time, be a model to other new UBGs (Antonelli, 2020). Nevertheless, gardens like RBGK with its historical background and exceptional status and position in the eyes of the world (OxfordEcons, 2019; Warren, 2021) has higher running costs as the site includes the Palm House (Minter, 1990) and other historical buildings.

Changing this structure to put plant conservation centre stage is proving to be a challenging task and rather than looking to completely overhaul this arrangement, future UBGs may need to be more creative in balancing their books. A good example – though not perfect – would be CPG (CPG, 2018) and the non-UBG, WSBE (WSBR, 2019). With the advent of conservation, UBGs should look to leverage this to develop an additional revenue stream through employing their in-house scientists as consultants to organisations which are looking to contribute to conservation efforts. These organisations could range from large-scale developers to part-time SMEs, which could benefit from guidance in how to ensure that their operation has minimal impact on the environment.

Alternatively, BGs could also look to restructure their own operations to embrace active conservation rather than focussing on developing a wide collection. Conservation should relate to local flora, meaning that each BG should prioritise conserving plants facing extinction in their region over those from other countries (Rbgsyd, 2019; Recupero, et al., 2019). This should also instil a sense of responsibility in their own natural assets and reduce the need for greenhouses or cooling structures to simulate the environment of plants not native to the BG's region. In this way, additional expense on infrastructure could be reduced as there would no longer be a need for an artificial environment.

4.5 Conclusion

This chapter follows on from Chapter 1, which mentioned the study of the effectiveness of UBG embracing the issue of endangered OS (IUCN, 2019) in order to protect them and engaging the broader community as well as educating the public on issues such as the loss of biodiversity, habitat loss and climate change (Cowan, 2019) in Kuching, Sarawak. However, as there are limited successful UBGs that focus only on OS, this chapter studied the effectiveness of major UBGs addressing and protecting plants. With the unmet CBD/GSPC targets CBD in 2000 (CBD, 2020), restructuring the roles of UBGs and their landscapes has changed radically due to deforestation and climate change. The importance of connecting the urban forest, ethnobotany and native plants with the daily lives and activities of locals has become an essential feature of the new UBG (BGCI, 2010; BGCI, 2018). This will need to further extend to engaging broader society, for example, secondary school students and management, as is mentioned in Chapter 5, and oil palm operators, which is elaborated on in Chapter 6.

The criticisms and concerns related to UBG activities, as well as the pressing needs of biocultural and ecological conservation, highlight the importance of not simply building a new

21st-century UOBG infrastructure, but first isolating the infrastructures and characteristics of the case studies which are the most effective so that the new UOBG in Kuching, Sarawak, can be built in line with them, as highlighted in Chapter 4.3 and 4.4 (BGCI, 2020). Despite the respected reputations and vast experience of established UBGs, visitors from broader society (especially those not exposed or aware of horticultural terms and issues) cannot relate the UBGs' role in plant conservation, as shown by the unmet GPSC (BGCI, 2015; CBDrGPSC, 2020). As mentioned by Smith, until UBGs refocus and realign their approach on addressing plant conservation (Smith, 2018), with practical improvements to people's lives, using relatable vegetation and agriculture and landscape architecture which imitates the forest aesthetic (Vanderoot, 2018), this will continue to be the case. Thus, identifying and highlighting effective UBG characteristics and features is critical to amplifying their effectiveness and encouraging these successful characteristics and features to be adopted into the new proposed UOBG in Kuching, Sarawak, which is further discussed in Chapter 7.

Chapter 4 explored the effectiveness of the integration of UBGS and orchids and addressed the barriers to ex-situ conservation of orchids (Koopowitz, 2001; Fay, 2018), as well as the factors that militate in favour of successful practices and collaboration through the highlighted case studies analysis in this chapter. This is followed by further support from the experiments conducted and explained in Chapters 5 and 6, where the collaborations between secondary school students (Chapter 5) and the wider community involving plantations and other stakeholders (Chapter 6) are explored. Together, these could further create and develop awareness, knowledge, skills, attitudes, commitment and interest in orchid conservation (Fay, 2018), meeting the GSPC (CBDrGPSC, 2020) targets and the IUCN action plans (IUCN, 2020).

As aesthetics are vital in drawing visitors, the biodiversity improvement of plantations using similar forestry landscape architecture to that in SGBG, NBG and GJBG, which is relevant to creating natural orchid habitats that are attractive, educational and unique (Gratzfeld, 2016; Chen & Sun, 2018), would give the UOBG the natural look of species orchid habitats through replication of the forest aesthetic representing the natural and man-made (monoculture) green cover of Sarawak (Wraith, et al., 2020). Concurrently, integrating these aspects could enhance citizen science (Turrini & Bonn, 2018) and, therefore, increase public awareness and engagement on the orchid extinction crisis while, at the same time, allow for the monoculture operators to relate and contribute to conservation after visiting the UOBG (Ballantyne, et al., 2008; Chen & Sun, 2018).

The results revealed that these botanical gardens:

- Displayed their respective unique identities through their scientific research and findings and through more public engaging displays and events such as encouraging community participation.
- Utilised advanced virtual technology displays from the entry point, informing the public of the importance of plant conservation.
- Demonstrated excellent return on investment, which benefitted the community and the country; it requires an understanding of the need for a strong collaboration led by the government with other academicians/scientists and industry players (Bean, 1908; RBG, 1957; Desmond, 1995; Nanakorn, 2008; Barnard, 2016) in developing Sarawak, which is rapidly losing its megadiverse forest, which contains orchids.

Observations of note are:

i. The five criteria: display, conservation, scientific research, education and marketing can help in discussions and in identifying the effective characteristics and features in the newly proposed Sarawak UOBG in Chapter 7;

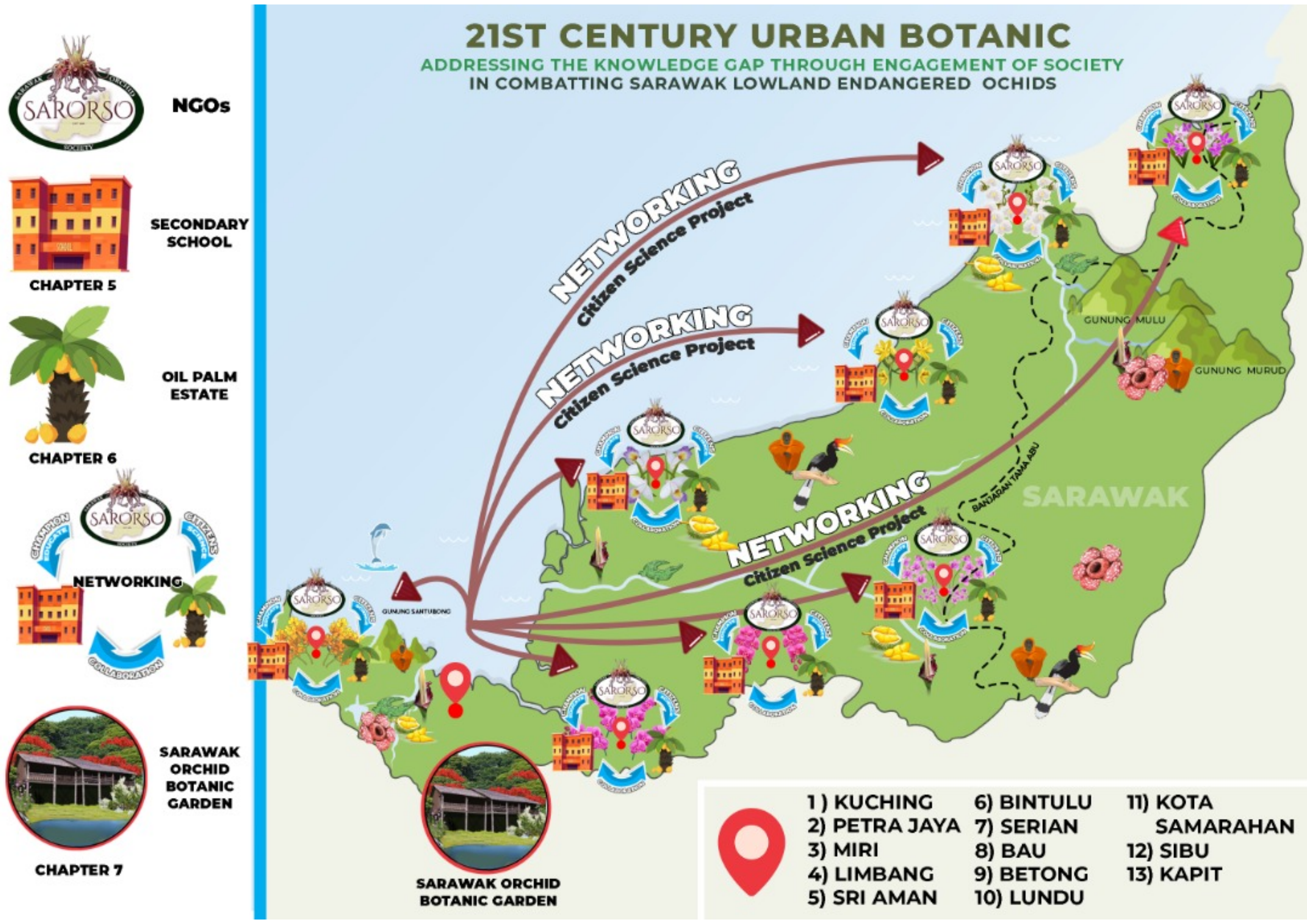
ii. A balance between resources and maintenance of collections and other activities in the UOBG is of great importance for increasing the possibility of meeting the objectives and targets of GSPC (CBD, 2020; CBDrGPSC, 2020) and IUCN action plans (IUCN, 2020);

iii. It is important to communicate and find common agreement with scientists and engage with broader society on what the specialisations are for improving orchid living collections, exchanging knowledge and plants, and sustainably using it in the context of climate change and deforestation.

iv. Collaboration with other UBGs such as securing records and exchanging seedlings from RBGK, WSBE, GJBG and also for the purpose of further orchid research and conservation.

The figure below sums up the findings from the case studies. The networking in the diagram will be further explained in chapters 5 and 6 to portray how citizen science projects can be utilised and implemented as features in the newly proposed Sarawak UOBG. Engaging a wider community such as secondary school children, oil palm estate operators and NGOs to be involved in the orchid conservation would effectively spread knowledge and awareness more effectively in the short term and, most importantly, in the long term. This concept would not only create the unique characteristics and features of the newly proposed Sarawak UOBG, but it could also lead to a fast-track way for addressing orchid conservation and motivating others from the same region to follow suit. In addition, it could improve the biodiversity of degraded areas due to intensive agriculture and encourage further research on mixed-species plantation forestry (Liu & Krutovsky, 2018). The figure below will be further explained in chapters 5, 6 and 7.

Figure 4-7



This figure explains the concept of the proposed Sarawak Urban Orchid Botanic Garden. It portrays how citizen science projects and networking involving secondary schools, oil palm operators and NGOs such as Sarawak Orchid Society create awareness and spread knowledge that addresses orchid conservation and the orchid extinction issues more effectively and in a fast way. Source: Tengku Auvaroza.

CHAPTER 5

5 Enhancing year 7 Students Performance in In Vitro Orchid Micropropagation: A Study on Efficient Techniques using Basic laboratory set up

A Study on the Effectiveness and Efficiency of Year 7 Students' Performance in Conducting in Vitro Orchid Micropropagation Using Seed Germination (Protocorms) and Seedling Development of Dendrobium anosmum (Sarawak Lowland Endangered Orchid) in a Laboratory at MRSM SS Kuching (the First Malaysian School with an in Vitro Orchid Micropropagation Laboratory).

5.1 Introduction

Introducing informal OC education to students in a school, initially starting with year 7, their teachers and an orchid society led by scientists in the field could develop school children's awareness and knowledge of the value of Sarawak OS as well as the unique environment of each specific OS habitat in Sarawak (Ikyaagba, et al., 2018; Taylor, et al., 2019; Rhodes, et al., 2020). As proven by Writhlington School Orchid Project (WSBE) team (WSOP, 2019; Pugh-Jones, 2020), the students have opportunities to work alongside scientists in BGs as well as different established organisations. This will be a powerful base for the school children to understand the OS situation in Sarawak before being exposed to OC education in other parts of the world (Rhodes, et al., 2020; WSBE, 2019). The collaboration will also provide lifelong learning opportunities which develop critical thinking, enhance communication, attitudes, values and their application (CBC, 2020). Most importantly the pilot project (PP) transforms the participating students into dynamic and knowledgeable individuals who are environmentally responsible and able to express themselves publicly (Plate 5-1).

In addition, based on the successful model project (WSBE), hands-on entrepreneurship, knowledge and skill also need to be implemented for the PP to be as sustainable as WSBE (WSOP, 2019). On the whole, so that the conservation goal of the PP to succeed and be sustainable, the PP, which is also a Community Project (CZ), needs to be replicated and repeated by students and teachers in charge in other schools in all 13 divisions throughout Sarawak. However, the prolonged pandemic, which has resulted in schools being closed from March 2020 until April 2022, has affected in vitro orchid micropropagation (IVOM) performance and activities in the laboratory.

Plate 5-1

The students were widely interviewed by television stations and other social media. a) MRSM students invited to local television station for their participation in World Orchid Conference in Taiwan, presenting a poster to scientists. b) Another session of interviews by another local television and newspaper in an IVOM lab. c) Students' first international conference, the Asia-pacific Conference where they had huge coverage and motivated other students and schools to be part of the effort.

d) Recent invitation to participate in a National Inaugural Conservation Conference in 2022 just when the country is recovering from the Covid-19 pandemic and children are returning to school. Source: Sarawak Orchid Society 2022.

Similar to the WSBE laboratory (Plate 5-2), a school IVOM laboratory which mass produces seedlings enables large scale OS data collection; it is also the fastest way to mass-produce affordable OS seedlings which could help address the OEC (Cardoso, et al., 2020; WSBE, 2019). It is also relevant in the light of the Sarawak Wildlife Protection Ordinance 1998, which prohibits any kind of propagation (Comm of Law Revision, 2008), assisting in avoiding illegal transactions (Malaysia Govt, 2014). Introducing knowledge and skills to SS students is beneficial as they have no interest other than gaining the attitudes, behaviour, knowledge and functional skills to apply and to enable them to influence others around them from their school years onwards (Ausubel, 1962; Alexander & Poyyamoli, 2014; Hammond, et al., 2020). In addition, the introduction of these studies would not only benefit them in their future undertakings but also address the issues threatening the dynamic equilibrium between humans, development, forest products and the ecosystem (Leung, et al., 2011; Esa, et al., 2011).

Plate 5-2

Grow rooms for orchid flasks produced by WSBE students in their IVOM lab. Source Tegnku Auvaroza 2018.

Using seeds in different divisions effectively and efficiently for IWOM addresses the mass, sustainable and affordable legal long-term supply of seedlings for the potential Urban Orchid Botanical Garden (UOBG) (Fay, 2005; Gonzáles, et al., 2010). Since 1921 (Yam & Arditti, 2009), most botanical gardens worldwide have adopted this clonal propagation in vitro with strict aseptic standard operating procedures, including Kew Botanical Gardens (Kew BG) (Fay, 2005; Baskaran & Staden, 2013; Mitrofanova, et al., 2021). Harvesting OS specimens from the forest, which is happening widely in developing countries (Hinsley, 2018; Bullough, et al., 2021), is not a sustainable method for mass replenishment of the UOBG for two reasons: orchid harvesting from forests is illegal, and orchid seeds are not guaranteed to germinate under natural conditions unless they have been colonised with compatible mycorrhizae (Rasmussen, et al., 2015). Hence, IVOM is the most effective method not only to restore the population of endangered OS to meet the fast pace of extinction, but also to satisfy the demands of hobbyists and supplies throughout the entire orchid industry (Cardoso, et al., 2020). Moreover, visits to two of Thailand's Orchid IVOM establishments in 2018 showed that they are similar to the one in WSBE, but a much simpler setup (Plate 5-3).

Plate 5-3

A successfully commercial, privately owned IVOM establishment in Bangkok, Thailand with a simple set up Source: Tengku Auvaroza 2018.

Further, with Sarawak having OS as one of its major natural resources, more than other world-leading orchid exporters such as Thailand (1300 OS) and Taiwan (330 OS) (Vermeulen, 1991; Wood, 1997; Beaman, et al., 2001; Wood, 2001; Wood, 2003; Thammasiri, 2015; Thammasiri, 2016; Lin, et al., 2016), Sarawak has excellent potential to excel in its orchid floriculture and horticulture industry (Ling, 2019; Dardak, et al., 2020) as well as its pharmaceutical (Pant & Raskoti, 2013; Teoh, 2019) and herbal food and beverage industry (Zhao & Marc-Andre, 2021). The lack of Sarawak community and consumer awareness of the untapped opportunity and knowledge of the substantial growth in demand for the billion-dollar orchid floriculture (Mordor, 2020), as well as for medicinal herb products (FAO, 2018; insightSLICE, 2021), needs to be addressed. Unlike in the Taiwan Orchid Industry (Huang, 2017), there is a lack of coordination among the various existing local organisations which would enable Sarawak to develop the necessary production model to achieve its targeted position in global trade in the abovementioned industries (SBC, 2015; FDS, 2020; MUDNRS, 2020)

Therefore, developing an IVOM laboratory in a SS is part of the effort to create early awareness, knowledge and skills, beginning with YG through a conservation strategy in line with the Global Strategy for Plant Conservation (GSPC) – Target 4.7 states that every child should be aware of plant diversity (including orchids) by 2030 (CBD, 2000). This PP introduces IVOM to a SS as successfully carried out by WSBE for 30 years (WSOP, 2019; Choo, 2019; Pugh-Jones, 2019). In parallel, SSs can also represent pre-biological orchid institutions capable of delivering an effective and sustainable Sarawak OC. However, the success and failure of extra-curricular activities in Sarawak depend on the school, especially the commitment, placement and transfers of schoolteachers, as it has been proven that many extra-curricular activities in Malaysia become ineffective due to the activities being left to the students to handle; the teachers are not passionate and are transferred, leading to unskilled trainers (Lim, 2014). The success of this pioneering IVOM laboratory in schools in Malaysia could result in it being the first of its kind in Southeast Asia and therefore have the potential to be the Orchid Educational Hub for the region. Thus the IVOM laboratory would be the perfect destination for enthusiasts, hobbyists, scientists/researchers, growers and the general public to not only learn about the valuable local orchids, but also to develop an appreciation for and interest in the field.

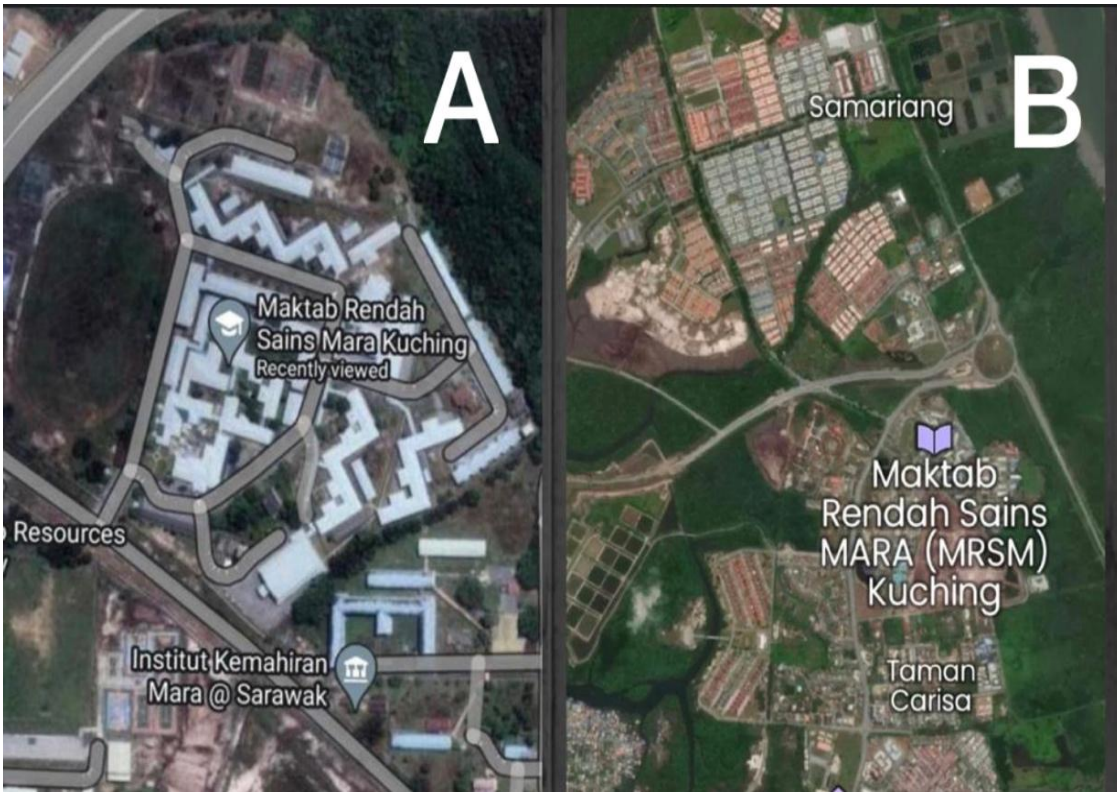
Moreover, if this PP is carried out like the WSBE, it could become a catalyst for not only improved OC but also the production of a new breed of leaders, local conservationists, orchidologists, as well as a successful floriculture, an advanced orchid cloning lab, and a herbal and tourism industry which could create vast employment opportunities; investing in IVOM and the development of new herbal/pharmaceutical/other products would generate a high value-added source of revenue for the community (as in Thailand, as a result of a cottage industry focussing on arts and crafts as in Plate 5-4 below) and Sarawak as a whole (Thammasiri, 2016).

Plate 5-4

Fine jewellery and corporate gifts from fresh orchids as a result of an advanced IVOM industry led to the existence of various other small industries, such as the above jewellery making cottage industry in Bangkok, which is able to address poverty as well as being a product of the state. Tengku Auvaroza, 2018.

5.2 The School – MARA Junior Science Ciollege (MRSM), Kuching

Plate 5-5



The MRSM Kuching campus is situated in a suburb of Kuching, the capital and largest city of East Malaysia. (A): A close-up aerial view of MRSM Kuching. (B): MRSM Kuching is surrounded by housing areas. Source: Google Maps 2020.

As shown in Plate 5-5, MRSM Kuching is a co-educational science-focused secondary boarding school for 700 high achieving pupils aged 12-17 in Samariang, Petra Jaya, Kuching, Sarawak. The school volunteered to take part in the Orchid Ex Situ Conservation Pilot Project (PP). The first students to participate were selected by the school board. An isolated empty unused room was renovated as an IVOM laboratory with a layout designed by Dr Pugh Jones of Writhlington School. The author was able to assist MRSM to secure sponsorship for this purpose and additional funding from the Sarawak Chief Minister's office in 2019, amounting to RM100,000 for the operation of the laboratory and a further RM50,000 from the Kuching North City Council for MRSM to purchase the equipment and tools needed. MRSM welcomed the collaboration of three parties, which were MRSM, the SARORSO and WSBE. While

WSBE was responsible for the initial technology transfer, SARORSO volunteered to handle the promotion of the OC programme to other schools and event management to create awareness, and MRSM oversaw the administration, safety and interests of the students and teachers involved. The collaboration was based simply on the understanding of respective interests and objectives and a similar goal to create awareness and increase knowledge and skills among the YG and the community. A Memorandum of Understanding document was neither formalised nor executed but all three parties share the same goals to reduce the OC gaps amongst the YG in line with the GSPC 2030 target 4, where at least 15% of each ecological region or vegetation type is secured through effective management and restoration, whether or not through schools (Sharrock, 2012; BGCI, 2021), and Sustainable Development goal no 4 on Education, especially 4.7 on sustainable development and global citizenship (UNESCO, 2020).

5.3 Research Aims

This study aimed to investigate the effectiveness and efficiency of Year 7 Students' performance in conducting sustainable IVOM using Seed Germination (Protocorms) and Seedling Development of *Dendrobium anosmum* (a Sarawak Lowland Endangered Orchid - SLEO) in a laboratory at MRSM SS, Kuching (the First Malaysian School with an IVOM Laboratory). At the same time, it was to recognise the potential and empower Sarawak SS (SS) students in becoming effective orchid conservationists, as well as leaders for the future (Floral Daily, 2019).

5.3.1 The Research Objectives

Based on the research aim in 5.3, the **primary research objectives** for this research were to explore the potential of Year 7 students to skilfully and effectively carry out mass IVOM from orchid seeds, adhering strictly to aseptic protocols, preparing the sterile medium, through the embryogenic development, to protocorms, right up to the development of in vitro plantlets

(IVP) ready to be planted outdoors and distributed to UOBG, green spaces and community conservation groups. The EC should complement and not adversely affect the students' main academic performance.

5.3.2 Secondary Objectives

I. To set up Sarawak's first IVOM laboratory in a SS to ensure its species' posterity (Choo, 2019).

II. To develop a model laboratory and pathway that can be shared with other SS in Sarawak.

III. To develop research and experimental skills to support the effectiveness of the project (WSBE, 2019).

IV. To assist in conserving the SLEO (CBD, 2000) by creating a mini OBG in the SS compound.

V. To share knowledge, skill and experience with other YGs and their parents for the benefit of the community.

VI. To enhance science and conservation education in SS.

VII. To develop innovative ex-situ conservation initiatives in monoculture estates.

VIII. To determine the conditions under which an IVOM growth room (not controlled, unlike in Writhlington) would be most successful; productive rates as well as dormancy periods, if any; and the response to different climatic conditions (rainy, dry hot and hazy) and other restrictions, such as during the Covid-19 pandemic (Zhang, et al., 2018). This is because the growth room will not be controlled until shown to be necessary.

IX. To evaluate the extent of the success of IVP and IVOM in terms of establishing or significantly producing new IVOM genera of orchids in flasks ready to be transferred to the field for conservation purposes.

X. To develop mini orchid nurseries/vendors in each of the SS compounds which specialise in the OS of their own respective areas.

XI. To act as a potential sustainable supplier of OS for the UOBG.

XII. To evaluate the extent of the success of IVOM in three areas as guided by the WSBE team (Thorpe, 2007):

a. *To examine the survival rate*

Stage 0 – to examine contamination of agar (culture medium) – both sowing and replanting process

– to determine causes of contamination

– to determine the quantity of successful IVOM jars according to the following stages.

Stage 1 – percentage of successful jars with non-contaminated agar against contaminated agar (culture medium)

Stage 2 – percentage of successful jars with germinated seeds – protocorms – against jars with contamination/dead seeds

Stage 3 – percentage of successful shooting and rooting of IVP against failed growth due to contamination/termination

Stage 4 – percentage of successful weaning/hardening against unsuccessful transfer to field, to evaluate cost of each successful IVP

b. *To evaluate timeline of each stage (feasibility). Examining*:

Stage 1 – time taken for IVSG

Stage 2 – time taken for embryo development – shoot appearance, foliage and hairlike appearance

Stage 3 – time taken to development of protocorms – appearance of leaves and roots

Stage 4 – time taken to replanting/multiplication of protocorms

Stage 5 – time taken to acclimatisation stage – transfer from in vitro culture (IVC) to appropriate substrate and a higher intensified growth light from low light 30-40%.

c. *To determine the cause of contamination*

XIII. To determine that trained and skilled year 7 students are then able to effectively train new sets of students (technology transfer) in the protocols involved under the supervision of the teacher-in-charge.

XIV. To evaluate the potential of Sarawak SS to be recognised as a pre-biological orchid institution capable of delivering effective orchid ex-situ conservation programmes to create awareness of the critical issue of SLEO extinction.

XVI. To explore the potential of developing an innovative next-generation of orchidologists, scientists, taxonomists, botanists, conservationists, environmentalists, leaders and entrepreneurs who would directly and practically address their nation's important issues, as they are aware of these issues having been exposed to them early in their life.

XVII. To develop hands-on key entrepreneurial skills for the project to be sustainable, as well as to equip the students with basic real-world skills, preparing them to think outside the box in a rapidly changing world, the COVID 19 pandemic being a great example.

To ascertain:

1. Whether students could efficiently run the IVOM lab as an aseptic environment using all protocols given
2. Whether, if the basic IVOM technology used by the WSOP team in glasshouses in the UK can be successful (apart from the WSOP growth room), the Sarawak natural climate and environment would be favourable for SLEO micropropagation in Sarawak SS without expensive glasshouses.
3. Whether students could successfully germinate 70% of seeds into healthy developed protocorms in jars and then replant these healthy in vitro plantlets (IVP) when ready (Utami & Hariyanto, 2019).
4. Whether the seedlings could be distributed at low cost for conservation purposes in the proposed UOBGs, green spaces of suitable habitat, cooperative oil palm estates and other areas identified by the Sarawak Forest Corporation.
5. Whether MRSM can become a role model for 176 other SS in Sarawak, duplicating the IVOM process in a typical IVOM laboratory and each SS specialising in conserving orchids native to their area (Beaman, et al., 2001).
6. Whether SS students could be developed to become orchid experts and reliable distributors of sustainable OS native to their area.
7. Whether the project will complement and not adversely affect the main academic performance of the students.
8.

(The MRSM orchid project (MRSMOP) team would retain 50% of its seedlings to raise funds to maintain laboratory activities and future awareness-raising activities among communities.) The research was undertaken to create awareness among the YG of OE issues which this part of the world is currently facing silently. In addition, introducing basic IVOM technology to SS is not only a way of increasing the number of knowledgeable young citizens who are also skilled in ex situ conservation, but also of opening opportunities to create an affordable, sustainable and legal way of producing orchid seedlings for both ex-situ and in situ conservation. The findings and conclusions may guide the Education Department and other stakeholders on future decisions, planning and further research in creating a new School Curriculum which involves OS as the State's untapped and valuable Natural Resource, so that the YG may benefit the State long-term.

5.3.3 Gap in Research

To identify:-

- The knowledge gap which exists concerning the sustainable and legal sourcing of seedlings of different species of orchid at reduced cost whilst using the latest tissue culture technology, equipment and basic aseptic protocols which are not easily available to the general public in developing countries such as Sarawak (Ahloowalia, et al., 2004). There are limited studies on creating awareness programmes and exposing basic IVOM technology to SSs in developing countries that need to accept the fact that their SLEO are under threat due to deforestation (Dixon & Phillips, 2007).
- The gap in knowledge transfer at a school level. Currently, there is also a lack of collaboration among organisations to link expertise and knowledge to encourage innovation like that which is being carried out in the successful Taiwanese Orchid Industry, which has an effective network and interactions among organisations (Huang, 2017). With the exposure provided for students to meet and exchange ideas with scientists from local and higher institutions, non-governmental organisations such as SARORSO and teams made up of various roles to complete the tasks, rather than simply a group of peers, the research seeks to fill this gap (CBD, 2000; Huang, 2017; Gale, et al., 2018; Wraith, et al., 2020). Instead, each individual is recognised for their own

knowledge, skill, experience and strengths by contributing their ideas. In this way, knowledge and ideas can be productively exploited, transformed and commercialised to create a sustainable competitive advantage for Sarawak (Cockburn, et al., 2000; Okatan, 2012).

This pathway could be integrated into large-scale micropropagation throughout the State, helping to address the illegal trade and implementing ecological restoration whereby orchids are reinstated legally into sustainably restored habitats or an artificial habitat (Gale, et al., 2018).

- The different protocols are suitable for Sarawak Highland endangered, rare and endemic orchids to prevent extinction and commercially meet local and international demand (LC, et al., 2014) as well as cater to the tourism industry. This research could lead to further investigations, using different orchid genera and controlled growth rooms in schools situated in the highlands, as they have a different habitat type.

5.3.4 Research Justification

The engagement of SS helps the Sarawak population to accept and acknowledge the fact that Sarawak is facing the challenge of the disappearance of its primary forest, directly affecting its orchids' natural habitat (Dixon & Phillips, 2007). This new approach to OC helps the community to realise the message conveyed by the scientists of the lost opportunity which goes with deforestation and understand the value of each orchid in terms of medicinal, environmental, economic and aesthetic values. This programme would contribute to acknowledging the need for children and young people to be aware of environmental issues, to care about and understand them and to act upon the issues identified by scientists and conservationists (CBD, 2000; COE, 2021). Consequently, it could further encourage the development of new homegrown technology compatible with Sarawak's needs, providing rich and meaningful resources for education, conservation and the development of the floriculture industry (Huang, 2017).

The IVOM programme could result in a sustainable, reliable, legal and low-cost source of SLEO specimens, and if spread widely within Sarawak it will allow OC of 60-70% of the OS from the lowlands of Sarawak (Beaman, et al., 2001). Thus, the participation of SS with over 176 sites applying IVOM technology will allow a continuous sustainable flow of OS (Ardoin, et al., 2020) for many different purposes, which will not only improve the landscape of OS, turning degraded land, artificial habitats such as oil palm estates, housing areas and green spaces into highly diversified areas (Dolins, et al., 2010), but also the floriculture industry. SS students will also be the future generation of passionate ambassadors for OC, not only due to their awareness, newly gained scientific knowledge and skill gained at school but also through their local and international network (Choo, 2019; Cowan, 2019). Sharing their practical experience within the community would be another efficient tool for the students to use to inspire one another regarding their learning about orchids supported by new technologies (IUCN, 2020). The findings from the newly introduced IVOM technology would provide innovative and captivating ways to engage each other as well as adults, which will allow wide and effective coverage in addressing OC issues.

5.4 Background

In the face of development, epiphytic orchids species are more vulnerable to extinction due to deforestation, as they grow in the crowns of forest trees (Wilson, 2001), and unlike the vast majority of other angiosperms, they do not scatter their pollen but instead, because the pollen lacks food reserves in the form of an endosperm or a large embryo, it needs to engage in a relationship with a mycorrhizal fungus growing on trees which helps to feed the emerging seedlings (Wilson, 2001; Hartmann, et al., 2019). These two traits (epiphytic and dependent on fungi to germinate) taken together could easily cause orchid extinction when the trees are cleared. Therefore, as Sarawak engages in massive development where century-old orchid habitats are destroyed, IVOM needs to be promoted extensively to match the speed of extinction.

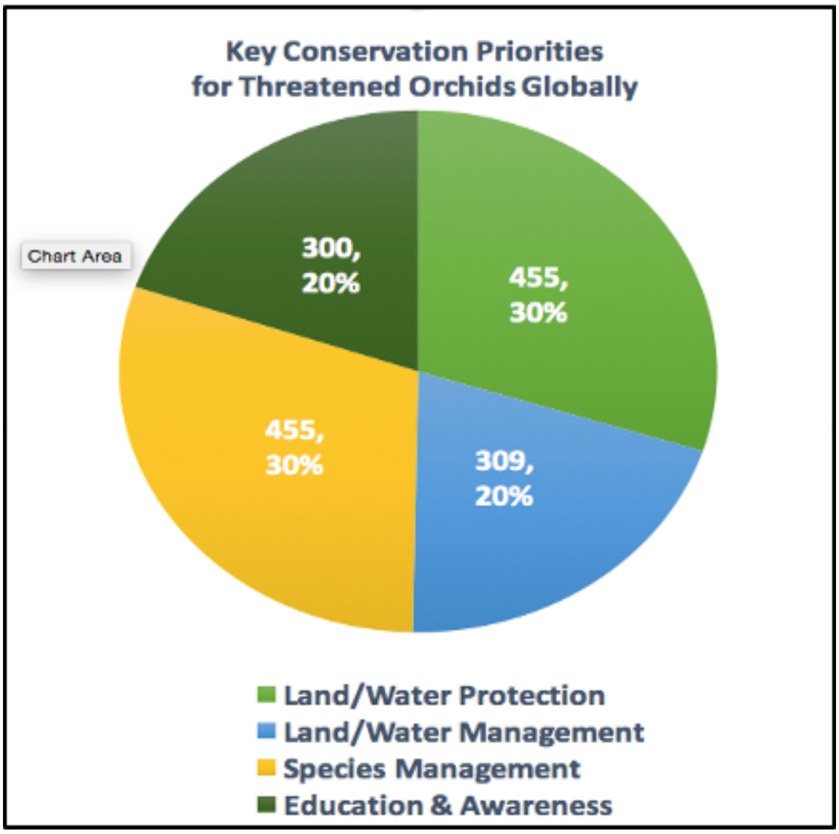
However, even though in vitro (aseptic culture) micropropagation through seed culture is primarily used to produce legal, sustainable and reliable orchid seedlings (Hartmann, et al., 2019), a common breeding programme among orchid enthusiasts in developed countries, it is however, in Sarawak, an illegal regeneration method for the general public (Comm of Law Revision, 2008). Consequently, it is nearly impossible to obtain or purchase any legally sourced seedlings of OS locally, and where it is possible, they are not available at an affordable price. It is much easier and cheaper to purchase mature orchids (some unidentifiable) from the Tebedu weekend markets at the Kalimantan/Sarawak border (Plate 5-6), on the outskirts of Kuching, or in neighbouring countries (Phelps, 2015). Many orchids on offer in these markets were found by conservationists to have been illegally harvested.

Plate 5-6

Illegal trade of unidentified species of orchids in Tebedu, Sarawak. One of the few places to purchase; an affordable choice for local orchid enthusiasts. Source: Tengku Auvaroza T. Abraham, 2018

As shown in Figure 5-1, one of the major gaps in OC is the lack of training and shortage of training resources (Figure 5-2) to match the increased rate of the global extinction crisis (Dixon & Phillips, 2007; Wraith, et al., 2020). For Sarawak, these issues must be addressed holistically rather than through stop-gap measures; this can be done by educating SS children in a similar way to Writhlington School, UK (WSBE, 2019). Writhlington School Orchid Project team (WSOP) is pioneering and living proof (McGiveron, et al., 2020) that SS children are capable of becoming experts in germinating seeds using the latest micropropagation techniques (Utami, et al., 2017), with guidance from teachers and fellow senior students to preserve their native orchids (Choo, 2019; Cowan, 2019).

Figure 5-1



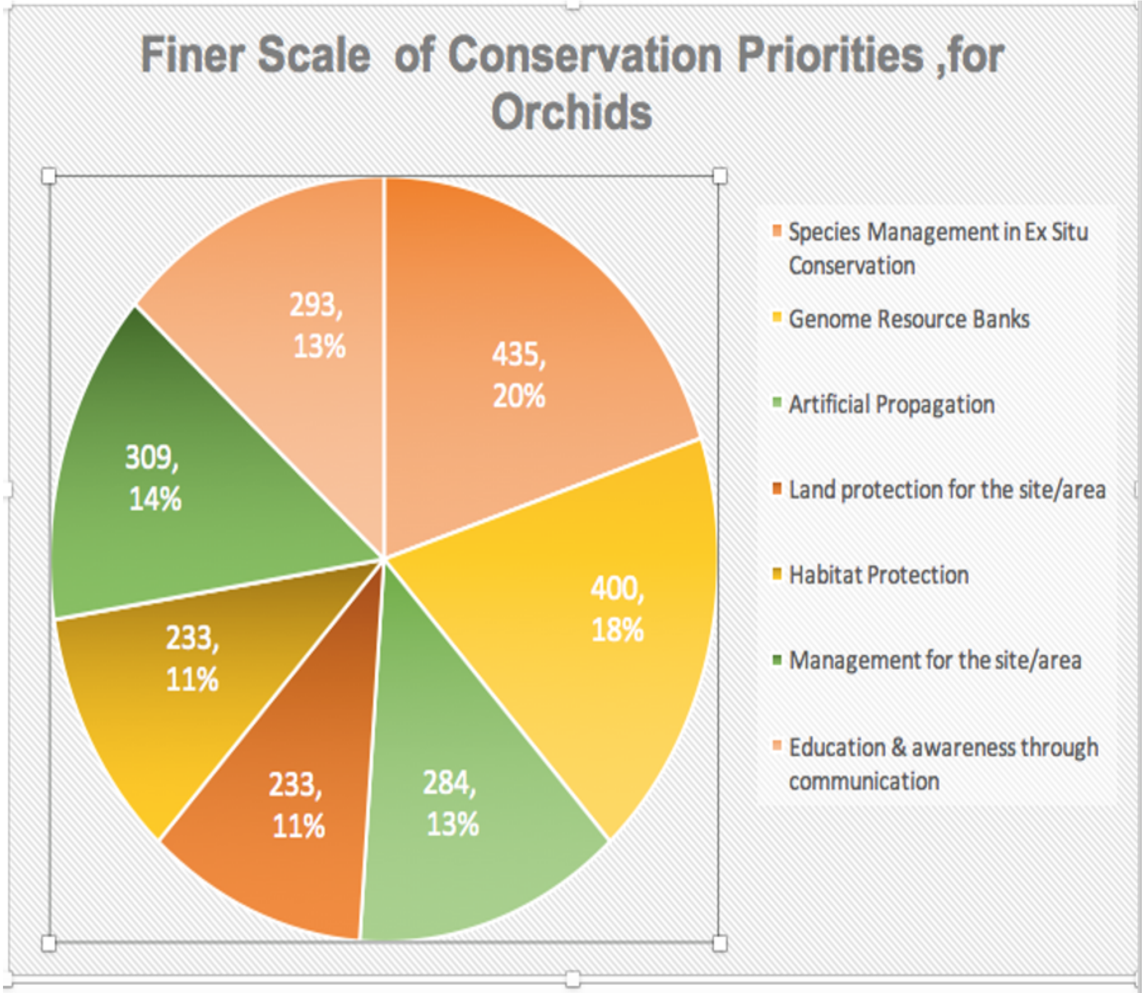
The four main conservation priorities for orchids. Data were collected from the online academic literature. Source: Wraith, et al., 2020

Evidence from research shows that children not only have a strong influence on their parents' attitudes and decisions (Blinkhorn, et al., 2003; Damerell & Howe, 2013), but are able to carry out basic IVOM (Ausubel, 1962; SERC, 2018; Pugh-Jones, 2003; SERC, 2018). Based on Figure 5-2 below, education and awareness are conservation priorities and educating SS children on sustainable OC could be a rapid and effective way to combat the high rate of orchid extinction (Briggs, 2017). For Sarawak, the future and effectiveness of conservation efforts, as well as producing citizens who appreciate sustainable lifestyles and development, lies with the next generation (Pugh-Jones, 2003; Pugh-Jones, et al., 2003; Monroe, et al., 2017).

5.5 The Pilot Project – IVOM Using Seeds

This pilot project idea was initiated based on the meeting the author had with Dr Simon Pugh-Jones and his team from Writhlington School Mendip Orchid Project at the 18th European Orchid Council Conference in Paris, 22-25 March 2018 (Pugh-Jones, 2003). The history and timeline of the project are in Appendix 8.

Figure 5-2



Education and awareness are major priorities for orchids, especially for those threatened by human intrusion including tourism. Source (Wraith, et al., 2020).

This in vitro (aseptic) micropropagation trial conducted by four Year 7 MRSM Kuching students in June 2019, using embryos extracted from a 60% mature green pod (Mala, et al., 2017; Hartmann, et al., 2019), is appropriate for OC (Fay, 2005). As the in vitro (IV) method allows a greater number of OS to be propagated in a given time than can be achieved by normal vegetation methods of propagation, it could act as a sustainable, reliable, legal and cheap method of supplying seedlings for the potential UOBG, in situ/ex situ conservation projects, and for orchid enthusiasts to purchase without having to poach them from the forest.

There is a total of 175 national SSs (excluding private and religious schools) throughout Sarawak (Mestr, 2020) located in the three different regions from coastal lowlands (including peat swamp, marrow deltas and alluvial plains), undulating hills, and mountains, each of which have their own orchids, amounting to 1500-2500 species (Beaman, et al., 2001; FDS, 2020). In the long term, there is significant potential that Sarawak SS students could become young OC ambassadors like the pioneers at Writhlington School (Eden, 2017; WSBE, 2019). Each school could be orchid nurseries/vendors, specialising in the species of orchids of their respective areas, which helps sustain the project as it did with WSOP (WSBE, 2020; Pugh-Jones, 2020).

Plate 5-7

Writhlington School, Bath, UK. 30 years ahead in the Orchid Conservation Programme, even though initially the teacher started by just sharing his passion. He teaches various scientific skills related to the orchid industry, as well as the currently much-needed conservation programmes, which also prepare students to enter prestigious universities such as Oxford University. Source: Tengku Auvaroza T.Abraham 2018.

As highlighted by Dr Pugh-Jones of WSBE (Plate 5-7), students may come across orchids which are difficult to propagate, but one should not underestimate the power of a child with awareness, knowledge and passion collaborating with private scientists and international partners, as proven by WSOP (Plate 5-3). Nevertheless, orchids which are difficult to propagate could be left for higher institutions to carry out the experiments. The successful participation of SS in this project could also ease the dependence on higher institutions, whose numbers are limited, so that they could focus on more complex propagations and OC issues.

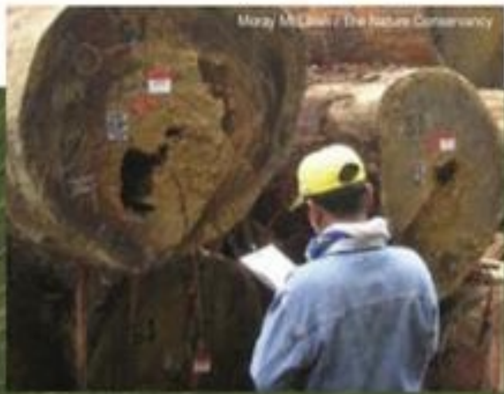
Plate 5-8

The GSPC and its targets

The Global Strategy for Plant Conservation (GSPC) is a cross-cutting programme of the Convention on Biological Diversity (CBD). It includes 16 global targets set for 2020. The aim of the GSPC is to halt the continuing loss of plant diversity and to secure a positive, sustainable future where human activities support the diversity of plant life, and where in turn the diversity of plants support and improve our livelihoods and well-being.

The GSPC provides a framework for working together at all levels - local, national, regional and global - to understand, conserve and use sustainably the world's immense wealth of plant diversity whilst promoting awareness of the importance of plants and their conservation needs.

The 16 targets adopted at the global level provide guidance for setting national plant conservation targets. These targets are to be understood in a pragmatic rather than literal way. They aim to be strategic, rather than comprehensive.



The GSPC objectives and targets

Objective I: Plant diversity is well understood, documented and recognized

Target 1: An online Flora of all known plants.

Target 2: An assessment of the conservation status of all known plant species, as far as possible, to guide conservation action.

Target 3: Information, research and associated outputs, and methods necessary to implement the Strategy developed and shared.

Objective II: Plant diversity is urgently and effectively conserved

Target 4: At least 15 per cent of each ecological region or vegetation type secured through effective management and/or restoration.

Target 5: At least 75 per cent of the most important areas for plant diversity of each ecological region protected, with effective management in place for conserving plants and their genetic diversity.

Target 6: At least 75 per cent of production lands in each sector managed sustainably, consistent with the conservation of plant diversity.

Target 7: At least 75 per cent of known threatened plant species conserved *in situ*.

Target 8: At least 75 per cent of threatened plant species in *ex situ* collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes.

Target 9: 70 per cent of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species conserved, while respecting, preserving and maintaining associated indigenous and local knowledge.

Target 10: Effective management plans in place to prevent new biological invasions and to manage important areas for plant diversity that are invaded.

Objective III: Plant diversity is used in a sustainable and equitable manner

Target 11: No species of wild flora endangered by international trade.

Target 12: All wild-harvested plant-based products sourced sustainably.

Target 13: Indigenous and local knowledge, innovations and practices associated with plant resources, maintained or increased, as appropriate, to support customary use, sustainable livelihoods, local food security and health care.

Objective IV: Education and awareness about plant diversity, its role in sustainable livelihoods and importance to all life on earth is promoted

Target 14: The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programmes.

Objective V: The capacities and public engagement necessary to implement the Strategy have been developed

Target 15: The number of trained people working with appropriate facilities sufficient according to national needs, to achieve the targets of this Strategy.

Target 16: Institutions, networks and partnerships for plant conservation established or strengthened at national, regional and international levels to achieve the targets of this Strategy.

The Global strategy for Plant Conservation, target 4. Source BGC1, 2020

Had Resolution 4 (Plate 5-8) from the GSPC, which was adopted in 2002 under the Convention on Biological Diversity (CBD) in 2002 (Sharrock, 2012), been implemented in Sarawak in the same way as this PP has been conducted in MRSM over the last 20 years engaging the YG, the children and students of that generation would now be completing their education and training and entering adulthood with awareness, similar to those of WSBE. Among them could be key players, the next generation of young orchid taxonomists, ecologists and conservationists implementing the much-needed improved OC in this part of the world and preventing habitat loss. As the scripture teaches '*Train up a child in the way he should go, and when he is old, he will not depart from it. So start students out on their way; even when they grow old they will not depart from it'* (Bible hub, 2020).

Plate 5-9

Dr Pugh Jones, his assistants and four students of Writhlington School shared their knowledge, skill and experience with the MRSM students, teachers and SARORSO Committee members at the new laboratory. Source: Tengku Auvaroza, 2019.

5.5.1 The Experiment Summary

The experiment investigates the potential of in vitro micropropagation (Alghamdi, 2019) of *Dendrobium anosmum (Da)* shown in Plate 5-10using two 'types' of seed: 12-week-old hand pollinated seeds from freshly plucked green pod (FGP) and eight-week-old refrigerated seed pod (FSP). Both seeds were sterilised and were sown in jars containing sterile media (as recommended by the WSBE team) which was made of a mixture of 76% Orchid Multiplication Medium, 14% agar, 4000ml sterilised water (H_20) and 1.5ml Potassium Hydroxide (KOH). The medium contained auxin α-naphthaleneacetic acid (NAA), Charcoal (C) and Banana Powder. KOH was used to adjust the pH of the medium to six. These were prepared by the four selected students whose backgrounds are further detailed in Appendix 7. The experiment was assessed through methods such as live observation and pictures and recordings taken every 30 days. A secondary trial in which propagated seedlings were replanted was also undertaken in October 2019.

Plate 5-10

Dendrobium anosmum with commercial and medicinal value. It was recorded in the Sarawak Herbarium Sheet dated 1912 that a specimen was found in Gunung Pueh. Source Tengku Auvaroza Tengku Abraham, 2019

It is worth noting that the study was conducted over a short period (15th July 2019-20th February 2020), and a longer observation period may yield differing results. In addition, the closure of schools due to the unexpected COVID-19 pandemic since February 2020 (Pokhrei & Chhetri, 2021; Babincakova & Bernard, 2020) has also had a huge impact on the experiment, as the PP requires hands-on participation of both students and teachers. Moreover, since the PP is considered an extra-curricular activity, which is not a priority, especially during these unprecedented times, and the grow room was not temperature/humidity-controlled, the impact on the experiment was a challenge for the PP. To date, the first week of April 2022, the students in MRSM Kuching have not fully returned to the school (Ofqual, 2021; Engzell, et al., 2021). Lastly, the implications for a sustainable and reliable source of orchid seedlings are outlined for potential investment in in situ and ex situ conservation and commercial trade.

5.5.2 Sustainable Supply of Orchid Species for Urban Orchid Botanical Garden

To develop a sustainable Sarawak UOBG, success is dependent on the long-term supply of orchids for its living collection and replenishing of flowering for aesthetic purposes as at Kew BG (Fay, 1988; BGCI, 2016; Kew Gardens, 2019). These seedlings could be used for legal long-term orchid seedling supply to the UOBG, as souvenirs sold at gifts shops – the same technique would not only meet the demand of hobbyists but orchid seedlings could also restore the population of endangered orchids (Gale, et al., 2018) and relieve the pressure in its original habitat or other similar habitats, helping to improve biodiversity. In vitro propagation is an effective method to rapidly and sustainably generate orchid seedlings en masse (Fay, 1994; Hartmann, et al., 2019; Wu, et al., 2014; Hartmann, et al., 2019).

Thus, this study helps students and teachers involved:

- to understand orchid reproductive biology from seed to embryo to protocorm and, finally, forming the plantlet.
- to prove that ex situ conservation through in vitro is possible even by students in a basic school laboratory.
- to understand the cost of investment and what is achievable at this stage.
- to have a picture of the quantity of protocorms it can produce at this stage producing about 500,000 seedlings (before re-planting), and then of plantlets as the process of re-planting takes place.
- to explain to government officials how in vitro could help them achieve their goals of economic conservation as it does not involve costly greenhouses, watering facilities or labour in order to have a constant and sustainable supply of epiphytic orchids, starting with *Dendrobium anosmum (Da).*

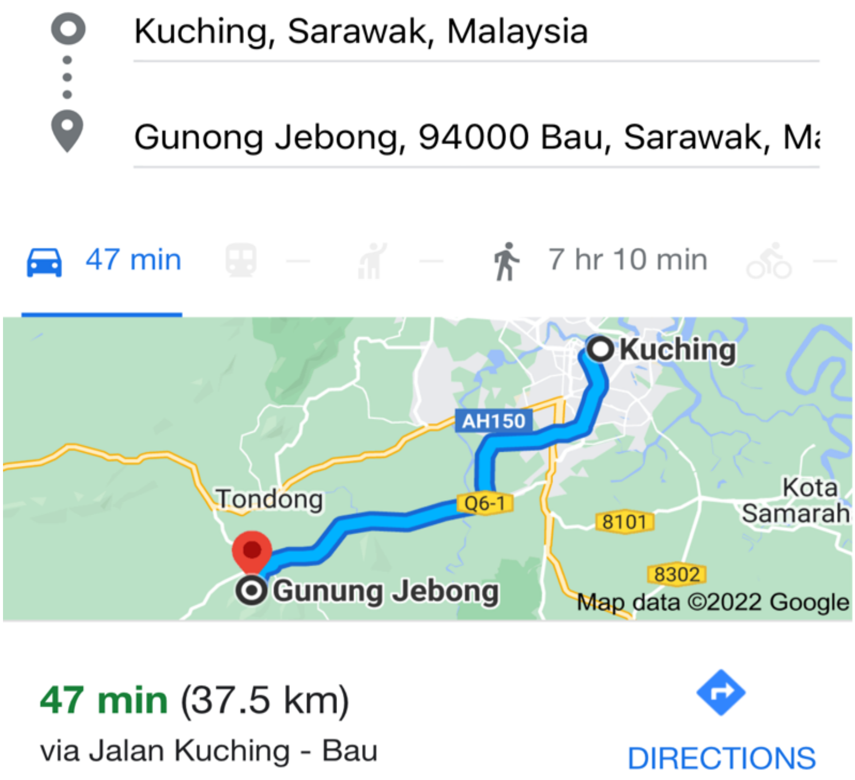
5.6 Materials and Procedure

5.6.1 Selection of OS for in Vitro Orchid Micropropagation

Da was last sighted in Mount Jebong, Bau, 47 minutes from the capital city Kuching (Plate 5-11), in March 2002, as recorded in the Sarawak Herbarium. Due to this, *Da* is considered rare and endangered and classified by CITES officers based in the Sarawak Forest Department (Jee, 2021). It was also discovered through the herbarium sheets stored in the Sarawak Herbarium that *Da* is both lithophyte and epiphyte of the lowland area, habitats which are greatly affected by development. Other properties which influenced selection are as follows:

- It is consumable as tea – (Bodos, 2019; Sarawak Forest Corporation, 2019)
- It has pharmaceutical properties – (Pant, 2013)
- The availability of seeds is limited, and seedlings are expensive.

Plate 5-11



Location of Gunung Jebong, Bau, where the last sighting of Dendrobium anosmum was reported 20 years ago. Source: Google Maps, 2020

5.6.2 Summary of Methods

Methods are written in a simplified, user-friendly way for young students to follow, and were based on standards of practice which were successfully practised by the WSOP team (WSOP, 2019) and at their partner's laboratory in a school in Rwanda, Africa (WSBE, 2014). The experiment also sought to identify the difference in propagation efficiency between fresh green pod (FGP) and fresh seed pod (FSP), as when there was an excess of seed pods, they were stored in the freezer until required instead of being stored in the refrigerator at 5°C (41°F) (Seaton, et al., 2015). The experiment was divided into two stages:

1st stage – Sowing seeds from FGP growth in vitro and FSP growth in vitro.

2nd stage – Replanting seedlings

5.6.2.1 The Process – IVOM .Using Da FGP and FSP

The *Da* seed pods/capsules of both FGP and FSP were donated by members of SARORSO. They were first sterilised; they were put in jars using 50% bleach, soaked for 20 minutes, and then washed twice using sterile water, placed in laminar and surface sterilised using household bleach or antiseptic. An alternative method shared by the WSBE team was soaking the capsules in 75% (v/v) ethanol for two minutes and dried at room temperature before being opened with a scalpel under sterile conditions, which in this case would be inside the laminar. All tools were sterilised in advance and placed into a cleansed hot bead steriliser for a few seconds before using them.

a. **1st Stage – Sowing seeds trial**

- **FGP – 12-week-old *Da* capsule, freshly harvested within an hour – length 7-8 cm**

The capsule (Plate 5-12) was placed on a sterilised surface in the laminar, and then cut into slices. When cut open the texture of the seeds was powdery, easy to apply to the culture medium. These *Da* seeds were sown in 80g Phytamax + 25g agar + 4 litres water + 1.5ml potassium hydroxide. Seeds were distributed onto the medium, and there were 10 replicates from the FGP trial. Variable observations included the start of the growing time (measured when the seeds visibly produce green embryos called protocorms).

Plate 5-12

Fresh Green Seed pod used for the experiment given by a member of the Sarawak Orchid Society (SARORSO). Source: Tengku Auvaroza, 2019.

- **FSP – 14-week-old *Da* capsule refrigerated for eight weeks – length 6-7cm**

When the seed pod was cut open, the seeds were in clumps, which made it a challenge to spread them onto the culture medium. This limited propagation to only five jars.

b. 2nd Stage -Replanting/Multiplication of Seedlings in Jar – Strict Aseptic Procedure

The second stage (replanting) was first performed on only one of the mother jars, labelled as TIDa 3/10, which had become overcrowded and the medium became too depleted in nutrients for further growth (signs of yellowing of shoots, as explained by Dr Simon Pugh-Jones). The procedure was performed by students under the supervision of Dr Pugh-Jones and the WSBE senior students on 4th November 2019 during the WSBE team's second trip, with strict aseptic procedure being observed. Prior to replanting, all surfaces, including the airflow, need to be cleaned with antiseptic surface cleaners or 50% bleach. All jars that need replanting need to be placed in the airflow cabinet and the external surfaces of jars need to be wiped thoroughly with sterilising solution. Tools/apparatus need to be sterilised. The jar of media culture prepared earlier by students was used. When replanting, both the opened jar with seedlings and its lid remained in the air flow cabinet to prevent contamination. Sterilised tweezers from the hot bead steriliser are used, their tips cooled in the new media jar. A small clump of seedlings was taken out of the mother jar and replanted into new jars and immediately sealed with the lid. A total of 25 new jars were obtained from replanting jar TIDa 3/10 (Plate 5-13)

Plate 5-13

Day 14 samples of the replanted jars performed by students. The jars were labelled with an additional letter R to the earlier label of the mother jar. For example, the left bottom jar is labelled TIDa 3/10 FGP R3/25. It denotes that it is the third jar of the new 25 replicates which were replanted from the third mother jar of 10. Source: Tengku Auvaroza,2019

5.6.3 Observation and Experiment

Initially observations and recordings were taken every 30 days and the success of propagation was analysed. It was found that seeds from frozen seed pods (FSP), when cut open, clumped together, unlike seeds from fresh green pods (FGP) which are powdery. The sowing of FSP was not as efficient in terms of propagation, as not all the FSP samples propagated, unlike the FGP which had a 100% success rate in developing protocorms in all 10 flasks sown.

It was also observed that preparing the medium in a concentrated form is not recommended, as some salt complexes may precipitate. Supplements may be added prior to sterilisation or added aseptically to a sterile medium. Certain supplements, such as heat-labile, may require filter sterilisation and may affect the shelf-life of the medium. The student-friendly and basic steps performed by the students for preparing the medium are further detailed in Appendix 9.

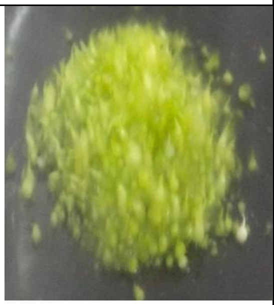
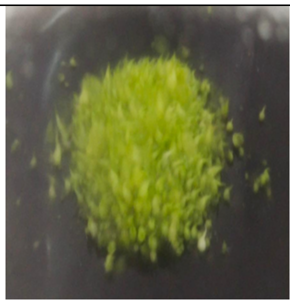
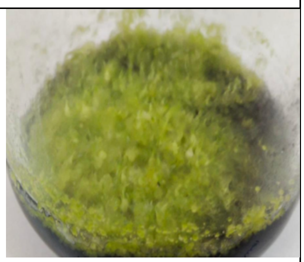
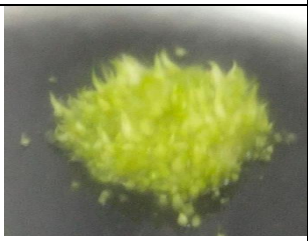
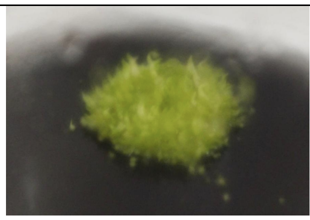
5.7 Results

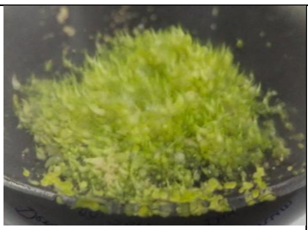
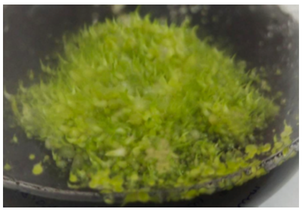
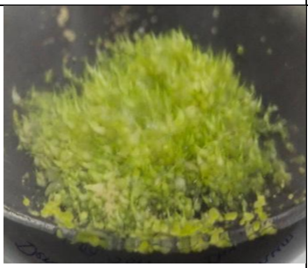
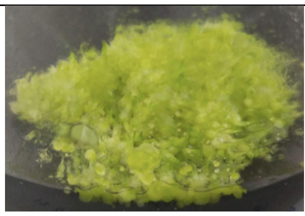
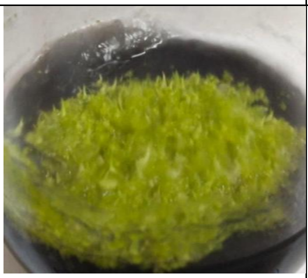
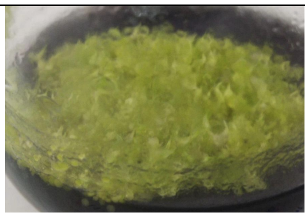
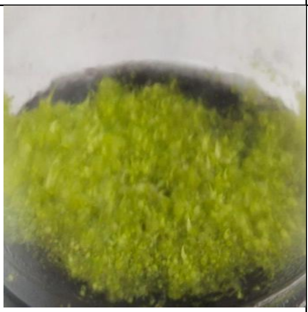
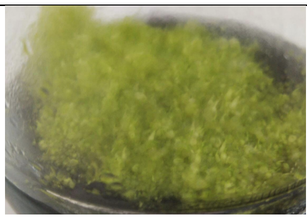
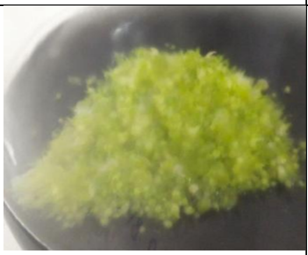
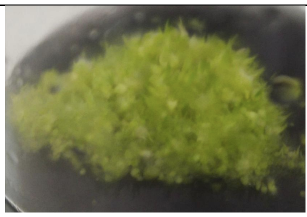
5.7.1 Fresh Green Pod (Results *Not Updated)*

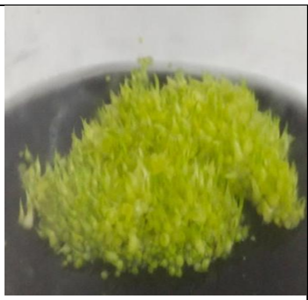
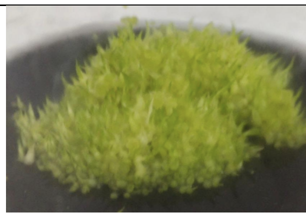
Of 10 bottles sown in July 2019, all were successfully sown without any contamination. However, when replanting was done in October 2019, there were batches that were contaminated due to the apparatus not being sterile.

Table 5-1

Growth Development – Dendrobium anosmum- FGP

Specimen ID	**Day 60**	**Day 96**
T1 Da 1/10		
T1 Da 2/10		
T1 Da 3/10		
T1 Da 4/10		

T1 Da 5/10		
T1 Da 6/10		
T1 Da 7/10		
T1 Da 8/10		
T1 Da 9/10		

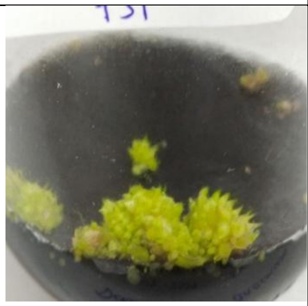
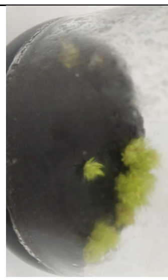
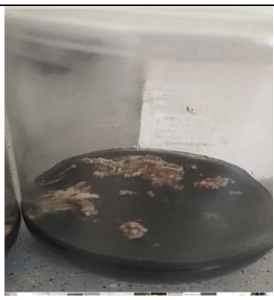
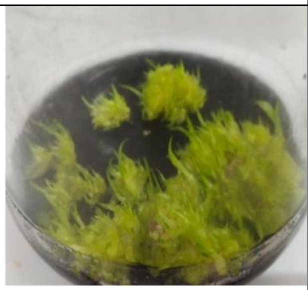
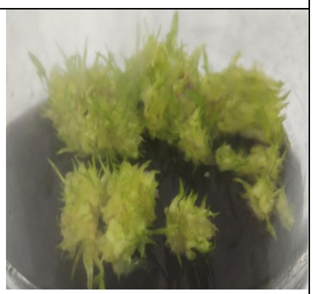
T1 Da 10/10		

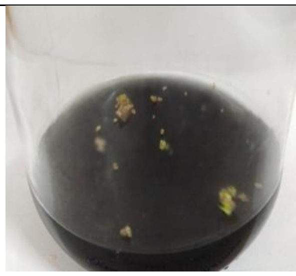
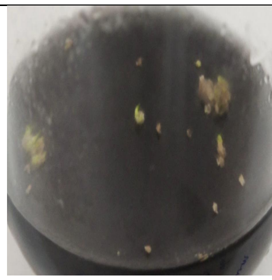
5.7.2 Frozen Seed Pod (*Not Updated)*

As for FSP, from the seed capsule, only three bottles were used as the seeds were clumped together. Five bottles were sown with FSP seeds but only three showed positive growth.

Table 5-2

Growth Development – Dendrobium anosmum – FSP

Specimen	**Day 30**	**Day 60**	**Day 96**
T1 Da FSP 1/5			
T1 Da FSP 2/5			

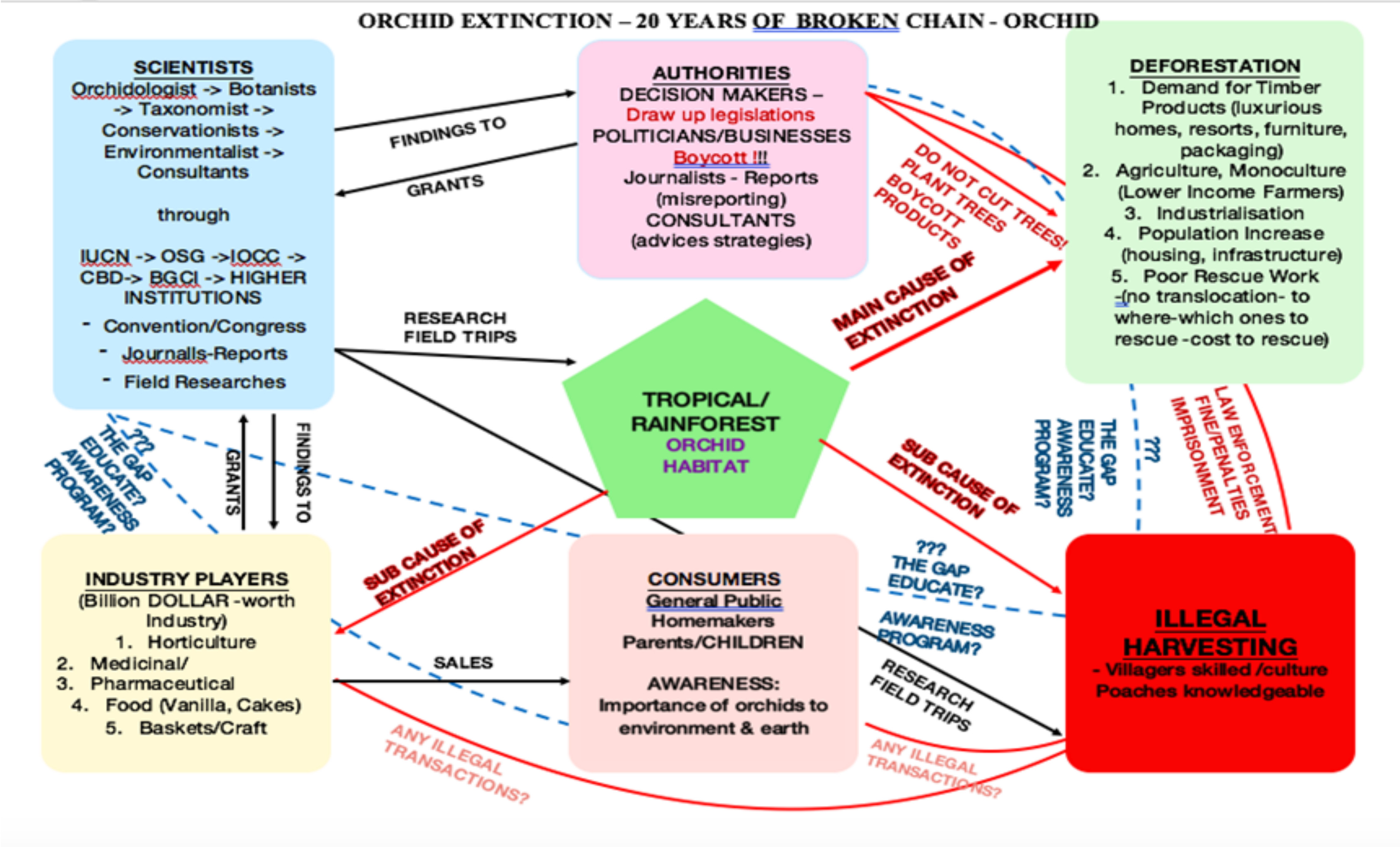
T1 Da FSP3/5			
T1Da 4/5	Not successful		
T1Da 5/5	Not successful		

5.8 Evaluation

The first International Orchid Conservation Congress (IOCC) in Western Australia in 2001 adopted four resolutions (Mirenda, 2011) from the Global Strategy for Plant Conservation (GSPC): 1) 90% of all threatened orchids should be secure in ex situ collections; 2) 50% should be in active recovery programmes; 3) no orchids should be threatened by unsustainable harvesting; and 4) every child should be aware of plant diversity (including orchids) by 2010 (CBD, 2000). Clearly, these resolutions have not been achieved in Sarawak. Resolutions 1 and 2 have not been implemented in Sarawak – with the presence of illegal botanical trades not only in Sarawak but in other Southeast Asian countries, these resolutions have not been achieved after twenty years. Illegal botanical trades have thrived and are frequently overlooked by authorities, as awareness among the public, especially the villagers in Sarawak, Malaysia (Williams, et al., 2018) of the value of OS to the environment is practically non-existent. The harvesting of non-timber products from the forest by forest-fringe villagers has been regarded as normal in Sarawak for centuries (Mjoberg, 1930; Harrisson, 1959; Ticktin, 2004; Sarawak Forest Corporation, 2019) for their basic daily needs and economic resources (Ghosal, 2012). In addition, economic factors and ignorance of the value of orchids invite irresponsible illegal traders to take advantage of them (Thomas, 2006; Blaser & Zabel, 2015).

The IOCC's twenty-year journey, in addition to other programmes by conservation organisations spending millions on highly funded scientific research, could be wasted on the fight against the extinction of OS (Lavorgna, et al., 2017; Williams, et al., 2018; Lavorgna, et al., 2020). This is because conservation movements (such as scientific conferences/conventions, reports, high-quality scientific journals, scientific papers on successful findings shared with fellow scientists, orchidologists, conservationists, environmentalists, consultants highlighting the poor conservation level and the efforts of a country, to decision-makers, law makers and economists, and boycotting products) will not be sufficient without conducting awareness programmes at grassroots level. This must include the harvester and the general consumer (excluding the traders as they are very aware). The best way to address this complex issue is to implement GSPC resolution no 4, (CBD, 2000) which requires governments and the business community, including scientific bodies, to invest in the long-term public involvement through training and public education. This is to prepare communities especially the YGs at school (Ardoin, et al., 2020) for the critical changes needed among the public to prevent the orchids from going extinct, which would lead to the loss of their potential medicinal, horticultural and ornamental value (Platt, 2020; Wraith, et al., 2020).

Figure 5-3



The Broken Chain – Orchid Conservation Overlooked – Resolution 4-EDUCATING THE GENERAL PUBLIC Gap Need to be Filled Urgently. Source: Tengku Auvaroza Tengku Abraham 2020

5.9 Discussion

There are far fewer reintroduction programmes for epiphytic orchids compared to those for terrestrial orchids; this is possibly because affluent countries have mostly temperate climates that support only terrestrial orchid flora, and do not have epiphyte orchids (IUCN, 1996; Bersweden, 2017). Therefore, it is a challenge to compare data and methods. Fortunately, we have collaboration with the WSBE Team, under the leadership of Dr Simon Pugh-Jones, who are willing to spend time guiding students to carry out the experiments, which has attracted students to participate, as per Plate 5-14(Pugh-Jones, 2003).

Plate 5-14

MRSM Kuching year 12 students leading Malaysia SSs with their first batch of in vitro micropropagation using Dendrobium anosmum seeds from a Fresh Green Pod cultured in July 2019 in a non-controlled environment. Source: Tengku Auvaroza.

The following discussion is a comparative analysis of qualitative and quantitative experimental data collated during controlled storage and trial environments. The results are discussed from a holistic perspective, debating the inter-related factors influencing the development of the seeds sown from stage 0 to stage 4, which include: the development of embryos to protocorms, replanting of seedlings, transfer of seedlings to greenhouses, and contaminations. The following sections will:

- assess detectable visual development influence on seed/protocorms and plantlet.
- analyse if statistical comparisons can be obtained between conditions after replanting and variety of seeds used.

Criteria considered are:

1. 60% Mature Fresh Green Pods (FGP), Fresh Seed Pods, Frozen Seed Pods (FSP).

2. The percentage of survival until transfer to greenhouse.

3. No of days taken from Stage 0 to Stage 4 of two varieties of seed pods under standard conditions within MRSM.

4. The establishment of plantlets from one seed pod in the greenhouse.

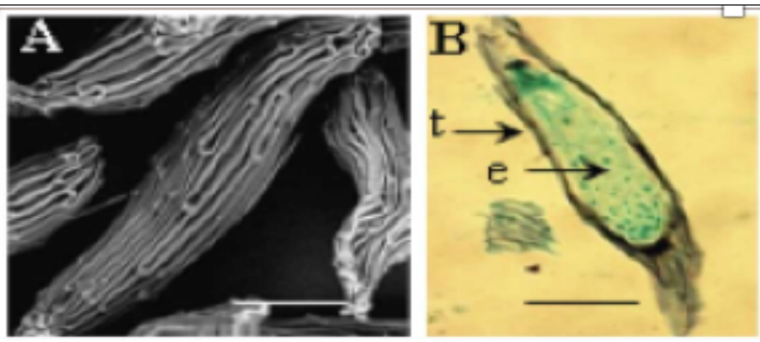
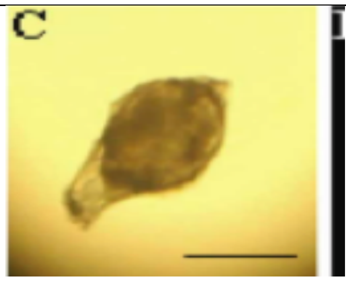
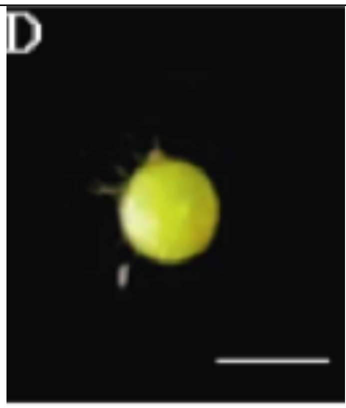
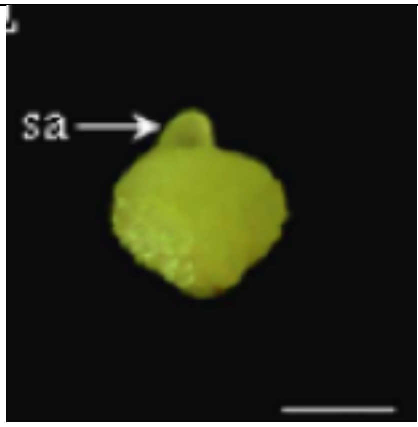
5. The cause of termination at each stage.

5.9.1 Monitoring of Samples and Assessing the Success of the Micropropagation

Table 5-3

Seed germination and seedling formation stages of in vitro orchid plantlet.- Stages of seed development into plantlet and transferred to potted plant 12 weeks after inoculation. Source: Utami & Hariyanto, 2019

Stage	Description of each bottle T1 Da1/10 to T1 Da 10/10 – yet to receive results.	Guideline Germination of *Dendrobium anosmum* Seeds

0	No growth of embryo occurs and testa was found intact	
1	Swollen embryo (germination)	
2	Embryo is completely discharged from the testa (protocorm)	
3	Embryo with pointed shoot apex (SAM)	

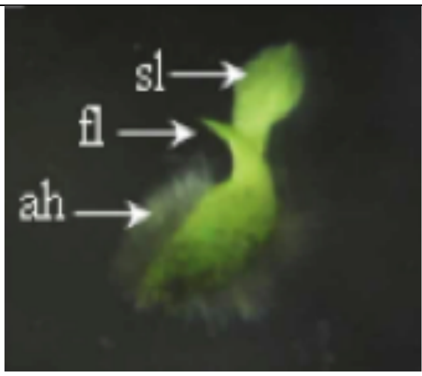
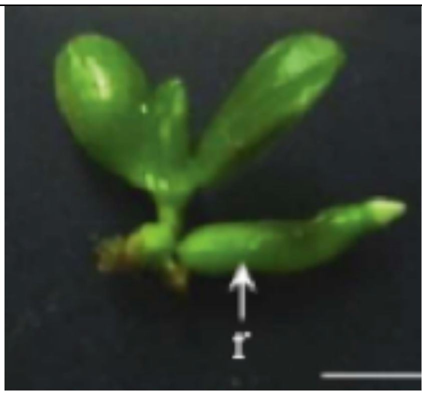
4	Stage 5, seedling stage, root with leaves; (H) in vitro seed culture and protocorm development on VW medium eight weeks after inoculation	
5	Stage 5, seedling stage, root with leaves; Ready to be transplanted to pot (r = root)	

Table 5-4

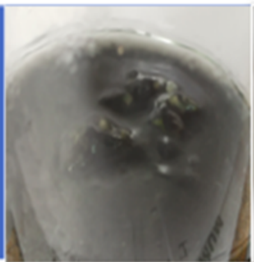
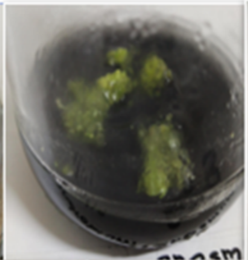
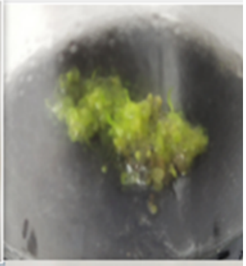
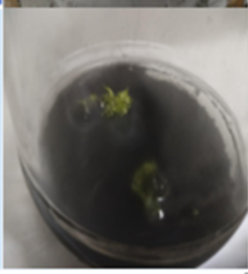
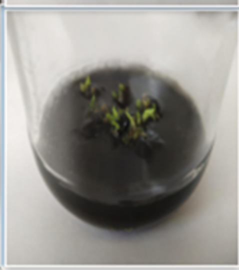
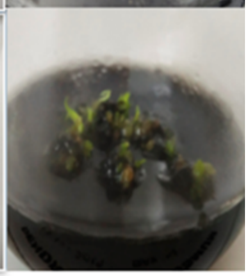
Seed germination and seedling formation stages of Da for FSP

Stage	Description
0	No growth of embryo occurs, and testa was found intact, elliptical embryo stage.
1	Stage 1, germination, swollen embryo; stage 2, embryo is completely discharged from the testa; (E) stage 3, embryo with pointed shoot apex; (F) stage 4, the appearance of absorbing hair and emergence of leaves; (G) stage 5, seedling stage, root with leaves; (H) in vitro seed culture and protocorm development on VW medium eight weeks after inoculation.
2	Embryo is completely discharged from the testa (protocorm)
3	Embryo with pointed shoot apex (SAM)
4	No updates

Table 5-5

Two sampling bottles of replanted bottles – pictures above from day 0 to Day 42

Stage (weeks)	Description
4th week (day 30)	100% of the 10 bottles of Fresh Green Seed Pod sown in July 2019 were successfully propagated and developed into protocorms just after one month.
8th week (day 60)	The protocorms increase in size.
12th week (day 90)	The protocorms start to develop into shoots.
16th week (day 120)	The shoots' increase in height.
20th week (day 150)	Roots start to appear.
Replatings	A few bottles were replated and and at this point that losses were observed.

Specimen ID	Day 1	Day 3	Day 14	Day 42
T1 Da 1/10 FGP R1				
T1 Da 2/10				

pictured courtesy of SARORSO

No bottles apart from bottles T1/Da 1/10 and T1/Da 2/10 were replanted as they were not mature enough. From T1 Da 1/10, 25 new bottles were raised from the replanted protocol. No details were received from T2/Da 2/10.

60% Mature Fresh green pods –Table 5-1and Table 5-5.

100% of the 10 bottles of FGP seed sown in July were successfully propagated and developed into protocorms after one month. The developed protocorms were replanted after month 4, and it is at this point that losses were observed due to contamination during replanting – yet to be updated in detail.

60% Mature Frozen Seed Pods – Table 5-2

60% of the initial five samples of FSP were successfully propagated. It is clear that freezing as a form of preservation is not efficient.

5.10 Causes and Percentage of Contamination

The majority of pathogen presence for both experiments occurred after replanting, observed to be growing around the seedling, and contamination of the flasks (Plate 5-15). The following was observed:

5.10.1 Pre Covid-19 Pandemic

It was observed that due to the change in temperature between the afternoon and the night, some seals ruptured (not seen if not inspected closely), causing the contamination. The change of temperature was due to the absence of students in the laboratory as the school holiday had started. Contamination could also be due to aseptic protocols not being observed.

5.10.2 Post Covid-19

Due to the exhaustion of nutrition in the medium, only two rounds of replanting were performed for two flasks before schools were closed down due to the Covid-19 pandemic. In addition, the laboratory was left unattended during lockdown and no one entered it until early April 2022. Thus, no further observations or analysis could be made until schools were reopened, which was planned for April 2022.

Plate 5-15

Contaminated Specimen: Pathogen growth around seedling, three months after replanting. Source: Sarorso, 2020.

5.11 Improvements to be Made

- The trials were based on the *Da* species, only using two different types of seed pods due to the limited supply of seed pods/capsules; this needs to be expanded.
- Short duration of four months, and virtual recording was done only once a month; it should be done on weekly basis.
- More specific observations needed to be done in person to observe minute changes.
- Seedlings with fully developed leaves and roots need to be replanted into fresh medium.
- The re-planting process is tricky and challenging when needing to ensure no contamination can happen.
- 100% sterilisation is needed to ensure no contamination will occur when replanting.
- A higher-quality camera needs to be used to improve quality of pictures taken.
- Agar-based medium needs to be improved to increase the rate of growth.

- Aseptic measures when sterilising equipment used need to be investigated to ensure 100% sterilisation to avoid contamination.
- An automatic timer is needed to control the temperature of grow room to prevent the seal rupturing.

5.12 Conclusion

The results of this study show that the establishment of a protocol conducted by year 7 students for IVOM on *Da* using the recommended medium and other ingredients recommended by WSBE team was successful. The protocorms exhibited vigorous growth to develop SAM. It is too early to confirm that this protocol is an efficient means for large-scale propagation of *Da*, which, if successful, may be applicable to other *Dendrobium* species. In addition, the experiment was abruptly interrupted due to the lockdowns for students from March 2020 to April 2022.

This trial, which was conducted in a basic laboratory in a public school, is a unique developmental strategy towards awareness of conservation with the goal of being the main resource for supplying the intended sustainable orchid botanical garden in Kuching. Similar projects can be carried out at other SS all over Sarawak so that each school could perform trials with SLEO that originate from their area with the assistance of the Sarawak Herbarium. This trial has fascinated many scientific organisations such as the Science Faculty of the University of Sarawak, Sarawak Forest Department, Sarawak Agriculture Department and Centre of Technical Expertise. The beauty of the resulting floral structures from seeds to protocorms and plantlets or SAM was also enthusiastically admired by the students and the general public, which caused much interest, enquiry and publicity. With the above trial, the following were achieved, showing positive support for the development of the intended Sustainable Species Orchid Botanical garden:

- The first orchid propagation laboratory in a school has proven to be effective in leading students, teachers and parents to be keen on the programme, which resulted in the expansion of the number of students from eight to 11 and the development of a long waiting list. Unfortunately, as the current budget only allows for one airflow per school, the rest will have to wait until MRSM or the society are able to generate extra funds.
- The development of a simple and sustainable orchid propagation programme that can be performed by the public by keeping everything sterilised and following the rules.
- The creation of a mini seed bank and herbarium by students on the SLEO.
- Successful in vitro propagation of SLEO from seed to the stage of protocorm to form a shoot apical meristem (SAM).
- Introduction and development of basic research skills and experimental skills to support the effectiveness of the project.
- Development of awareness of threats to OS, thus creating interest among the public to conserve the OS of Sarawak.
- Transfer of technological knowledge, skills and experience to benefit the local community for future careers in biotechnology and related industries.
- Enhanced science and conservation education in schools, based on real current issues.
- Development of basic innovative ex situ conservation initiatives in the local community, which was never done before.
- Development of a model that can be shared with other communities, schools, or organisations which benefit OC.
- Recognition of the potential in empowering young people in Sarawak to become leaders in OC in the future.

- Potential method for providing long-term sustainable supply to the Orchid Botanical Park of Sarawak.
- Potential solution to reduce illegal trade.
- It should be noted that different genera of orchids might prefer different types of medium and nutritional support (Mahendran, et al., 2012).
- The teaching staff in the laboratory reported high levels of meaningful conversation, critical proposition and analysis of problems, and improved confidence in their students, resulting in documented academic success.

The main advantage of tissue culture technology using seeds is that:

- it addresses the orchid extinction issues and illegal trade.
- it allows the production of high quality and uniform IVO.
- it can be multiplied on a year-round basis under disease-free conditions anywhere, irrespective of the season and weather, as it is done indoors.

Disadvantages:

- Technology is capital-, labour- and energy-intensive.
- In many developing countries, such as Sarawak, the resource of trained personnel is often not readily available
- Equipment, apparatus and materials are not readily available in Sarawak.
- Energy, particularly electricity, and clean water are heavily used. The energy requirements for tissue culture technology depend on day temperature, day length and relative humidity, and they have to be controlled during the process of propagation. Individual plant species also differ in their growth requirements. Hence, it is necessary to have low-cost options for weaning and hardening of micro-propagated plants and finally growing them in the field.

Prior to the outbreak of the Covid-19 pandemic, the success of the IVOM laboratory shows that the Writhlington School Orchid Propagation model can work in Sarawak. The laboratory aims to replicate where possible the methodologies and operation of the Writhlington School laboratory. However, it is necessary to understand the differences between the two, in that the IVOM laboratory does not have a climate-controlled grow room, which during the Covid-19 pandemic led to many specimens perishing due to excessive heat, etc. It is important to also temper expectations, as in order to develop a sustainable supply for the proposed BG, covering the 2,500 species, this programme needs to be adopted by most if not all of the schools in Sarawak. This success shows that it is feasible, but MRSM Kuching, like Writhlington School, is the success of a solitary school. The larger-scale involvement of schools across the state will take time; this is just a pilot project, and it takes leaders' involvement to change the policy. However, the recent establishment of the Ministry of Energy & Environment, Sustainability and Natural Resources, and the Inaugural Malaysia Conservation Conference in April 2022, where MRSM students were invited to set up a booth (Plate 5-16), give hope for a wind of change. Thus, the intention to urgently develop a sustainable alternative supply chain to the proposed UOBG through schools depends on the involvement of leaders.

Plate 5-16


Food delivery rider dies in crash • P12

Damaged cables cost SEB loses of RM2.1 million • P15

WEDNESDAY MARCH 30, 2022 PPK378/10/2012(031613) RM1.00

ST

NEW SARAWAK TRIBUNE

Your New Voice

Queen visits weaving workshop

Raja Permaisuri Agong Tunku Hajah Azizah Aminah Maimunah Iskandariah visited the SaraPride weaving workshop in Puncak Borneo Prison Complex here yesterday.

• Story on page 3

IN PURSUIT OF CONSERVATION … Abang Johari tours an exhibition on the sideline of the first Malaysian Conservation Conference 2022. The event held in Kuching yesterday was hosted by Corporation (SFC) together with the Department of Wildlife and National Parks Peninsular Malaysia (PERHILITAN), Sabah Parks and Sabah Wildlife Department. Photo: Bernama

SUSTAINABLE SARAWAK

A blueprint is being developed to guide all state stakeholders to achieve sustainable development goals. Premier Datuk Patinggi Tan Sri Abang Johari Tun Openg says the blueprint will address biodiversity conservation, natural resources management, and climate change mitigation while creating an enabling environment consistent with the country's fourth industrial revolution (IR.4.0).

Story on page 4

Special EPF withdrawal

• Details on page 11

Tel: 082-510005, 082-647375

The Premier of Sarawak gave the MRSM orchid team booth a surprise when he stopped and communicated with the students while one of them was replanting an OS during the Inaugural Malaysia Conservation Conference 2022. The MRSM Orchid team was invited by Sarawak Forest Corporation to participate and attend the conference – a first for the students and they were so excited. Source: Sarawak Forest Corporation, 2022.

5.13 Future – A Modern UOBG Which Attracts YG Involvement

The idea of each SS in Sarawak having an IVOM laboratory and a living orchid herbarium featured in the UOBG to encourage youth involvement could be realised if the urgency of Objective 4 Target 14 (BGCI, 2021) is understood. IVOM would not only encourage the establishment of ex-situ OC efforts involving the YG and the community in sustainable and legal breeding of native SLEO, but the UOBG would be the brainchild of these children who are exposed to developing the school's miniature OS botanical garden. In addition, the knowledge of IVOM can be used for the development of genetic engineering and molecular biology techniques allowing the appearance of new and improved orchid-based products such as hybrid orchids for ornamental and cut flowers, which are in increasing global demand. The success of IVOM has proven that even with a very minimal amount of OS, a difference could be made not only to OC but also to the country's economy, as in Taiwan (Taiwan Review, 2018; Floral daily, 2021). This would have been impossible without the basic development of tissue culture techniques, a comprehensive business model which links every sector, and programmes which are interconnected, transforming the Taiwan floriculture industry into the largest exporter of orchids. Today one of the most promising methods to produce proteins and other medicinal substances, such as antibodies and vaccines, is the use of transgenic plants, which is an economical alternative to fermentation-based production systems. OS are known to have medicinal value (Pant & Raskoti, 2013); Sarawak, with its 2500 OS, has an untapped resource. With the introduction of IVOM to MRSM Kuching came the idea of producing herbal Sarawak Orchid Pink tea (resourced from the OS planted in the school compound in July 2019) which the PP has started recently, as perPlate 5-17, in collaboration with Malaysian Agriculture Research Development Institute (Mardi). These new findings and achievements could be featured in the UOBG which would interest guests, especially the YG.

Plate 5-17

Year 10 students of MRSM Kuching, showing off the new PP – Herbal Sarawak Orchid Pink and Amber Tea. during the First Malaysian Conservation Conference held in Sarawak on 29th-31st March 2022. Source: SARORSO 2022

Additionally, as well as developing the IVOM method for SLEO sustainability and contribution to the UOBG, the following can and should be explored:

- Development of pre-harvest, harvest and post-harvest technologies for major commercially grown orchids for specific target groups like the domestic and export markets and hybrid/variety-specific technologies.
- Development of OS-based technologies for air-dried flowers and floral arrangements.
- Use of orchid waste for the production of phytochemicals including pigments, food, feed, herbal medicines and essential oils.
- Patenting technologies related to OS.

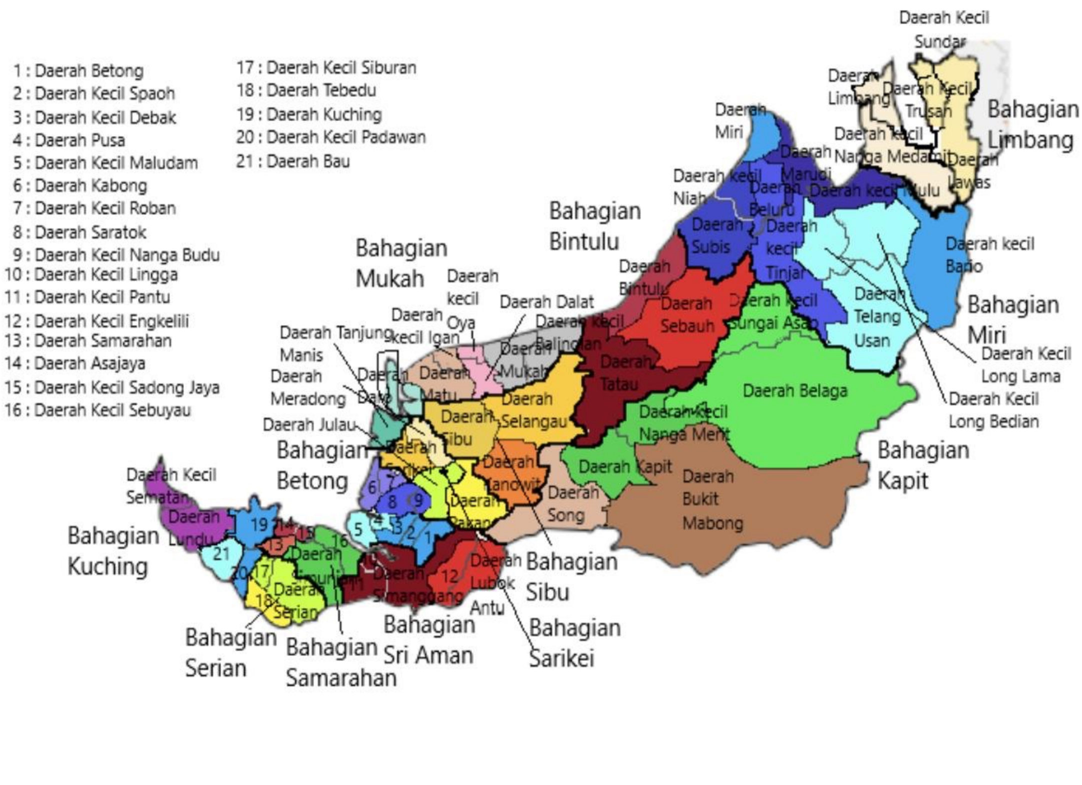
The only difference between the IVOM industry in other countries and Sarawak is that IVOM has been embedded into SS activities, which in turn contributes to funding projects, purchasing more sophisticated equipment, or organising educational trips abroad. This shows that if implemented correctly, IVOM can even be done in homes, villages, oil palm estates (detailed in Chapter 6) and even on trees in every corner of Sarawak that have endemic SLEO growing on them. Only sophisticated IVOM technology is handled at a higher level e.g., pharmaceutical or commercial hybrids, for example, crossing terrestrial with epiphytic orchid. The oil palms and other monoculture plantations are flush with native OS, and the aim is that basic IVOM technology is made available freely to anyone who wants to learn it. In this way, the issues of OE and the illegal orchid trade are contained.

There are still many gaps in knowledge in which future study is recommended:

- Aseptic protocols to be tested by mentors to the PP, who are retired local scientists.
- An improved Clean Airflow Cabinet which is cheaper and more effective, as one is enough.
- Storage of seeds – seed banks in school.
- Orchid identifier app for students and the community to use.
- A virtual herbarium sheet that shows orchids in their habitat, and all information about the orchid.
- A map of Sarawak with GPS readings on it for permanent record.
- School children from pre-school level are exposed to SLEO to inculcate a sense of belonging.

The push from the SDG has led to the opening of Sarawak's first plant cloning laboratory (Pei, 2021) in November 2021. Whilst these kinds of laboratories are commonplace in the UK, the opening of this first private commercial laboratory in Sarawak symbolises awareness and the demand for mass production of seedlings. Individual SS operating their own IVOM laboratories would be an alternative to the plant cloning laboratory because, in essence, they aim to deliver the same results as proven by the success of the WSBE model. Therefore, this is a critical time, as the opening of the plant cloning laboratory can be used as a jumpstart or justification to conservation leaders for more SS to adopt the WSBE model. Independently, SS in each division (Plate 5-17) act as a mini-laboratory, but as a collective they represent the OS of each division and a sustainable supply for the proposed UOBG or other commercial purposes. These SS laboratories will serve as inspiration to the community to aspire them to involve themselves in OC, be it children who develop an interest in, or monoculture plantations that look to improve their biodiversity through the translocation of orchid seedlings (detailed in Chapter 6) developed by these laboratories.

Plate 5-18



There are 2176 SSs throughout Sarawak. Each of these divisions has a different OS habitat due to its geography. Therefore, each division has its own endemic orchid. The idea could sound ambitious but it is not impossible.

CHAPTER 6

6 Translocating SLEO to Oil Palm Estates: Assessing Species Adaption within Known Range

A Study to Examine the Effect of Translocating/Introducing SLEO to Oil Palm Estates Where They Have Not Previously Occurred While Still Within The Known Range of the SLEO Species, Providing a Similar Habitat to Previously Known Occurrences

6.1 Introduction

Once a tree in the rainforest falls, epiphyte orchids will lose their home permanently, as they grow in the crown of the forest (Wilson, 2001). Over time, as global agriculture is expanding in order to meet the needs of the human population and increasing consumption (Tilman, et al., 2001; Godfray, et al., 2010; Bonhommeau, et al., 2013), more tropical forests where most epiphytes live will be developed, and to date, there are 1.37 billion hectares (Pirker, et al., 2016) of oil palm plantations across the world. Orchids must be maintained as they are bio-indicators, key climate indicators (Schuiteman, 2019) and their complex symbiotic relationships contribute to human basic needs (Willis, 2018). Hence, in this research, the author is investigating the possibility of conducting (OS) ex situ orchid conservation (OC) programmes in *Elaeis guineensis* (*Eg*) establishments. The substantial variation in plant communities, including epiphytes, found growing naturally on *Eg* trees between the edge, core, trunk and other microhabitats indicate high levels of heterogeneity within the plantation (Luke, et al., 2020). Thus, it is believed that commitment from the stakeholders, especially plantation establishment management, is needed to investigate further possibilities to improve plantation biodiversity using wildlife-friendly options such as orchids.

6.1.1 Research Definition

The research examines the effect of translocating/introducing SLEO (*Dendrobium anosmum-Da, Dendrobium crumenatum-Dc* and *Arundina graminifolia-Ag*) into monoculture estates, in this case, *Elaeis guineensis-Eg,* where they have not previously occurred, but within the known range of SLEO species and providing a similar habitat to previously known occurrences.

6.1.2 Aim

This study aims to prove that selected endangered Sarawak Lowland Epiphyte and Terrestrial orchids, *Da*, *Dc* and *Ag,* can thrive when translocated/introduced (Commander, et al., 2018) into an *Eg* estate in Kota Samarahan, Sarawak.

6.1.3 Research Objective

The primary objective was to explore the potential survival of SLEO (*Da, Dc and Ag*) when translocated/introduced into monoculture estates (*Eg*) or other similar habitats, using anchoring methods for the epiphytic *Da* and *Dc,* and planting the terrestrial orchid *Ag* in the ground. The translocation/introduction must not be detrimental to the farmer, the yield of the estate or reproduction of the orchids.

Secondary objectives include:

I. To determine the conditions under which introduction/translocation would be most successful, productive rates as well as dormancy periods, if any, and the SLEO's response to different climatic (rainy, dry and hazy seasons) and other restrictive (such as the Covid-19 pandemic) conditions.

II. To evaluate the extent of the success of the introduction/translocation in terms of establishing or significantly augmenting viable, self-sustaining populations in nature, and the survival of the two genera of orchids in the *Eg* plantation on a monthly basis. Examining:

- Foliage growth (colour)
- Root appearance (colour)
- Flower production
- Causes of termination
- New Seedlings

III. Seed pod production

IV. To observe diseases present on the orchids.

V. To explore potential ways to conserve SLEO.

VI. To gather new data, available for future scientific trials in perennial monoculture estates and to assist future medium-long term orchid conservation planning.

VII. To establish a model as catalysts for the restoration of at least part of the badly affected lowland and wetland ecosystems.

VIII. To evaluate the presence of more pollinators for increased natural propagation and germination for the development of new orchid populations. Orchid seeds that are produced from naturally pollinated flowers may be blown to the safe sites where appropriate mycorrhizal fungi are present, thus creating natural germination and subsequent establishment.

IX. To further encourage the investigation of the existence of mycorrhizal fungi, and their symbiotic relationship within the trunk of the oil palm tree.

X. To evaluate any effect of the harsh harvesting process of oil palm on vulnerable orchids.

XI. To examine the potential of the oil palm business to integrate with relevant cottage industries to dissuade illegal trade.

XII. To investigate potential development of additional cottage industries producing value-added products from palm oil within the oil palm estate.

The research was undertaken to establish a foundation for the creation of a sustainable oil palm tree arboretum whose main purpose is to create awareness and develop skills in conserving SLEO on site as an alternative habitat. It intends to also save them from extinction and potentially improve the biodiversity of oil palm plantations using native OS. The findings and conclusions may provide guidance to stakeholders on future decisions, planning and further research.

6.1.4 Gap in Research Knowledge and Research Justification

Despite Sarawak having one of the largest collections of unique OS in the wild, her people are generally unaware of their contribution to the ecosystem and the economic potential they have. A successful trial will allow a new perspective on orchid conservation to be portrayed in botanical gardens, especially in Sarawak and other tropical countries. It is hoped that it will also stimulate the creation of new legislation and approaches to handling orchid conservation, deforestation and the conversion of land into monoculture plantations.

With the success of the translocation of *Da, Dc* and *Ag* into a new yet familiar habitat, the success of future translocation and propagation would allow market flooding with OS (Bhatia & Sharma, 2015). This would reduce their price and indirectly reduce illegal trade, enabling initiatives to allow for orchid-based cottage industries, such as orchid hybridisation to capture and penetrate both the domestic and international cut and ornamental flowers industry, as in Taiwan and Thailand. An integrated approach to OS within OPE will cushion any fluctuations in seasonal demand for palm oil through the generation of other orchid-based products, as mentioned in Chapter 5.

6.2 Background

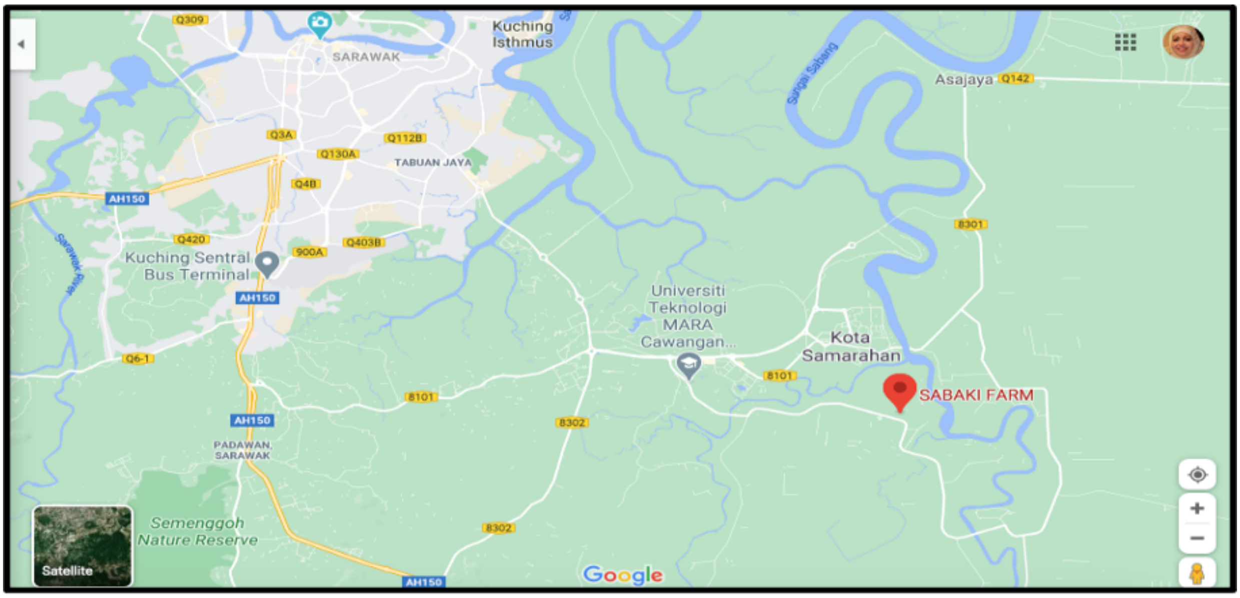
Putting aside the major controversial issue in political and public debates in the West and Far East regarding sustainable food and agriculture in the light of the production and expansion of palm oil (Dawe, et al., 2019), the fight for the conservation of SLEOs for the purpose of their protection from deforestation and the conversion of cleared land into monoculture plantations (Sarawak Data, 2019) will continue to be a losing battle if the public sector is not involved in the effort (Ernest, et al., 2015; SARORSO, 2019). Therefore, optimising the 12% of Sarawak lowland which is covered with oil palm establishments (Ali, 2017; MPOC, 2019; Sarawak Data, 2019) could prove to be a game-changing strategy for public awareness and participation in conservation SLEO (SARORSO, 2019). Hence, the proposed arboretum of oil palms would not only represent Sarawak's current agricultural landscape (Potter, 2015) through a living SLEO collection, but also promote SLEO conservation (Wallace, et al., 2002; Koopowitz, 2001), scientific research (Kew RBG, 2018), horticultural programmes and education (Kew, 2020) as well as providing an area which would be ideal for ecological tracking (Reiter, et al., 2016). This unique feature of the UBG would generate wide public (Clark & Walace, 1998) and educational appeal (Powledge, 2011), which is important for the success of the UBG (Penchevam, 2012) as well as creating interest and a potential advanced research centre for developing ecological restoration technologies (Gale, et al., 2018) to prevent mass extinction of SLEO due to the Anthropocene (Dislich, et al., 2017).

6.3 The Pilot Trial

6.3.1 Study Area

The research was carried out from 28th June 2018 to 31st October 2019 on an oil palm farm of six-year-old trees, planted five to seven metres apart. The farm is a small, privately-owned plantation of 0.38 km^2 in area, located at Kampung Tanjung Tuang/Parang (coordinates 1.43695303, 110.49985134), Kota Samarahan, 30 km from Kuching city (Plate 6-1).

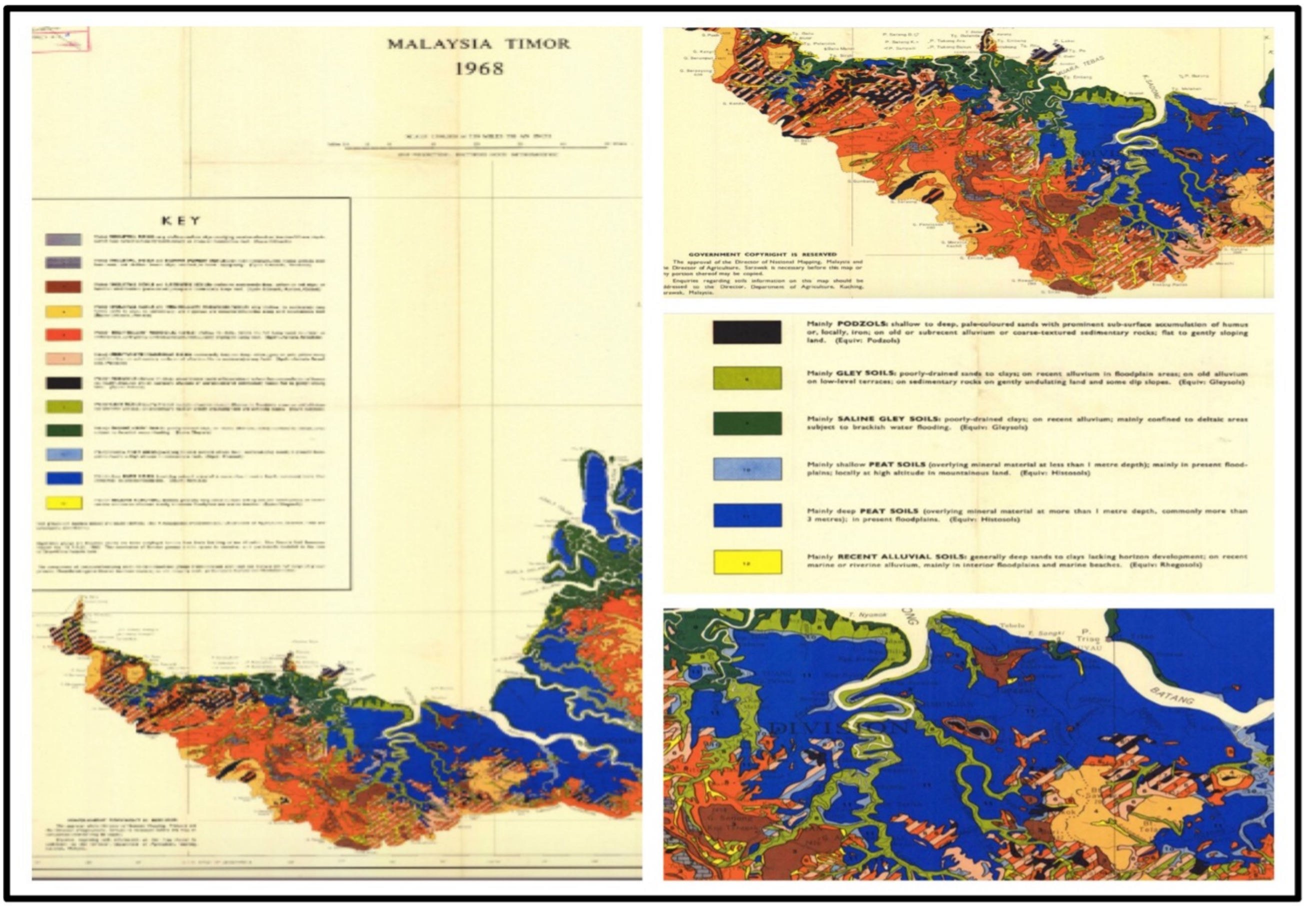
Plate 6-1



Map of the location of Sabaki Farm in Kampung Tanjung Tuang, Kota Samarahan, 30 km from Kuching City. Source: Google Maps, 2020

The area has a humid tropical climate with an average annual temperature of 27 °C, an average annual precipitation of 2710 mm (Bruun, et al., 2013) and an elevation of approximately 27 to 810.2 metres above sea level. The soil of Kampung Tanjung is classified as mainly deep or shallow peat (Plate 6-2) in floodplains, and most areas contain poorly drained saline gley or gley soil which is subject to flooding (Department Of Agriculture, 1968). The oil palm plantation was in an established clearing of logged lowland, mixed with a dipterocarp rainforest turned into a rubber plantation. However, the production of the rubber plantation was poor, and it was cleared and replaced with a vegetable farm which was then abandoned due to the high requirement of pesticides which the farmers were not happy with; on visiting the farm it was observed that only a few species of vegetable and fruit trees were able to thrive due to the poor soil conditions.

Plate 6-2

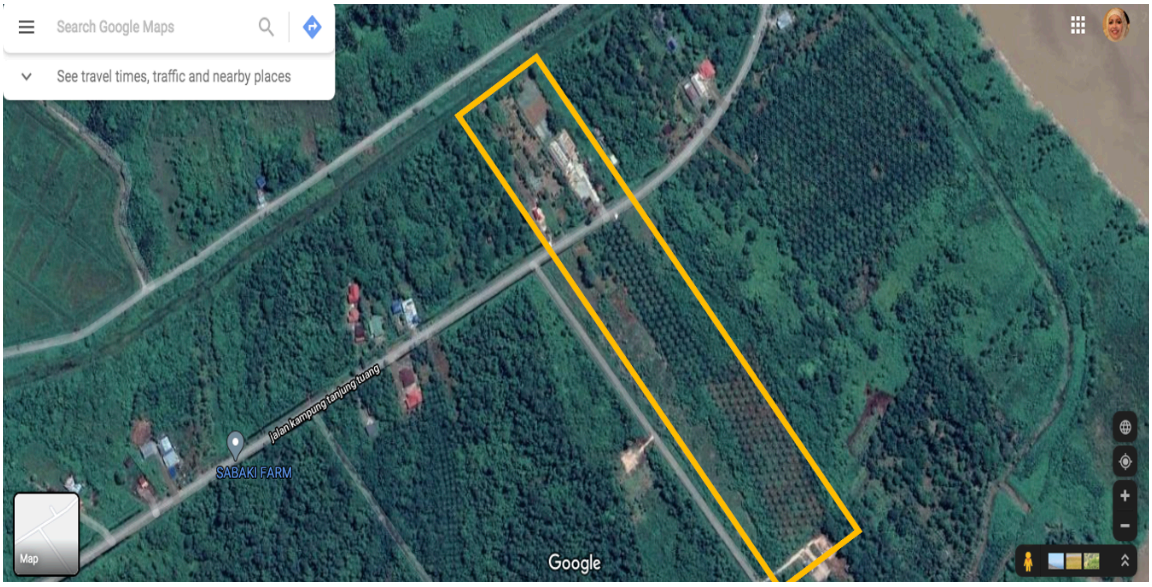


Soil Classification of Kampung Tanjung Tuang, 1st Division of Sarawak. Mainly peat soil, poorly drained and flood area.

Source: Department of Agriculture Sarawak, 1968.

In 2015, the owner decided to convert the farm into an oil palm plantation. In this village, there were several small oil palm plantations (Plate 6-3) as well as large plantations owned by the Federal Land Consolidation and Rehabilitation Authority (FELCRA) corporations nearby. The passion and interest of the farmer in further improving the biodiversity of his already semi-integrated oil palm farm, by introducing buffalos and cattle (Plate 6-4), is not only a solution to the limited availability of grazing land but also the answer to the lack of local meat in Sarawak (Banji, 2018).

Plate 6-3



Satellite Map of Sabaki Farm. The Oil Palm Farm itself is 0.038 km^2. It is located near a river and flood plain. Source: Google Maps, Oct 2020.

Plate 6-4

The Site: A scene of a typical young (six-year-old) Integrated Oil Palm Farm - The Sabaki Farm. A nine-acre farm located at Kampung Tanjung Tuang/Parang at Kota Samarahan- Source: Author 2018.

6.3.2 The Botany of Oil Palm Trunk (OPT) and Oil Palm Foliage (OPF)

As the trial focuses on SLEO which account for 71.9 per cent (Beaman, et al., 2001) of Sarawak's OS (excluding epiphytic orchids which also belong to other categories – see Chapter 1: Introduction), the main concern for the life cycle of these epiphytic orchids would be their phorophyte host (Rassmusen & Rassmusen, 2018) and the density of the canopy of the host (Fitrianto, et al., 2017) (Table 6-1below). On the other hand, for tropical terrestrial orchids, the classification of soil is an important condition for growing them successfully (Nor Ain, 1999). Therefore, before translocating or introducing SLEO to a new habitat, the requirements of the SLEO need to be identified (Teoh, 1980; Beaman, et al., 2001).

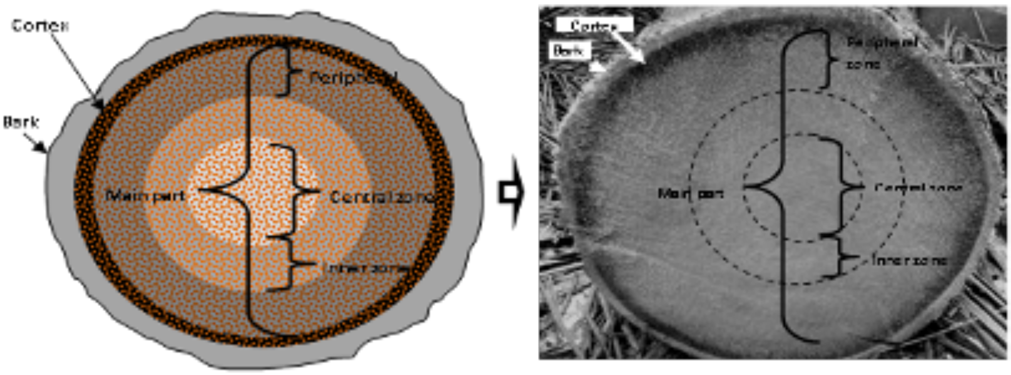
Table 6-1

Age of Oil Palm Trees Against % Canopy Density

No	Class	Stands Age	% Canopy Density
1	Seed	0-3	<10
2	Young	3-8	10-40
3	Teen	9-14	41-80
4	Mature	15-25	>80

Correlation between the age of the oil palm tree and canopy density was measured, based on Forest Canopy Density (FCD) to estimate oil palm tree age with the assumption that older trees will have higher canopy density. Stands ages were divided into four classes, according to oil palm classification from the Plantation Education Agency of Indonesia. Many plantations have this policy to sustain the amount of sunlight in the plantation and the density of the oil palm tree canopy will be different from that of natural oil palm trees. This will be a useful guideline when determining the type of SLEO to be transferred. Source ICERM, 2007.

Figure 6-1



Cross section of Oil Palm Trunk – outer layer bark fibre. Source: Bio Resource (2013)

6.3.2.1 Physical Characteristic of Oil Palm Trunk (OPT)

Like all monocots, oil palms do not have the ability to increase the width of a stem (secondary growth) via the same kind of vascular cambium found in non-monocot woody plants (Hartley, 1977). This explains the cylindrical shape and almost constant diameter of the oil palm trunks unlike those of hardwood trees. However, secondary growth arises from old, dry petiole bases tightly stacked on each other, with no bark, again unlike hardwood trees (Mangurai, et al., 2017). See Plate 6-5.

Plate 6-5

The characteristics of the oil palm trunk. Only one-third of the outer layer is hardwood. Source: Kauffman, Leni, 2020.

The trunks are covered with fibrous husks between the petiole bases (Figure 6-1). As per Table 6-2 below, the average increase in height will be from one to two feet per year (Henson, 2006).

Table 6-2

Relative Oil Palm Heigh with Field-Observed Ages			
Age (Years)	**Height (Meters)**	**Age (Years)**	**Height (Meters)**
1	3	11	9
2	3	12	9
3	3.5	13	15.5
4	5	14	22
5	6	15	22
6	7	16	22
7	7	17	22
8	8	18	22
9	8	19	22
10	9		

Minimum height of trunk, important for translocation/introduction of SLEO into Elaeis guineensis (Eg). Eg height and age estimation from WorldView-3 Imagery and LiDAR Data Using an Integrated OBIA Height Model and Regression Analysis. Source: Journal of Sensors, 2018.

This character of the trunk efficiently intercepts and retains falling leaf litter which then decomposes, trapping nutrients. When it rains, it accumulates further nutrients allowing various types of ferns (epiphyte) to festoon the trunk (Praptosuwiryo, et al., 2019).

Other plants grow on the trunk such as Labiate, Melastoma and Legumes as inPlate 6-6; underneath these ferns and plants, arthropods such as ants and centipedes nest to seek shelter and lay eggs (Potter, et al., 2009).

Plate 6-6

Observation of numbers of ferns, labiate, legume and melastoma on OPT at Sabaki Farm. Source: Tengku Auvaroza, 2019.

Thus, while the single trunk's primary function is to support the frond and its fruits, in an additional function as a phorophyte to hold translocated and rescued SLEO, it has the capacity as a host for biodiversity. Thus, the trunk represents a vital component of the plant. Besides that, it has other commercial value such as the solid wood, plywood and a soft fleshy centre as food for animals such as elephants, orangutan and wild boars, especially when the plant is still small.

6.3.2.2 Physical Characteristics of *Elaeis guineensis* Foliage (OPF)

The density of the canopy of OPF (Table 6-1) plays an important role for SLEO, especially the epiphytes, as too much light would cause growth stress for some epiphytes (Zhanga, et al., 2018) whereas for some it encourages flowering (Teoh, 1980; Nor Ain, 1999; AOS, 2020). It is imperative to know the classification and natural habitat of SLEO (Beaman, et al., 2001; Herbarium KEW, 2020) to determine which type of oil palm would be suitable for translocation of a particular species. Nevertheless, at the correct age and height of the phorophyte (Table 6-2 above), the removal of selected fronds by pruning could help control density (Fitrianto, et al., 2017), and since it is also the practice of the management of oil palm plantations to maximise assimilation availability irrespective of plantation age (Henson, 2006; Hartley, 1977), it is not an additional task for the oil palm farmers who participate in the orchid translocation/introduction programme. The practice of pruning tall *Eg* to facilitate complete and correct harvesting and quick recycling of nutrients is recommended (Fairhurst & Griffiths, 2014) and would be in line with the flowering requirements of some SLEOs (Teoh, 1980), although at this point the growth and survival of the orchid is the main concern.

6.3.3 Selection of SLEO for Translocation Introduction for this Trial

Translocating/introducing foreign plants is not a new activity in Malaysia, as the first official large scale single species translocation/introductions for economic purposes were done for tapioca, gambir, sugar, coffee, cocoa, crows, rubber, and later, oil palm plantations by the Portuguese colonial settlement in 1511 and then the British in 1786 (Fauconnier, 1931; Boulle, 1959; Hartley, 1977; Colin, 1978). Although the problems that arose due to translocation/introduction implemented two centuries ago were very different from today's problems (Drabble, 1973), history recounts that each successful translocation/introduction was driven by trade and gain (Barlow, 2018). Therefore, for the initiative to translocate/introduce orchids for conservation to be attractive enough to attract stakeholders, the element of positive economy and trade which benefits stakeholders needs to be incorporated (Weeks, et al., 2011). Orchid identification for translocation is as labour intensive as the translocation/introduction process itself (Goldenberg, et al., 2019), time-consuming and a long-term process (Commander, et al., 2018). Therefore, a well-planned selection of species for translocation to each specific site and system to ensure a high probability of survival is necessary.

However, this pilot project, which focuses on SLEO that could be proven to grow and regenerate positively, and which is of a new kind, had limitations in terms of supply, quantity and time; priority was given to the availability and accessibility of specimens to be used. Once this pilot project is successful, stakeholders could develop the ideal criteria for selecting specimens (ideally all SLEO are to be rescued, translocated and introduced) and a more detailed standard operating system on translocating/introducing SLEO which would be based on the experience of trials conducted in other countries (Hágsater & DumontVinciane, 1996; Commander, et al., 2018) and the following values, adapted for Sarawak:

- Priority is given to SLEO listed in Red Books of IUCN (IUCN, 2020)
- OS which are not possible/difficult to cultivate in laboratories.
- Species of plants characterised by properties of usefulness, having important economic value (medicinal, food, ornamental, beauty products, air purifiers) (Hinsley, et al., 2017).
- Species of plants having cultural and historical value (Bodos, 2019).
- Species that are rare, endemic and in limited numbers, that can be propagated but are complicated (Beaman, et al., 2001).
- Species that are terrestrial, hardy and beautiful as pot plants or as garden orchids, but not as popular as *Phalaenopsis* or *Dendrobium*, therefore scientists and nursery

owners do not have an interest in propagating them in vitro but collect them direct from their natural habitats, hence making them endangered.

- Species that give sustainable economic benefits to stakeholders (Chouinard, et al., 2011).

6.4 Plant Materials

Materials for the pilot conservation via the ex-situ translocation project were collected using three separate procedures. *Da* were donated by an orchid hobbyist who had kept and grown the plants in her personal garden for more than three years. *Dc* were collected during a rescue exercise executed by SARORSO members (Plate 6-10) upon invitation by the Kuching North City Hall authorities. These specimens were stored in a cool place until translocation to the introduction site.

Plate 6-7

From left to right, Dendrobium anosmum Da, Dendrobium crumenatum, Dc and Arundina graminifolia Ag. Source: Tengku Auvaroza, 2018.

As oil palm tree canopy density (Fitrianto, et al., 2017) is directly related to age, (Table 6-2) the phorophytes in the translocation site being six years old meant that orchids that tolerated full exposure to sunlight were targeted (Beaman, et al., 2001; Teoh, 1980). Next, the availability of specimens according to genus, native, endangered (in fact, all SLEO are endangered as habitats are being destroyed), quantity of stock available, price and time were considered, which were then followed by consideration of weather conditions. As the specimens will be left with little monitoring and have a high dependency on rainwater, the start of the pilot project had to coincide with the rainy season. Therefore, the end of the month of June 2018 was selected, as this marked the beginning of a rainy cycle.

6.4.1 Dendrobium anosmum (Da) – Endangered Epiphyte

Plate 6-8

Herbarium Sheets of Dendrobium anosmum kept in Kuching Herbarium. There were several herbarium sheets dated 1963, 1975 and 2002. These are useful documents to identify the natural habitat of the orchid as they are now very rare. Source: Tengku Auvaroza, 2019.

Based on the basic sampling strategy, theory and practice guidelines for purposes of scientific conservation (Brown & Marchall, 1995; Crosa & Vencovsky, 2011) for establishing a genetically representative ex-situ collection requires 50 specimens per species sampled. However, it is impossible in such a short span to collect so many endangered species of orchid. In addition, the purpose is to establish ex situ conservation and the priority is to bring them into cultivation (Oldfield, 2009; Chen & Weibang, 2018). Thus, only 40 healthy, mature *Da* plants were used as specimens in this pilot project. The colour of the flowers was identified as lavender with two burgundy spots on either side of the lip towards the inner base. The pseudobulb is long and slender, with the longest recorded two metres long, and grows downwards (Beaman, et al., 2001). *Da* is an endangered species (Hágsater & DumontVinciane, 1996) with high economic potential as cut flowers (Thomas & Goonow, 2013; De, et al., 2014). They are scented and the plant is suitable as an ornamental as they have postharvest qualities. The flowers are consumed as teas by locals (Bodos, 2019). The last time *Da* was sighted in its natural habitat was in Mount Jebong, Bau (Kuching Herbarium, 2002), about 31.8 km from Kuching, in 2002 (Plate 6-7).

6.4.2 Dendrobium crumenatum (Dc) – Known as City Orchid Epiphyte

Plate 6-9

Rescue work by SARORSO members from trees which were trimmed by city council workers. The City Council Staff contacted SARORSO to collect. Source: SARORSO, 2018.

40 *Dc* plants, also known as Pigeon orchids (Plate 6-9), which demonstrate a flowering process associated with temperature changes (Seifriz, 1923; Foster, et al., 2019), were also planted alongside the *Da*. They were rescued by SARORSO members from trees along Semariang Road, Kuching, which were trimmed by the Kuching North City Council (SARORSO, 2019) for safety purposes. *Dc* have a typical height of 60-92 cm but may reach a height of 152 cm, are spindle-shaped, swollen basally with nodes, ridged, yellowed stems that can branch,

carrying four to 19 thick, leathery, eventually deciduous, five to eight cm long leaves (O'Bryne, 2011).

Dc produce white and slightly sweet fragranced flowers when they bloom (Nathan, 2015). It was observed that they are fast-growing, robust, weather tolerant, regenerative and vegetative. They grow on trunks and crowns of phorophytes along city roads as weeds. However, when they burst into bloom, they produce a stunning view for one day, which could be a unique seasonal tourist attraction (Turpie & Joubert, 2001). *Dc* orchids also have medicinal value (Pant & Raskoti, 2013; Sandrasagran, et al., 2014).

6.4.3 Arundina graminifolia (Ag) – Evergreen Perennial Terrestrial (Suitable as Borders)

A clump of *Ag* (Plate 6-10) was rescued from a field which was due for development. *Ag* produces several flowers sequentially from the top of the canes. It requires abundant sunlight to flower continuously. *Ag* flowers have two colour variants, white or pink, with a purple-to-pink lip, and are shaped similar to a Cattleya. *Ag* are reedy terrestrial plants that have vegetative resemblance to bamboo, hence they are also known as bamboo orchids (O'Bryne, 2011). *Ag* flowers are five to eight cm across, at the top of tall cane-like pseudobulbs. *Ag* is the only species in the genus *Arundina*. The plants can grow up to two metres tall; they will reach at least hip level and the long pseudobulbs have leaves alternating along their length. *Ag* grows in clumps and is available in newly-developed habitats of anthropogenic origin, such as roads and open fields, and continuously reproduce. With rapid development in Kuching, *Ag* is no longer easily seen in the city. *Ag* is anti-bacterial, and a decoction of its roots has the chemical compound, Arundinin (Liu, 2004), known to have medicinal purposes for the treatment of tumours, hepatitis and diabetes (Pant & Raskoti, 2013). Locals consume *Ag* flowers and young shoots by stir-frying them in dishes (Bodos, 2019). High-quality material for introduction is very important, but in order to not damage such populations, no more than 20% of the specimens were to be collected.

Plate 6-10

Edible and medicinal Ag used to be seen along the road and used to be consumed by locals. However, due to a lack of awareness, fields of Ag are bulldozed before being rescued. Source: Tengku Auvaroza, 2018

Table 6-3

SPECIES	SAMPLE ID	SOURCE COUNTY CITY	ORIGIN
D. Anosmum	Da	Kuching, Sarawak	wild
D. Crumenatum	Dc	Kuching, Sarawak	wild
Arundina Graminifola	Ag	Kuching Sarawak	wild

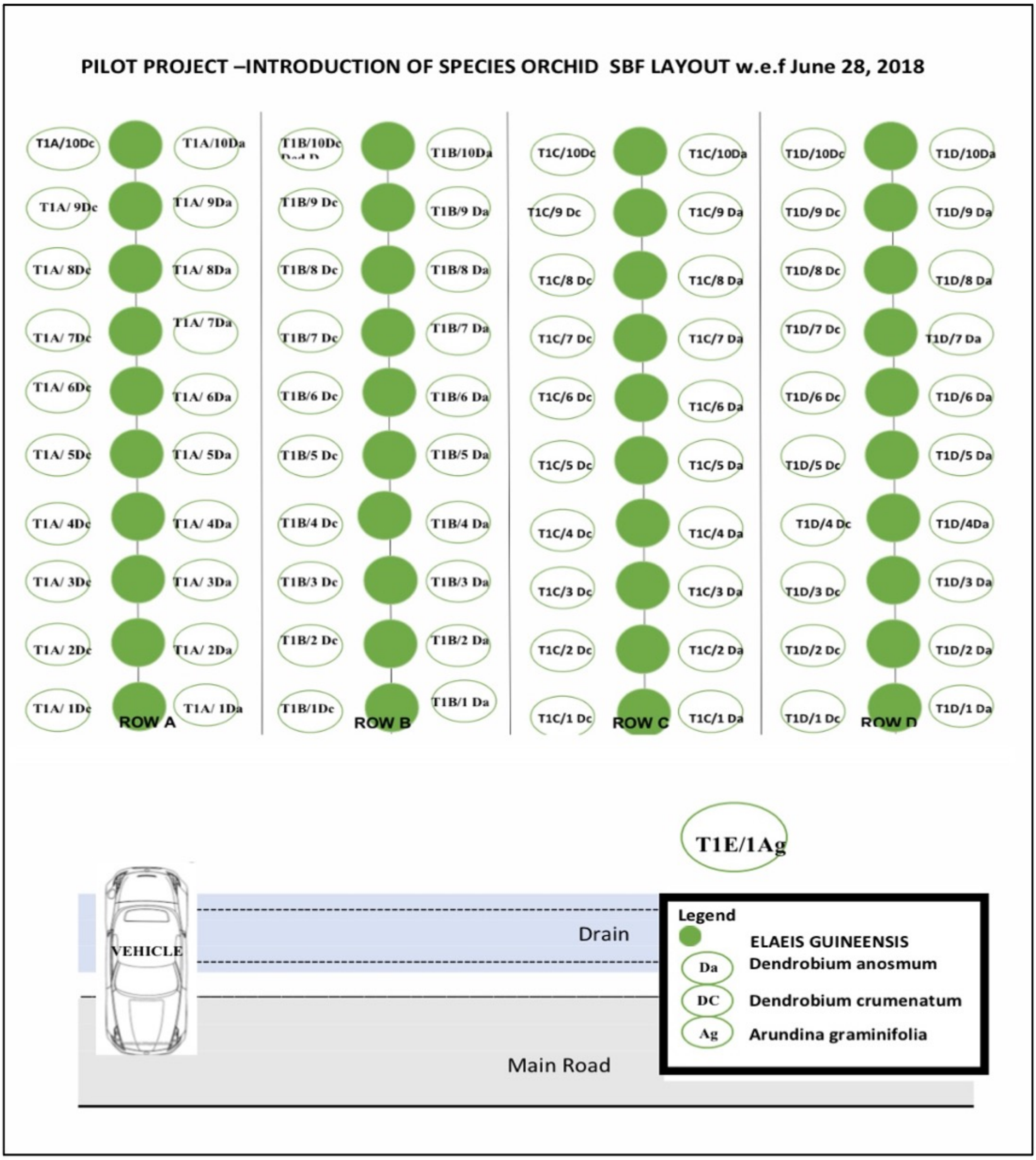
Summary of sources of the specimens of Da, Dc and Ag used in this study. Information on source is important as it is illegal to collect any OS.in Sarawak without a permit. Source: Author, 2018.

The anticipated challenge for the future introduction of *Ag* to act as a border is that insufficient numbers can be rescued, especially from small populations which are disappearing due to development. This can be solved by collecting seeds from the same populations and propagating them by the IVOM technique (Chapter 5). However, if seed pods cannot be picked and the plant propagates, the bulbs, bulbils, corms, tubers, rhizomes and sprouts can be collected for tissue culture propagation (Bhattacharya, Paromik; Tandon & Pramod, 2016).

6.4.4 Elaeis guineensis (Eg) – The Surrogate Phorophytes (Plate 6-6)

Forty-five-year-old Eg were used as specimen hosts for both Da and Dc. The first ten rows of the Eg were used in this trial.

Figure 6-2



Translocation Layout Plan, Sabaki Farm. Two respective plant labels were attached to each phorophyte. Source: Tengku Auvaroza, 2018.

6.5 Preparation and Process of Trials

The participants of the pilot project (PP) consisted of 10 volunteers including five from the farm (including the farmer) and five SARORSO members. All members including the author participated in the preparation of specimens. Two farm workers climbed and mounted the *Da* and *Dc* orchids in pairs and were assisted by two SARORSO members who handled the plant specimens. Concurrently, the farmer and the author attended to the translocation of the *Ag* before assisting with the remaining *Da/Dc* translocation. The process took approximately five hours to completely mount 80 *Da/Dc* orchids onto the 40 identified phorophytes. Additional specimens were brought and left to the farmer to introduce to other fruit trees on his farms, so as to informally compare their survival, growth, flowering and seedling and seed pod production against the 80 specimens translocated in the contrived environment.

Plate 6-11

Two labels were attached to each individual phorophyte. The trial process of translocation/introduction requires much planning, taking into consideration the weather, labour and safety of members from wild animals such as snakes, scorpions and rats. It is a labour-intensive process to identify each specimen, clean, label and mount them onto oil palms. SARORSO members contributed to the execution of the trial. Source: Author, 2018.

6.5.1 Process of Translocation/Introduction

6.5.1.1 Epiphytic Orchids (Da and Dc)

80 plant labels (black and green for *Da* and *Dc* respectively) were prepared (Durham Uni, 2020) to be attached to the 40 *Eg* for monitoring to ensure accurate data collection (Plate 6-11). The *Da, Dc* and *Ag* specimens were trimmed and rinsed with distilled water to remove dirt, snails and slugs (Teoh, 1980; Nor Ain, 1999; Rittershausen & Rittershausen, 2007). They were then submerged in a 3% solution of hydrogen peroxide, two to three ml to a gallon of water,

for not more than five minutes to prevent discoloration of leaves. Specimens were rinsed well to remove chemicals (Commander, et al., 2018). Both *Da* and *Dc* specimens were then individually labelled temporarily with paper tags to avoid confusion between the species during the mounting process. Soaked coconut husks (effective, cheap and readily available) were wrapped around the roots (Nor Ain, 1999; Teoh, 1980) to protect them from drying out. The OS were mounted firmly on the phorophytes using eco-friendly rope. Both OS were split evenly into four groups of tens and put in pairs. Each pair of *Da* and *Dc* were mounted onto opposite sides of individual hosts (Plate 6-12). The same process was done on each of the four rows of 10, totalling 40 phorophytes.

Plate 6-12

Each of the phorophytes has two labels, for Da and Dc respectively. Source: Tengku Auvaroza,, 2018

The PP is referred to as ‘Trial 1’. The observation and data collecting (see Appendix 10) of the orchid specimens were done monthly over a period of 498 days. As the main objective of this experiment, besides conservation and biodiversity, is to show that SLEO could sustainably grow and successfully regenerate in the artificial habitat, their flowering status, the number/size of pseudobulbs, natural seed production and survival was monitored and recorded monthly by filling in a standard form, as shown in 6.6 (Plate 6-13).

6.5.1.2 Terrestrial Orchids (Ag)

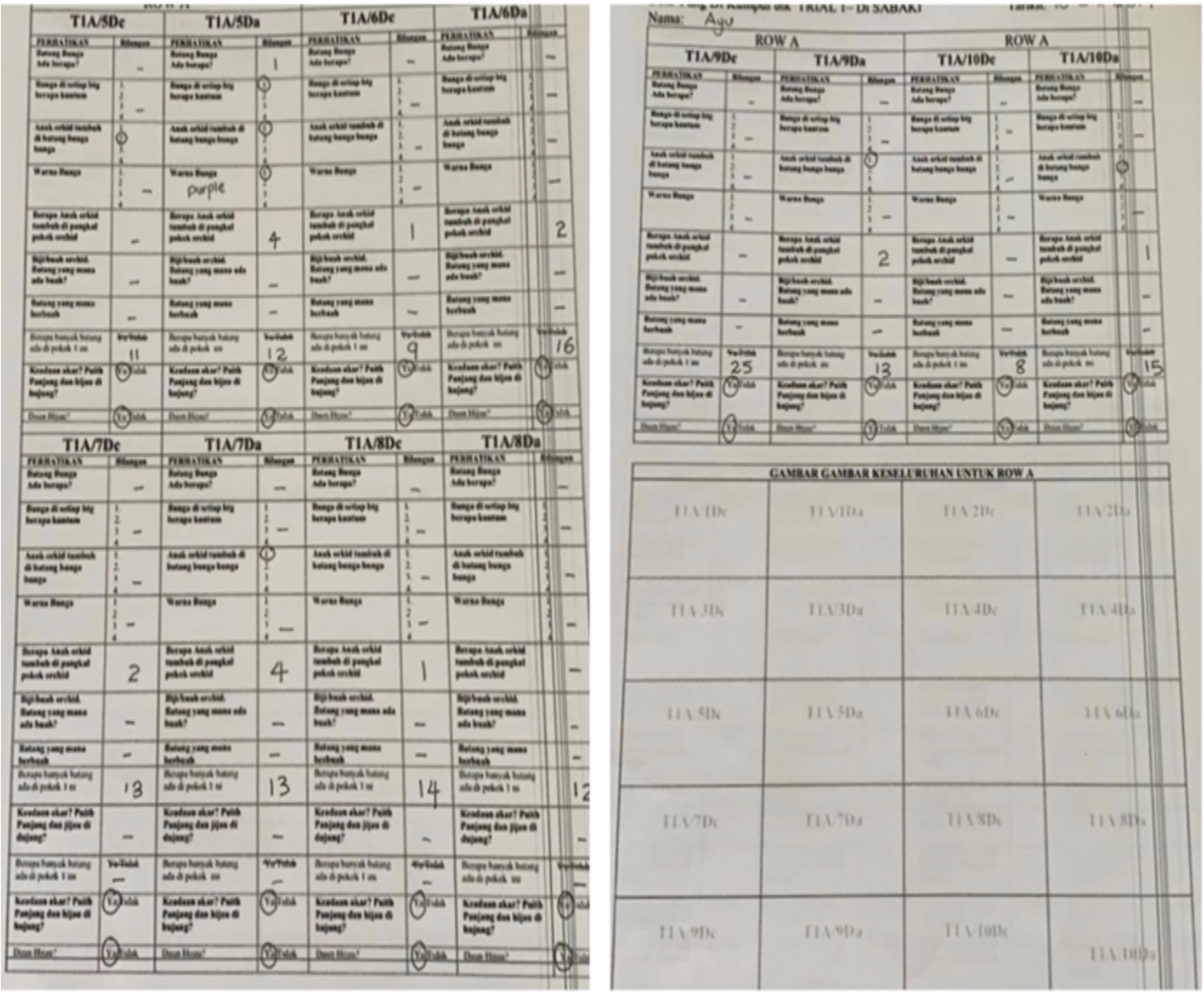
As with *Da/Dc,* the specimen was prepared and labelled (Durham Uni, 2020). A location with greatest sunlight intensity was identified along the perimeter of the oil palm plantation (Figure 6-2 and Plate 6-13). This is because *Ag* requires strong light for flowering (O'Bryne, 2011). This position was also selected as a trial for planting the *Ag* as borders, and also because there were three adult buffaloes grazing in the oil palm estate. A one-foot square hole, one foot deep was dug, and the *Ag* clump was planted, its roots covered in six inches of soil (Nor Ain, 1999; orchidresourcescenter, 2021). No additional soil was added. A label was affixed to a wooden stick to mark the position, and minimal protection was placed around the *Ag* seedling to prevent obstruction of oil palm harvest work. As for the epiphyte specimens, *Ag* flowering status, natural seed production and survival were monitored and recorded monthly.

Plate 6-13

Five Ag seedlings were planted in the brightest spot, where Ag flowers best. Source: Tengku Auvaroza, 2018.

6.6 Monitoring Criteria

Plate 6-14


T1A/5Dc T1A/5Da T1A/6Dc T1A/6Da
T1A/7Dc T1A/7Da T1A/8Dc T1A/8Da
Nama: Ayu
ROW A ROW A
T1A/9Dc T1A/9Da T1A/10Dc T1A/10Da
GAMBAR GAMBAR KESELURUHAN UNTUK ROW A

Trial 1 monthly monitoring forms for Sabaki Farm w.e.f June 28th, 2018 Source: Author 2018

Since we are trying to imitate the natural habitat, there is very limited human interference after 28th June 2018. Every orchid plant was left to itself, and not watered or fed. The monitoring criteria for Trial 1 were based on Australian botanists' assessment of a successful translocation/introduction (Vailee, 2004); they are best divided into short-term and long-term:

6.6.1 Short-term Criteria

- More than 70% of plants survive, providing genetic diversity in the population.
- The newly created population has characteristics similar to wild-growing plants.
- Plants survive to reproduction stage, giving blossoms and fruit.
- The levels of reproductive crop productivity and vitality of seeds are close to those of wild-growing populations.
- The community is encouraged to take interest in taking the same steps.
- The community is aware of negative implications and threats in the absence of conservation efforts.

6.6.2 Long-term Criteria

- Emergence of seedling offspring (*this could be included in short term also).
- The number of specimens within the population is stabilised or increased.
- Adequate level of biodiversity, especially genotypes, is preserved during changing generations.
- The main results of the experiments on species reintroductions and features of the methodology are published in scientific journals.
- The creation of a model for others to follow and apply in their organisation.
- Citizens are aware of any unethical or unhealthy specimens.
- A change in legislation to suit the demand of people.

Monitoring of translocated/introduced specimens is the most crucial yet challenging part of this PP. This is because the project is in Malaysia and the author has been based in the UK for a significant period of time during the project due to the pandemic. All plants need to be monitored personally to obtain accurate observations and results and to be able to translate and record findings other than in the form. Monitoring is mainly based on observation of growth

(Denisova et al., 1986), flower colour, increase or decrease in number of pseudobulbs and colour of foliage, as per the form in Plate 6-13 (format based on master's programme monitoring 1000 stems of supermarket cut roses daily for two weeks). Data collected could be used for comparisons between natural (found wild, growing by the roadside, garden and open field) and artificial populations for *Dc* and *Ag,* but not *Da,* as information regarding natural population for this species in its natural habitat has not been identified. However, a comparison could be made with *Da* on fruit trees on Sabaki farm. Thus, we can observe the performance of those species in comparison to their natural habitat and so rate the success of the project. Due to the author being unable to be physically present on-site, visual observations were made based on videos and pictures sent by the members of SARORSO at the middle or end of every month, or when it wasn't raining heavily (as then it is too dangerous to go to the site as the waist-deep pools/puddles created by the herd of buffalo, covered by muddy water, are everywhere).

For the purpose of this PhD, reporting assessment of the success of the introduction work includes the following parameters:

- Duration: Year-to-year.
- Percentage of surviving specimens.
- Vigour and health of the specimens by the colour of foliage, roots, and existence of new seedlings and seed pods.
- Time required for transfer of plants to take place.
- Flowering and viability of seed pods, as seen in pictures and videos.
- Young seedlings/new growth/young plantlets as recorded in the forms – however, it is challenging to count the new seedlings as the shape changes even within a month. The only way to do this is to label each pseudobulb.

- Productivity of the host plant compared to the amount of harvest before the conservation project, as reported by the farmer.
- Monitoring frequency.

6.7 Results

When this project was initiated, the main objective was to observe when the plants survived the translocation/introduction, and if so, did they produce flowers, because, in general, orchids are appreciated for their flowers (Hinsley, et al., 2017) more than other parts of the plant. This trial is at a very preliminary stage. More detailed data on growth, foliage, pseudobulbs and roots need to be taken. Nevertheless, it has shown positive results in sustainable orchid conservation. Time is a factor and different genera of OS need to be introduced in future trials. The usage of seedlings from in vitro propagation from another project will also need to be tested, as mature non-commercial orchid plants are not easily available legally.

The flowering, growth (foliage colour, pseudobulb, white roots and new seedlings) and seed pods of each specimen were observed and recorded. Each specimen was observed every month from the date of introduction in June 2018, and after every period of significant rainfall the plants produced flowers without fail (Figure 6-3 to Figure 6-9). In this section, we report only the flowering occurrence period (OP) which also represents growth. This correlates to seven flowering periods in:

1. Initial Phase Observation: 18th to 23rd October 2018 – Adjusting period

   I. Observation Period 1-(OP1): 23rd October 2018

   II. Observation Period 2-(OP2): 30th November 2018

   III. Observation Period 3-(OP3): 25th January 2019

2. Observation: No Findings (NF): February-April 2019 (Heavy rain followed by unhealthy haze season)

IV. Observation Period 4-(OP4): 11th May 2019

3. Observation No Findings (NF):3 June 2019 – (Rained)

V. Observation Period 5-(OP5): 19th July 2019

VI. Observation Period 6-(OP6): 11th August 2019

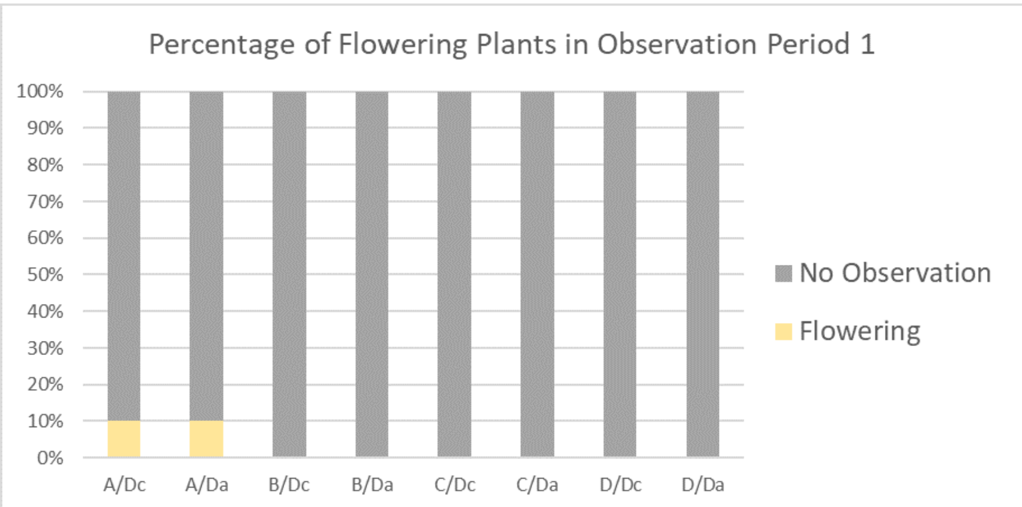
4. Observation No Findings: September 2019 – (Dry & hot season)

5. Observation Period 7-(OP7): 18th October 2019.

6.7.1 Experiment Analysis – 28th June 2018 – 18th October 2019

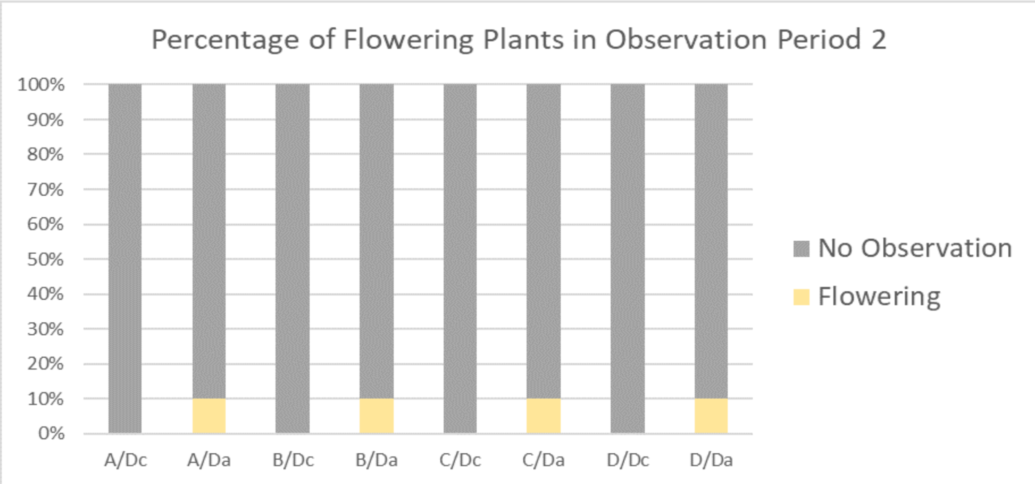
The first records were taken three months after translocation as the author only returned to the site, Sarawak, from UK in October 2018, meaning the specimen needed to be adjusted. In 2019, Sarawak faced unhealthy air pollution levels of 267 due to thick haze (Ling, 2019; The Star, 2019), which caused poor vision and made it unsafe to be in the estate, followed by continuous heavy rain, 580 mm in February to 320mm in April 2019 (WWCI, 2019), giving dangerous knee-deep mud and water holes made by buffaloes; all this disrupted the data collecting task.

Figure 6-3



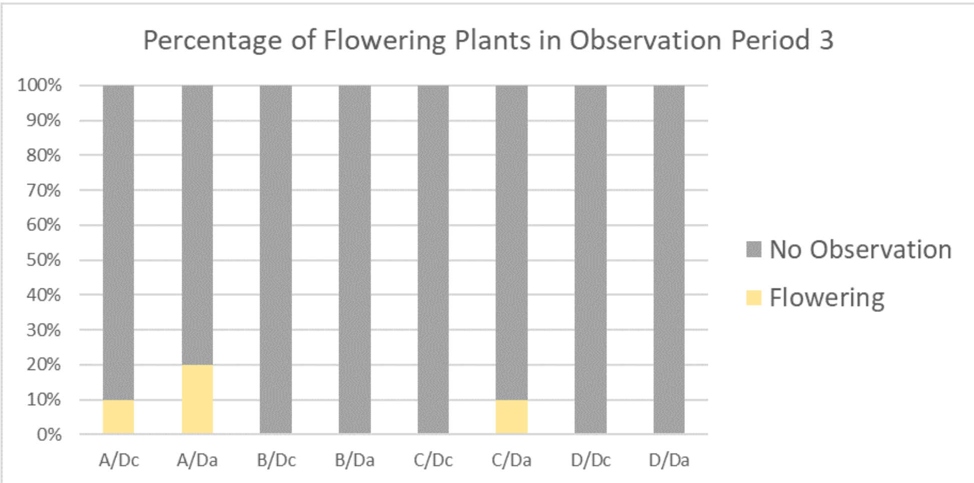
OP 1, 23rd October 2018.Only 2% of the plants were flowering; row A, No observation means no flowers or seed pod observed in the remaining specimens, but specimens were growing healthily

Figure 6-4



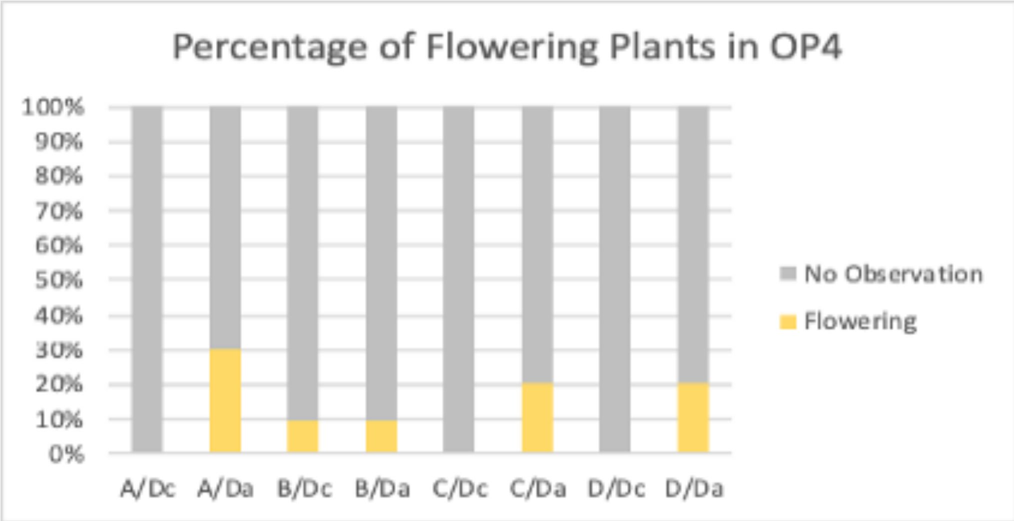
3 OP 2 -30th November 2018, only 4% of Da were flowering. 10% of each row were flowering. None of the Dendobium crumenatum was flowering. No observation means no flowers or seed pod observed in the remaining plants, but the remaining specimens, foliage and roots were growing healthily. Source: Author, 2019.

Figure 6-5



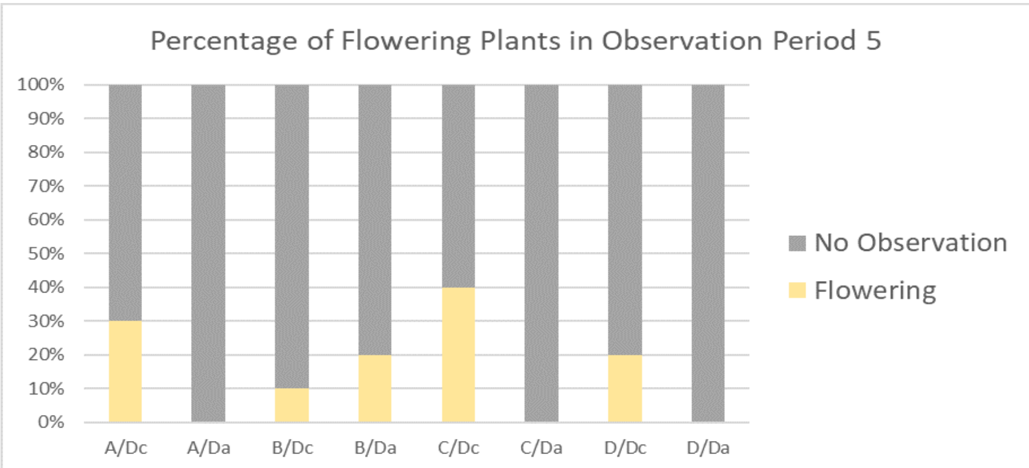
12th January 2019. 4% of the specimens were flowering but this time Row A has an increase in percentage of flowering. Both Dc and Da were flowering in row A and in row C, Da was also flowering. No observation in either row B or D. All specimens are healthy

Figure 6-6



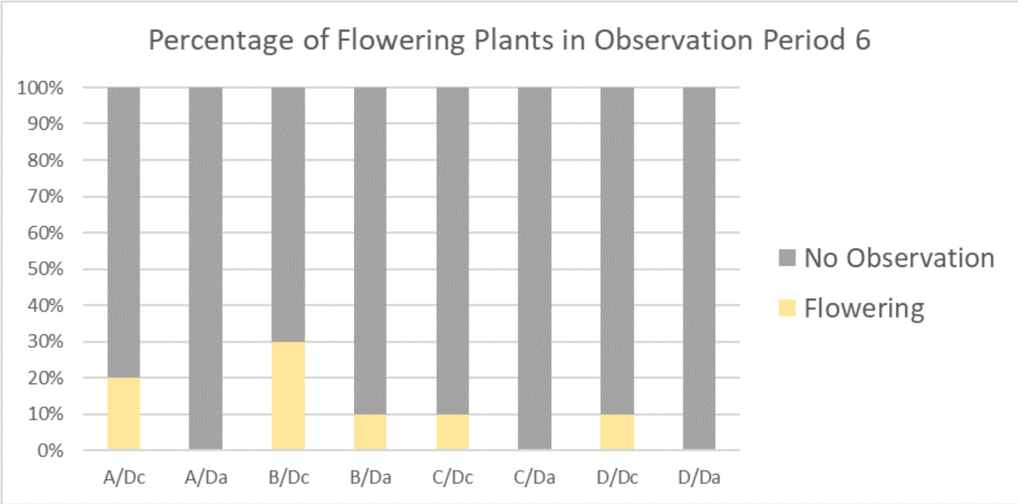
11th May 2019. A total of 9% are flowering. Out of this 9% of every row of each Da have bloomed. Dc bloomed only on one of the hosts in Row B.

Figure 6-7



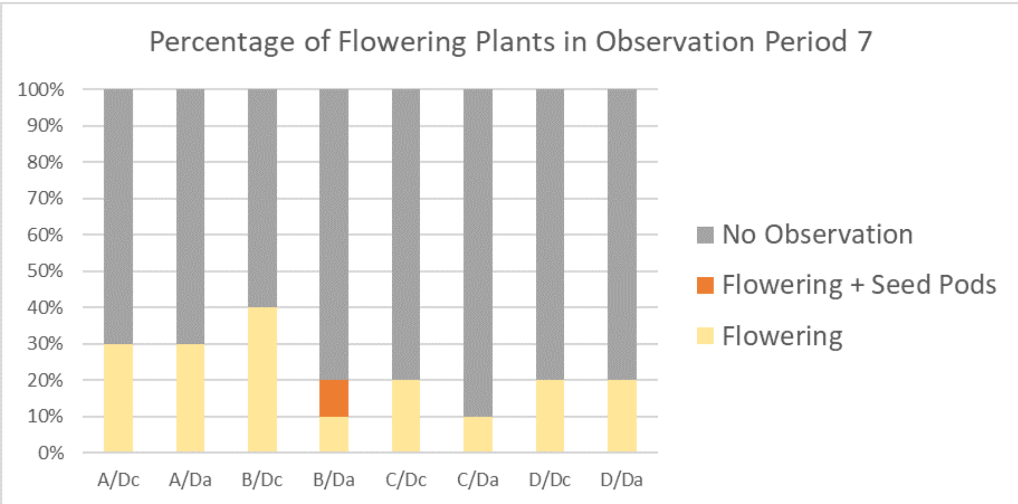
OP 5 19th July 2019 4%

Figure 6-8



11th August 2019 8% flowering

Figure 6-9



OP 7 18th October 2019, flowering at 19% rate for each row except for row B. Every host has at least one host with flowering Dc or Da. On only one host, a Da finally produced a seed pod 17 months after being introduced in June 2018, plants are more mature. Source: Sabaki, 2019.

OP 1 showed that on 18th October 2019. each row of the *Eg* – A, B, C, D had at least one of the 10 *Da* and *Dc* plants attached to *Eg* flowering. And one *Da* attached to row B had produced two seed pods on a single spike. Unfortunately, when the SARORSO ladies came back to collect it for micropropagation, the seed pods were gone. It was observed that the plant which produced seed pods was the one growing at the very end of row B, which is at the very centre of the estate.

6.7.2 Summary – Observation of Specimens – Da, Dc and Ag

In general during the first year after the translocation (OP 1 to OP 7), the number of plants flowering increased from 2% to 19% after the introduction date and the clumps on most hosts increased in volume also. *Da* seed pod development was only observed 17 months after translocation. Even though the trial monitoring stopped at the end of 2019 due to restrictions in movement caused by Covid-19, a trend could be seen that as the orchid matures and produces more seedlings over time, the more flowers it produces, and finally, after 17 months, *Da* started to produce seed pods naturally and the scent of an increased number of flowers was attracting the pollinators. As for *Dc* the presence of seed pods was only seen and captured by the farmer on 11th July 2020 when he was allowed to visit his farm after the lockdown in Malaysia.

The blossoming of both fragrant tropical *Da* and *Dc* seemed to be associated with temperature change. It was observed that after a period of heavy rainfall (exact temperature was not recorded due to absence), the development of flower buds was promoted.

Unlike the *Dc, Da* flowers lasted for more than seven days after blooming and could potentially last longer if the temperature remained cool (caused by rain) after blooming (no exact temperature was recorded to identify drop or increase). The buds were visible to the naked eye for approximately two to three weeks (no recording of duration of bud growth before blooming in response to an increase in temperature).

For *Dc*, the flowers started to bloom after nine days of rainfall but were only at their best for approximately 24 hours. However, there were times they remained for 48 hours before wilting.

Plate 6-15

Left – Tiny buds of Da buds were visible to the eye about two or three weeks before blooming. Right: The flowers bloom and last for about seven days before the first one starts to wilt. Source: Author, 2019.

However, as mentioned by William Seifriz (Seifriz, 1923; Xu, et al., 2010; Wang, et al., 2019) the conditions necessary for when each species initiates the development of flower buds could be different depending on other requirements e.g., nitrogen content, light intensity or plant maturity. As there is no record of the maturity level of each plant and its surroundings, it is not possible to evaluate the necessary conditions.

Plate 6-16

Left Tiny Dc bud would be formed on leafless single nodes after heavy rain and will remain dormant until there is a drastic change in temperature again. The stem of Dc is slender. However, since recording was made once a month, we could not capture the exact time it bloomed.

6.7.3 Summary Observation of Pseudobulb/Foliage for the Period June 2018 to February 2020

The foliage was all green and did not show signs of senescence or termination after being attached to the host. However, during the dry season and exceptionally hot weather in April 2019, September 2018 and September 2019, when there was no rain for more than three weeks and the temperature was over 38°C, the clump of the plant looked smaller, and the pseudobulbs shrivelled. Nevertheless, when the rain starts to fall, new shoots start to develop and if we do not mark each individual stem, it is challenging to tell which stem has grown in length.

In addition, it was also noted that for most Da, the buds will appear on leafless cane/stem just like Dc, however, there are Da which produced buds on cane/stem with leaves (Plate 6-17).

Plate 6-17

Left: Da bud appearing on canes with foliage. Right: Da buds appearing on leafless cane. Source: Author, 2019.

After a flowering season in 2019, it was noted that there were pseudobulbs, which were missing when we compared pictures from the previous months. There were instances during the rainy season of the orchid plants being covered with mud. For the missing pseudobulbs it was suspected that either the squirrels took them while they were climbing up or down the trunk, or that they have dried up during dry spells; another explanation is discussed in 6.7.5. As for the mud, if could be the buffaloes rubbing their body against it. Therefore, whilst integrated farming or agroforestry, which include mixed-species plantations, livestock and poultry, could increase the biodiversity and ecosystem (Liu & Krutovsky, 2018; Paramesh, et al., 2020), there are challenges that are worth looking into for the ex situ orchid conservation project to be effective.

6.7.4 Summary Observation on Roots

New velamen roots, white with green tips (Freitas, et al., 2016; Morlina & Echem, 2018; Deepthi & Ray, 2020) for *Da* and *Dc* were observed to be forming, especially after the rainy season. However, healthy hanging velamen aerial roots of keikes remain after the flower wilts (see 6.7.5).

Plate 6-18

Left: Healthy Da (Left) and Da roots (Right) appearing at the bottom of plants to attach themselves to the oil palm tree trunk and branches. Source: Author, 2019.

6.7.5 Summary Observation on Seedlings

Da – At the base of some plants, new shoots with multiple white velamen aerial roots were observed to grow after the rainy season.

However, it was observed also that in some plants, keikes or baby plants grew along the bare cane (normally after flowers wilted) or at the very end of the cane (Plate 6-17, left and right) with healthy velamen aerial roots. However, it was observed by the Sabaki estate owner. Wilson Harith, that the stem/cane which has keikes will eventually dry out, break from the mother plant and fall to the ground and, if not collected and replanted, it will die and be wasted. Hence, to prevent this, he mounted the keikes on a higher part of the oil palm tree, tucked in between the frond base (Plate 6-20c).

Plate 6-19

New shoots/plantlets growing from base of the mother plant. Source: Author, 2019

Plate 6-20

(a) Keikes with healthy white and green tip velamen aerial roots (var) growing at the end of cane which will detach itself when the cane dries up. (b) Another keike with var growing along the middle of the cane with healthy var. (c) Keike securely tucked in between the oil palm tree frond base. Source: Baki, 2019.

Dc – Similar to *Da, Dc* Produces plantlets at the bottom of the pseudobulbs, as well as keikes along the cane.

Plate 6-21

Left: New shoot/plantlet growing from the base of pseudobulb. Right- Keikes growing from canes. Source: Tengku Auvaroza, 2019

Terrestrial Arundina glaminifolia (Ag)– Growth, Flower and Propagation

Within six months, *Ag* could produce 48 stems from a single stem. Each small clump of *Ag* which was translocated and introduced on the ground grew approximately ten times its original size within six months (SARORSO, 2019). Unlike the epiphyte orchid *Da* and *Dc* specimens, only a single row of *Ag* of five clumps, with each clump having three stems of seedlings, were planted and observed. *Ag* had to be replanted twice, as during the first attempt, only one clump survived the translocation, and the label went missing. It was believed that the road construction workers who were building a new drain may have accidentally dug it out. The second attempt involved replanting four mature seedlings which were gathered from the initial attempt. The second attempt utilised mature specimens planted alongside the drain within the compound.

Plate 6-22

(L) A Row of Ag seedlings were planted on 28th June 2018. (M.). 1st February 2019, only one clump survived but had multiplied in volume and height. It grew taller than the gentleman. It produced flowers and seed pods but not as many as if the Ag was planted under direct sunlight. (R) another row was replanted using the single clump of Ag which survived.

Source: Author, 2019.

6.7.6 Production of Seed Pods

During the trial period, flowering *Da* did not easily develop into seed pods. From June 2018 to October 2019, on one occasion in that period, two seed pods were observed (Plate 6-23). It was also observed that the seed pod which developed was from a plant in the 10^{th} row, which was the last row of the trial but not the last row of oil palm trees in the estate. It was located in the middle of the estate.

Nevertheless, it was observed that *Da* produced lots of seedlings/plantlets at the base of the pseudobulbs after rain, and it flowered along the cane. Therefore, even though successful pollination in the oil palm trial study area would be ideal, as it would indicate the presence of pollinators, millions of seeds produced in a single capsule could also be used in ex situ orchid conservation efforts through seed micropropagation (Yeung, 2017); the ability of the plants to reproduce asexually by vegetative propagation through offshoots (Ming, et al., 2017) along the stems and at the base of pseudobulbs in the study area is still an accomplishment.

Plate 6-23

Two seed pods found at the last row of the trial in October 2019. However, when we revisited it in early November, it was no longer found. (Source: Author, 2019)

On the other hand, despite *Dc* being highly scented, commonly found, and producing plenty of seed pods in its natural habitat, it did not seem to be as successfully pollinated at the trial site. No seed pods were seen developing during the trial period; however, in July 2020, the farmer observed that a *Dc* plant produced seed pods (Plate 6-24).

Based on the natural pollination of both *Dc* and *Da,* it can be concluded that the pollinators of both *Dc and Da* are present at the farm, though it took a while for the complete process to take place.

Plate 6-24

Dc produced seed pods through natural pollination after two years. Source: Sabaki, 2020

6.8 Discussion

Various parameters that positively influence orchid reintroduction outcomes were identified, e.g., knowledge of the type of species, a dedicated farmer, using mature rescued seedlings, knowledge of weather and preparation of material. This pilot study also revealed shortcomings in new experiments that greatly limit the interpretation of plant translocation studies:

(1) insufficient monitoring following reintroduction; there is more accurate data if it is done on at least a fortnightly or monthly basis, as only then can changes be detected.

(2) inadequate references, which is especially important for reintroductions/translocations that are regarded as new, with no other benchmark or reference to refer to.

(3) lack of understanding of the underlying reasons for the decline in existing orchid populations, especially in a developing tropical country.

(4) overly optimistic evaluation of success based on short-term results. The full term of an oil palm estate is 30 years, with different stages of canopy thickness over time, changes in vegetation cover after human interference over decades, epiphytes and microhabitat growing on palm trunks, and height.

(5) poorly defined success criteria for translocation projects.

(6) the effect on oil palm yield itself with the orchids growing on the palm trees has not been thoroughly studied. Nevertheless, the Sabaki farm owner reported that there was no negative change in production in the main oil palm business since the translocation of orchids three years ago,

It was therefore concluded that the value of plant translocation and reintroduction as a conservation tool could be improved by:

(1) an increased focus on a higher number than just two varieties of OS to an estate according to its native location;

(2) using sustainable seedlings (preferring seedlings of rescued and cultured orchids) instead of an unknown source;

(3) taking better account (data and pictures) by two people instead of one to reduce erroneous recording of flower, shoots, roots and seedpod production when assessing the success of translocation;

(4) consistent long-term monitoring after translocation;

(5) prolonging the study to have long term results; and

(6) a comparative area with higher biodiversity.

The materials used were mature specimens. The flowering of both fragrant tropical *Da* and *Dc* seems to be associated with temperature change. It is observed that after a period of heavy rainfall (exact temperature was not recorded) the development of flower buds was promoted. Unlike the flowers of *Dc,* which lasted only for 24-48 hours, *Da* flowers have potential commercial value as they lasted for more than seven days after blooming and could potentially last longer if the temperature remained cool after blooming. After the development and wilting of flowers, keikes and minimal seed pods were produced. However, it was noted that *Da* and *Dc* mounted on a fruit tree *Annona muricata* nearby produced seed pods consistently after most flowering events (not part of the experiment). *Ag* grew from a single plant to a healthy clump of 37 plants within five to six months. It continued to flower with or without rain and produced seed pods.

Da produced seed pods 474 days after being introduced, whereas the *Dc* did not produce seed pods during the same period, even though it managed to produce pods easily in its natural habitat. *Dc* only started to produce seed pods 740 days from the day it was translocated.

Nevertheless, the observation may not be accurate as during the lock down no observations were made.

Therefore, from the observations addressed in Sections 6.7.1 to 6.7.6, subject to the same conditions these epiphyte and terrestrial orchids will be able to repopulate the oil palm plantation successfully if they are not removed. It also shows potential for addressing the threat of the depleting orchid population as a result of the increasing disappearance of forests in Sarawak, especially at lower elevations where the forests rich with biodiversity are being replaced by monoculture farms such as oil palm plantations (World Conservation Monitoring Centre, 1992). Orchids originating in these habitats are fast becoming extinct. Therefore, this ex-situ conservation conducted in oil palm estates in Sarawak would at least provide options for lowland epiphyte and terrestrial orchids to survive, leaving the more difficult ones to the experts.

6.9 Conclusion

The presence of seed pods of Da and Dc, naturally pollinated by their respective pollinators, send an invaluable message for the conservation of OS in Sarawak, supporting the species' survival. With this finding, the massive 1.58 million hectares of oil plantations could very quickly be the 'Noah's Ark' for endangered SLEO, and potentially improve the biodiversity of oil palm plantations and create value-added economic opportunity for farmers in floriculture without affecting the production of palm oil, assuming there is no adverse impact on the host in the long term.

Terrestrial orchids could act as hedges and restore the soil ecosystem due to how easily they thrive in an alternate habitat. However, any issues due to introduced epiphytic OS recolonising and invading a site would be negligible, as epiphytes are harmless to other plants, including trees. In fact, they are indicators of environmental improvement (e.g., as air pollution bio indicators). In addition, there needs to be the provision of potential incentives for landowners of oil palm and other plantations (such as cocoa, rubber, sago, durian, rambutans, etc.) to further promote the adoption of this trial in their plantations for the purpose of conservation and biodiversity regeneration. Incentives proposed could be:

I. For the protection and management of the introduction of orchids, distribute awards and benefits for participating as citizen scientists, educational kits, and property tax rebates. Stewardship programmes are becoming an increasingly popular means of protecting and managing valuable natural resources.

II. Improve legislation by the prohibition of collection and trade in orchids; the country's orchids may be destroyed along with their habitats and the opportunity for ex situ propagation lost. There is no reason (other than that the privilege could be abused) to prohibit the salvaging of plants from destroyed habitats. A system of licensing and management that is not open to corruption would make plants that would otherwise die salvageable, a desirable option for artificial propagation. Ideally, this would reduce the pressure to collect those still in the wild by flooding the market with artificially propagated specimens.

III. Improved incentives for implementation of a new integrated model of the oil palm estates whereby the owners of the estate sacrifice a strip of living habitat on their land, creating borders which could also be planted with a variety of other types of flora, including endemic fruit trees or endangered trees such as iron wood, which would attract pollinators as well as other native wildlife e.g., Amorphallum, for improving both biodiversity and the ecosystem of the area, such in the case of the Belize project, focusing on improving forest plant diversity, wild life population, and educating the community on conservation and species identification (Korach & Myers, 2020).

Add value to economic activities through planting orchids in oil palm estates in line with the Agriculture National Key Economic Area (Tan & Syed Mohamed, 2020), identifying high-value botanical drugs which could contribute to the transformation of herbal products into nutraceuticals and pharmaceuticals (NPCB, 2015), thus creating a second income for the oil palm farmer and the rural community around them. Orchids have been known as aphrodisiacs, medicine or food by the Malays and other local communities in Sarawak and other states in Malaysia for many generations, providing their basic needs, knowledge of which slowly faded when modern medicine from the West took over (Bodos, 2019; Teoh, 2019).

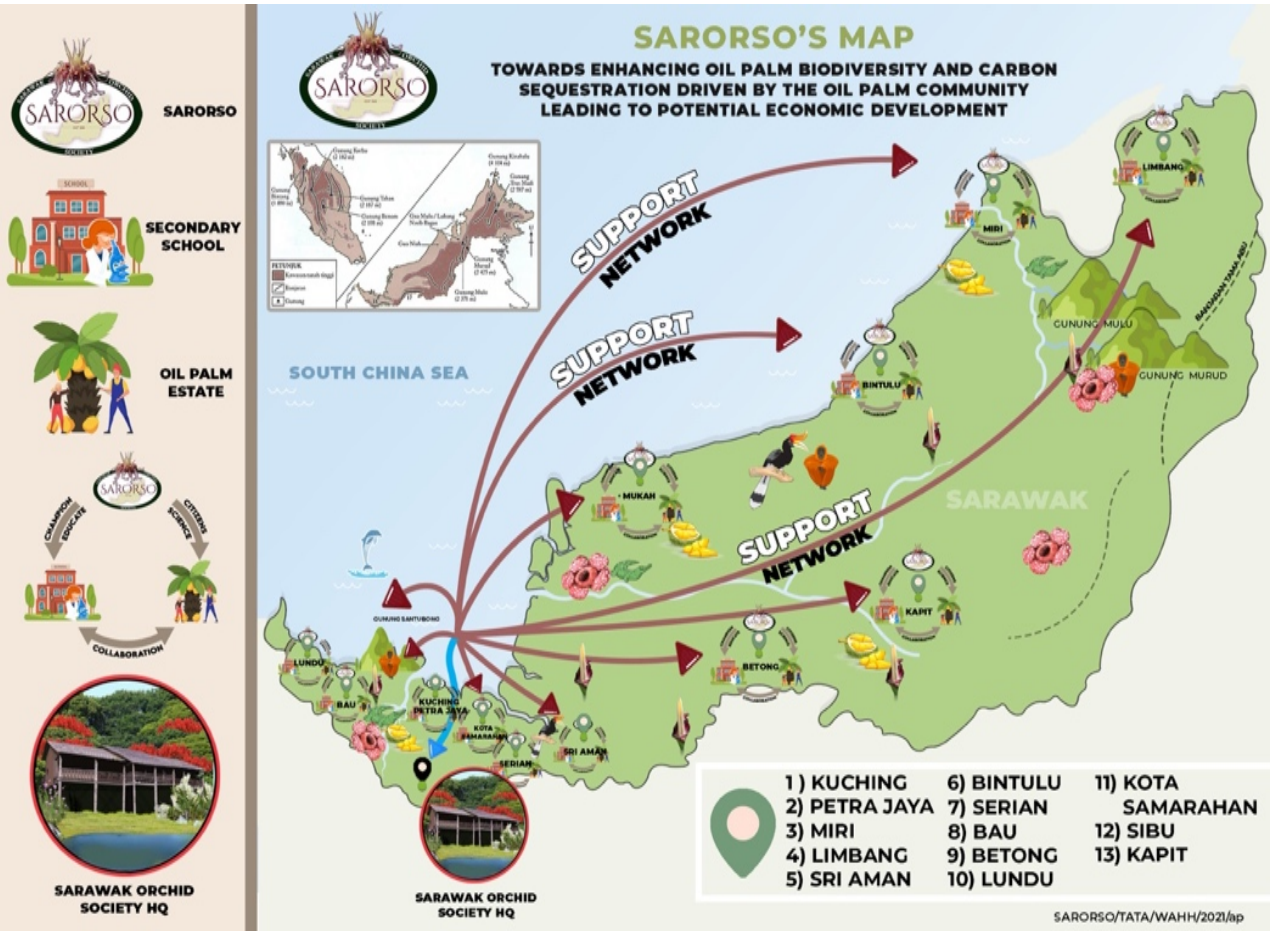
IV. Need for an amendment to Part IV (30), Chapter 26, of the Wildlife Protection Ordinance, 1998, on totally protected plants and protected plants, which prohibits cultivating orchids unless for scientific or educational purposes or the protection and conservation of such totally protected plants, unless approved by the Controller, authorisation which is almost impossible to obtain. This discouraged rural folks from being part of conservation programmes, preferring to opt for the extraction of mature plants which are plentiful and easily accessed in the forest (Hinsley, 2018).

These findings should be able to stimulate research to address the identified gaps and provide a foundation for more in-depth research and discussions among government, NGOs and the stakeholders in areas which could benefit not only the fate of OS, the ecosystem and the biodiversity of plantations and their cultivation, but also the economics of many sectors, including the State Orchid floriculture, tourism and herbal industries.

Lastly, the research also investigated how a functional arboretum (Povis & Welte, 2010), representing the monoculture plantation with introduced SLEO, has led to opportunities to improve orchid conservation management, reintroduction, translocation and long-term orchid ecological restoration outcomes. Therefore, representing the artificial landscape of Sarawak can shape not only the environmental learning experience, but expose visitors to the botanic garden to new perspectives (Oldfield, 2007; Oldfiled, 2010; Oldfield & Newton, 2012). Constructive links between the public, industry, policy makers and the messages that scientists have been trying to deliver could be achieved through environmental learning experiences in the garden (RBG, 2020) and citizen scientists (Oldfiled, 2010; Gale, et al., 2018; Lloyd & Rochelle, 2020). An interactive perspective on the experience is implied when visitors have a direct experience within the UBG environment.

The concept of these arboretums is based on the trial involving the introduction of either rescued orchids from areas being cleared or new seedlings, both for conservation purposes. The findings from this trial to introduce SLEO into a monoculture forest showed that success can be achieved when combining the conservation of orchids with a monoculture plantation (Plate 6-25). The success of the trials drew interest from parties such as other plantation owners and farmers (who were keen on replicating the trials in their own plantations) as well as international groups (who were keen on further understanding the trial as well as contributing to the efforts).

Plate 6-25



Author inspired ex-situ conservation idea presented to Sarawak Orchid Society members, positively received, whereby each division representative of SARORSO will work together with Sarawak Forest department and with interested oil palm estates in their respective division and use SLEO orchids which are native to that area (following the template performed in the kota samarahan trial 2018) based on information extracted from Hebarium sheets available in Kuching Herbarium and Sarawak Orchids, Beaman, 2001.

6.10 The Future

These findings could be used for ex-situ conservation propagation of native SLEO of each respective division specialising in their native orchids (Plate 6-25). A database obtained from these various divisions would not only help better understanding of the strengths and weaknesses in terms of what species are growing ex-situ, and which of those still in situ need to be addressed immediately, but also the model for future oil palm estates. Sarawak authorities could then better focus on other challenging endemic orchids that are threatened with extinction through ex situ or in situ conservation efforts. A ‘proof of concept’ example of a database is the Living Orchid Collection in this new alternative habitat which imitates the concept of successful trials of animal reintroductions/translocations in other parts of the world (Wrobel, 2020); this could attract and encourage dedication, commitment and collaboration from established orchid organisations throughout South East Asia in order to further improve the region’s ecosystem with the assistance of scientists from other parts of the world. The productive life span of oil palm trees, which is currently 30 years, could increase further with new scientific research and a sustainable oil palm estate area, much better than in an area of developed emission-heavy industrial projects as in most industrialised countries.

Establishment of an ex-situ orchid conservation database through sustainable strategies would not only greatly facilitate conservation efforts with wider local community involvement throughout Sarawak and other countries with similar situations (Lloyd & Rochelle, 2020), but it has potential for sustainable ecotourism, instead of that which threatens wild orchids, (Ballantyne & Pickering, 2011; Boley & Green, 2016), for pharmaceutical products and for a variety of cottage industries including herbal tea which is forecast to be worth USD 500 billion by 2050 (Singh, 2017; Choopak & Aunyawong, 2019; Hui & Zhang, 2021). However, as Sarawak has an area as large as England, it is not feasible to expect visitors to travel to various conservation projects all over Sarawak; so visiting the proposed UOBG with an arboretum of oil palm trees with OS mounted on them, with a display of the cottage industries being carried out, would be a viable way for visitors to experience conservation efforts in situations which benefit them, thus raising awareness. Nevertheless, the presence of OS in oil palm estates in various divisions would lessen the pressure on wild orchids in the forests. A display of translocation/introduction efforts with sustainable strategies, distributing economic benefits to the oil palm community and the local population, would attract their commitment to make the project a success, since their needs are represented and attended to instead of only those of industry.

Contrary to the belief that climate protection and conservation are key to a country's successful economic growth, developed nations as leaders in conservation have also not appropriately protected, restored and maintained their ecosystems but instead, historically and currently, their authorities show little concern for sustainability (Carrington, 2021; Reader, 2021). Even more for the authorities of developing countries, conservation can only be effective and successful if it complements the economic development of the local people (Pelicice, 2019). Ideally, these should be mutually beneficial, as economic growth is imperative to meeting the social and environmental standards of a developing country (Purvis, et al., 2018; Pettinger, 2021).

Plate 6-26

Fragrant Dc (seasonal) and Cattleya, like Ag continuously blooming, were collected, dried and made into floral tea; this could be a cottage industry carried out by the oil palm estate community and the people around them as a secondary income, which also encourages tourism, like the Sakura tea in Japan. Source, SARORSO, 2021

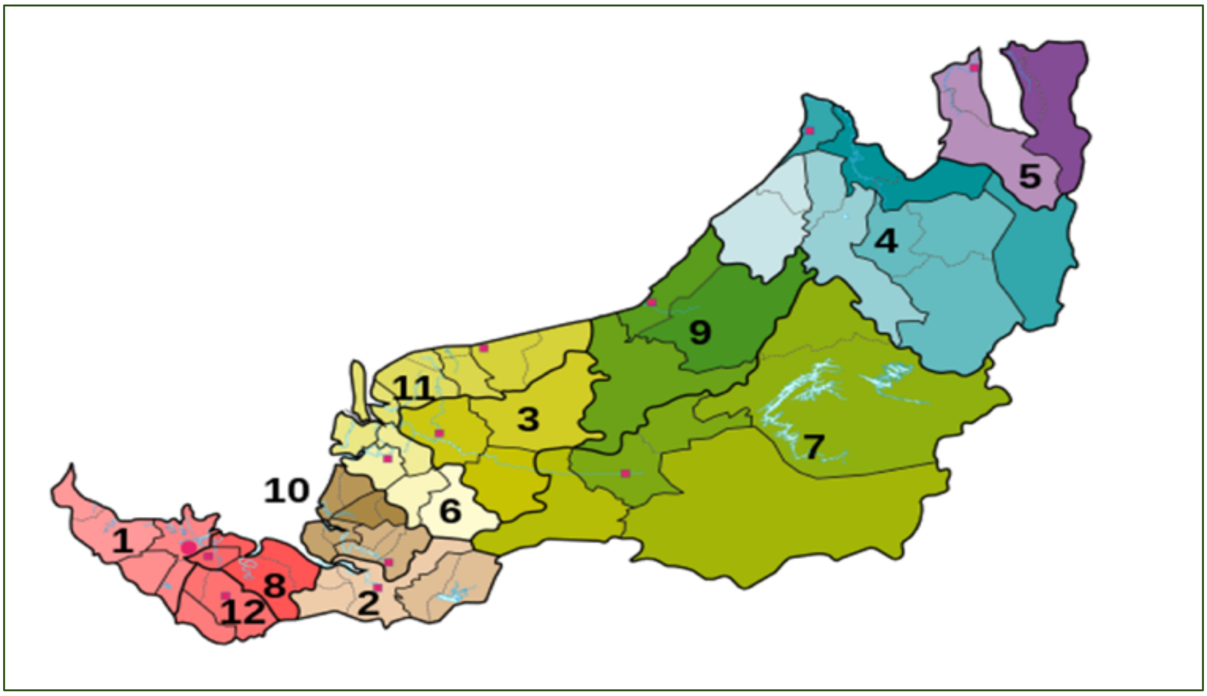
CHAPTER 7

7 The Proposed Concept of a Sustainable UOBG in Kuching :A Recommended Solution to SLEO Extinction Crisis

7.1 Introduction

Based on the findings of Chapters 2, 4, 5 and 6, and the evolving roles of Botanic Gardens (BG) today, as well as the level of Orchid Conservation (OC) issues in Sarawak (BGCI, 2015; GPC, 2016; Gale, et al., 2018; BGCI, 2019; BGCI, 2018; Swee, 2020; BGCI, 2020; BGCI, 2021), this chapter focuses on the proposed set up and design of a non-conventional Urban Orchid Botanic Garden (UOBG) to **address OC issues.** Its **vital functions** include a living botanical museum of OS, similar to Kew Gardens (RBGK) which has the world's largest collection of orchids (Volis, 2017; Feaster, 2020). However, unlike Kew, this proposed UOBG will only focus on **its native OS, set in their 'natural habitat setting'** rather than in a conservatory. In some parts of the UOBG, plants that act as phorophytes to the OS are boldly and creatively grouped at the outer border of the site according to categories of Sarawak forest ecosystems, representing each of the 12 Sarawak divisions (Figure 7-1) creating functional learning arboretums and gardens with interactive scientific hands-on education (instead of just an observation area with restrictions) to create awareness and encourage engagement by the community, including the younger generation (YG) (MacQuarrie & Nugdent, 2022).

Figure 7-1

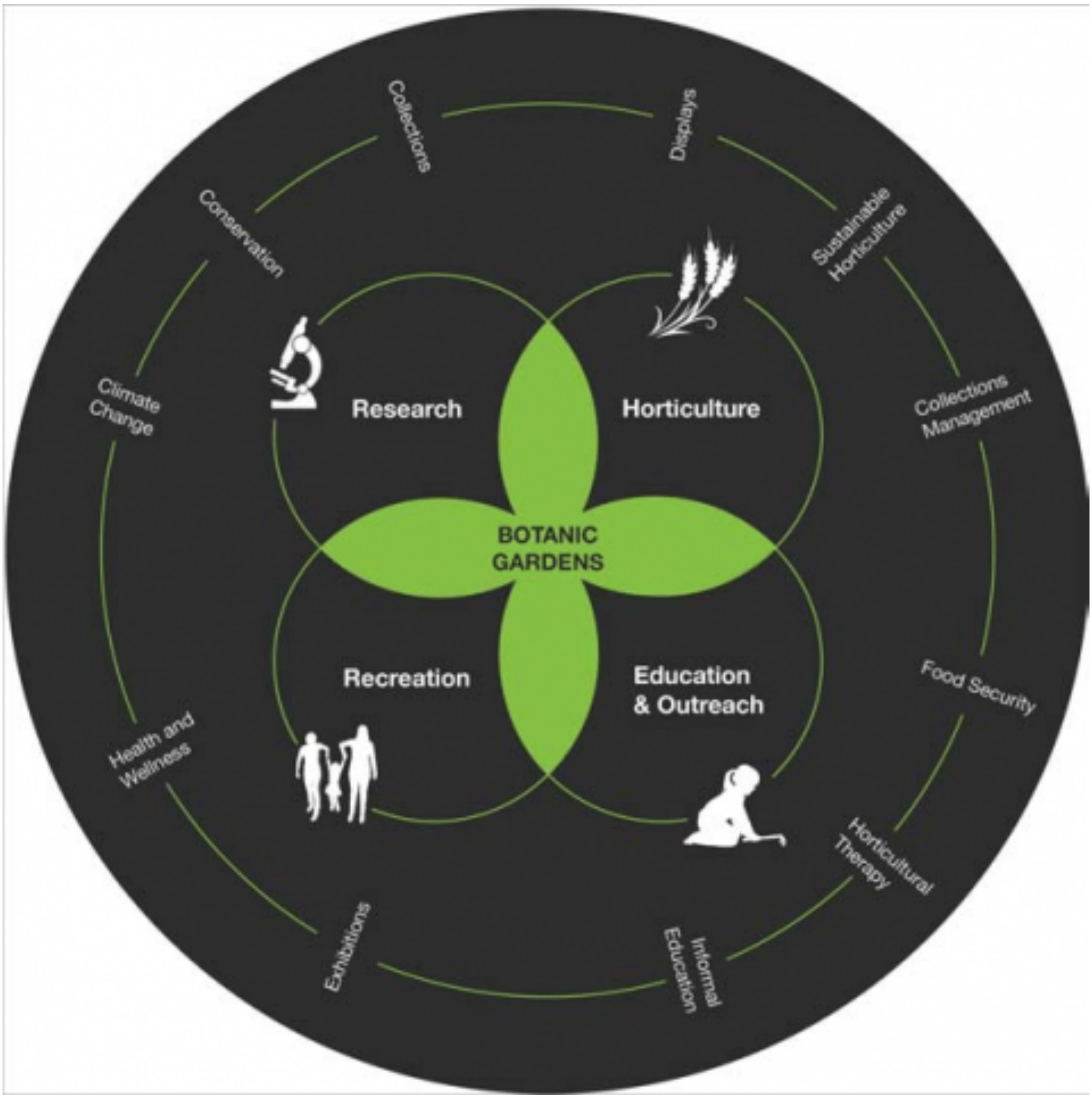


Ecosystem types of Sarawak, divided into 12 divisions with diverse forest ecosystems ranging from mixed dipterocarp forest to secondary forest of various succession periods. Source: SFC, 2021

In addition, the function of the UOBG is **to collect, preserve and display ethnobotanical knowledge on local OS**. For example, most local people are not familiar with the scientific names of OS; they know their traditional uses, but refer to them by local names. Therefore, by visiting the UOBG, visitors could learn and benefit from the available interactive technology, and at the same time, the UOBG will be able to store data from the interaction for research purposes (Elburz, digi, 2015). Meanwhile to further **establish a unique selling point (USP)** for the proposed UOBG and to **ensure the sustainability** of the project, besides highlighting Sarawak's OS, **Sarawak's unique and diverse culture and heritage** will be incorporated into the landscape of the UOBG (Mohd, 2021; Sarawak Yes, 2021). The Sarawak community has a close relationship with its OS in that orchids have traditional uses which include medicine, charms and food (Christenses, 2002; Eng, 2019). The proposed traditional design of the state-of-the-art buildings in the UOBG will also **feature interactive content and digital experiences** where visitors can not only learn about the different aspects of OS, but also engage with the tangible and intangible cultural heritage of each building which complements the outdoor landscape. The purpose of the UOBG design is also to educate the public on legislation and various methods of conservation and provision with regard to OS.

This proposed design for a UOBG employs the lens of a permaculture design that consciously improves and supports the natural ecosystem, both sustainably and economically (BGSA, 2021). The UOBG displays beauty in an unconventional and novel way to explore in detail concepts, sites, vegetation and community engagement by bringing together horticulture, architecture, ecology, economics, culture, history and creativity, with a focus on educating, engaging and inspiring visitors. As a third of Sarawak's population lives in Kuching city, this would provide a much needed recreation centre, offering both educational and relaxing urban forest outdoor activities, increasing the opportunity for sociability, and moulding an interactive and OS-aware community (Figure 7-2). This restored green belt therapeutic recreation establishment could be used as a meeting place for exercise, social exchange, intellectual stimulation and emotion regulation, whilst also having the potential to motivate visitors to be advocates for OC.

Figure 7-2



21st-century BGs are challenged to address issues that extend beyond the aesthetic horticultural taxonomy by having social and environmental responsibility as a key mission, contributing to the Sustainable Development Goals. Illustrated by Krishnan, 2016

This chapter is not about applying and discussing the technical principles of landscape design, but rather explores the role of the proposed UOBG in supporting OC efforts to address orchid diversity and sustainable development in line with the Sustainable Development Goals 2030

(SDG) (Sharrocok & Jackson, 2017; Smith, 2018). Nevertheless, ideas and creativity could only be realised with the involvement of experts and experienced professional landscape architects, horticulturists, orchidologists, engineers, sculptors, local arboriculturists and administrators (Willison, 2006; BGCI, 2016). In addition, the realisation of the proposed design concept may face challenges such as water and soil management, the procurement of materials, use of native vegetation, working with existing substrate and soil management to transform it into various OS habitats, volunteer work, etc., which would be assessed and addressed by the professionals. The proposed concept of the design is to create a critical tool suitable to the requirements of Sarawak in addressing its Orchid Extinction Issues (OEI) by effectively and efficiently disseminating the OC message by creating a primary physical interface with the non-orchidologist community, which plays a big role (BGCI, 2012; Chen & Sun, 2018).

7.2 Overall Proposed Concept

7.2.1 Natural-Looking Landscape

The proposed UOBG should utilise aesthetic displays and sustainable relatable functional facilities to engage visitors in novel ways to participate in OC efforts (Smith, 2018; BGCI, 2016; BGCI, 2019). Therefore, creativity, vision, and a storyline (with the integration of a character to engage the younger audience) should be incorporated into the UOBG (Sylt, 2015; Blaszak, et al., 2019; Beattie, 2020). In addition, in this 21st century sustainable natural-looking landscape, natural resources, culture, architecture, and gastronomy are sought-after elements in a visitor attraction (UPFB, 2019; Mirabent, 2019). Whilst the habitat and landscape of Sarawak's OS are wild, it is also unique and filled with culture – many interesting and exciting stories need to be told and shared to inspire and to aspire to (Hudson & Ritchie, 2009). However, despite aiming to be all-natural, for safety and design control purposes some materials and structures will inevitably be artificial; these, however, will be concealed or sculptured to imitate natural Sarawak forestry. Similar techniques are applied in other well-known BGs (Plate 7-1).

Plate 7-1

Structures of artificial tree trunks covered with moss, orchids and other epiphytes in the Princess of Wales Conservatory, Royal Botanic Gardens, Kew. Source: Tengku Auvaroza, 2019

7.2.2 A Powerful Evolving Storyline

The first chapter of the storyline will revolve around the 200 years of rich historical adventures by orchid collectors since the era of the first white Rajah, James Brookes (Low, 1848; Russan & Boyle, 1893; Wallace, 1962), and their exceptional contribution to the 'orchidelirium era', a name given to the Victorian era of orchid flower madness for collecting and discovering orchids (Zhou, 2015; Harris, 2020). The second chapter will detail the novel OC projects discussed in Chapter 6, involving the greening of monoculture estates as alternative habitats by mounting OS on the phorophytes. The project of the translocation of rescued OS which successfully bears flowers followed by seed pods could have economic potential (EP) in the cut flower industry similar to that in Taiwan (Yin-Cheng, 2009; Chang, 2016; Yang, 2019) and

Thailand (Fernquest, 2011; orchidasia, 2014; Thammasiri, Kanchit, 2016). EP includes the herbal industry, such as floral teas and food, as mentioned in Chapter 6. Within the same context, the development of **seed pods** is not only a successful sustainable OC project with the presence of pollinators, but also, with vanilla (being an orchid seed pod) as an example (Plate 7-2), it shows that it has the potential to discover among the 2500 OS 'another vanilla' (Correl, 1953; Sethi, 2017). Finally, stories about not only past figures but also **new historical figures** in OC could be borne out of community involvement in novel OC projects, or school children's involvement in ex situ conservation through their school's IVOM and BG project, as mentioned in Chapter 5, which ensures that the **UOBG will continuously update** itself with new discoveries and achievements and always be relevant to its time.

7.2.3 Digital Technology in Disseminating Strategies

In this 21st century, especially when the unprecedented coronavirus pandemic and lockdown caught the world off guard, paralysing almost all physical contact, communication and progress, not to mention its emotional and mental implications, indicates that technology is no longer a choice. For many BGs, the closing on 22nd March 2020 with restrictions continuing until now, was unexpected and challenging because, since their establishment, BGs have thrived on physical interaction with their visitors. On the other hand, on a positive note, most BGs have responded by developing an online presence to share their latest garden news and teaching. For example, RBGK has created an online community page to interact with visitors, improved their Wi-Fi connection for visitors and staff and converted their weekly Kew Mutual Improvement evening lectures to be held online, which is more convenient for participants (RBGK, 2020; Jodrell, 2021). Nevertheless, even without the pandemic, digital technology (DT) is necessary and fundamental for interaction, transforming experiences, and elevating BGs' sustainability. DT is also crucial for education and disseminating information without the use of bulky labels or posters in the garden (Genlott, et al., 2019). In addition, DT could be used to not only convey powerful mission statements and clear OC messages, but to effectively convey the history of 200 glorious years of Sarawak OS stories, as mentioned in 7.2.2, which have been forgotten and found only in old orchid travellers'/collectors' books, as mentioned in Chapter 2. These interesting untold stories incorporated within the elements of Phase 1 could develop emotional connections for visitors and, when the experience is taken as a whole, create an overarching story beyond expectation, creating a USP (TA, 2014; Cavanagh, Suzanne, 2019).

Plate 7-2

A is a seed pod of Den anosmum, taken by a SARORSO member, 2020, and B is a vanilla seed pod taken on a farm in Kuching.

7.2.4 Community Participation and Engagement

According to research done in 2007, to attract the YG and non-conservationist communities to visit BGs, more hands-on activities focusing on plant conservation related to their daily lives should be promoted and included (Ballantyne, Roy; Packer, Jan; Hughes, Karen, 2008), in order for these people to understand and support conservation efforts. Projects in the UOBG would act as a window into science, culture, and the economy, as it did with a similar conservation project in Belize (The Nature Conservatory, 2021); similar to the IVOM projects in schools, representation would attract school children as well as their parents to participate in OC efforts in the UOBG. Therefore, engagement and interaction with real activities involving the community as well as the YG, who would later share with the people around them and future generations, and with the oil palm community from farmers to end-users, are an indirect effective marketing strategy that would put the UOBG at the forefront of globalised OC branding (Morgan, et al., 2011)

Based on the findings in Chapter 4, sections 7.2.1 to 7.2.4 address key points that are crucial to the success of the proposed UOBG, which, while they may not be critical to the success of other BGs, are elements that are tailored to the community in Sarawak who will be the primary targeted audience of the proposed UOBG. It is important to recall the context of the creation of the proposed UOBG: to increase awareness of OS and OC in order to combat the SLEO extinction crisis. However, the practical difficulties in dealing with different interests amongst the stakeholders in achieving the shared image of a UOBG for branding could be a challenge.

7.3 Mission and Vision

According to Gillet, images are processed 60,000 times more rapidly than text, and 94% of content with visual aids gets more total views (Gillet, 2017; Newman, et al., 2019). The mission, which is relevant to Sarawak, its cultural context and economic returns for people at the end of the cycle, and most importantly addresses the global OC issue (Defra, 2011) with a focus on the endangered endemic SLEO (Beaman, et al., 2001; Ling & Sang, 2018), displayed in bold graphics (Plate 7-3) on a huge LCD screen at the entrance, would have a profound impact on visitors, customers, investors and employees (ASStudio, 2017). The list of Sarawak OS is still growing, according to the Sarawak Forest Corporation, with 10 new records unique to Sarawak recently discovered around Murum Dam (Appendix 12); but at the rate that habitat is disappearing, many orchids could be endangered or extinct before being formally described (Vermeulen, 2011; O' Bryne, 2017).

7.3.1 Mission

'Creating awareness of and engagement with SLEO and OC amongst the general public to halt OE for future generations, establishing a coherent orchid project network connecting Sarawakians to OS and their habitat, thus resulting in a transformed Sarawak with the beauty and richness of diversity of SLEO'.

7.3.2 Vision

Sustainable in its practices, relatable to the daily lives of the citizens with broad community support, a centre of excellence for research, learning about orchids, a hub for sustainable Sarawak orchid economic development, a garden displaying outstanding beauty, the historical, pharmaceutical, gastronomical and ethnobotanical use of SLEO as well as eco and cultural tourism development.

Plate 7-3

Example of a clear, large display of Mission and Vision upon entry, giving the visitor the experience of the UOBG, the 'why' (Mission) and 'what' (Day to day Operations) with creative presentation. Source: Alpine Sign Studio, 2017

7.3.3 To Achieve the Mission and Vision

Inspired by RBGK arboretums, CPBG's small gardens, Writhlington School Orchid project's (WSBE) educational and entrepreneurship activities engaging students, (SGB), Singapore National Orchid Garden's (SNOG) horticultural strength, GBB's advanced technology**,** and other BGs as discussed in Chapter 4, the proposed UOBG should create:-

i. Interesting, educational, and engaging sustainable arboretums and gardens, representing the major Sarawak SLEO and their natural habitat zones woven with historic and current everyday life events for the community and the YG.

ii. Features and facilities providing interactive, interpretive, and educational conservation opportunities for the YG as inspired by the WSBE.

iii. Economic, floriculture and horticulture business-related centre which conducts workshops and weekly lectures for the community, managing the nursery and souvenir centre inspired by the Writhlington School Orchid project (WSBE) and Chelsea Physic Garden (CPG).

iv. Heritage and cultural buildings for specialised work, such as laboratories and herbariums, and for events and occasions such as conventions, recreational facilities, weddings, exhibitions, music performances for members, inspired by the visitor-friendly Queen Sirikit Botanic Garden and Science Museum (QSBGM).

v. Functional recreational park and public gathering areas for educational, cultural and art programmes which convey knowledge, information and skills related to orchids and their conservation, as in Bangkok Botanic Garden (BBG), Thailand.

vii. Other structures and art designs represent various ethnic groups with a storyline linking back to nature with local historians, their contributions, and those of foreign botanists who came to Sarawak during the Rajah Brooke regime (Reece, 2004). This is to make the UOBG engaging and relatable to both local visitors and foreigners, thus delivering the key message.

viii. A UOBG is driven by smart digital technologies to create effective presentations of the message, enhancing visitors' experience as in developed countries' museums and gardens (Msichicago, 2021; NYSI, 2021).

7.3.4 Key Objectives

Key objectives of the proposed plan for a sustainable UOBG for the benefit of SLEO and its phorophytes, community and future are as follows:

i) Educational: to create a safe educational UOBG, maximising the ecological and geographical landscape of the unattended green belt in Kuching.

ii) Awareness: to preserve the phorophytes and other types of vegetation in the greenbelt area and create awareness among the local population and visitors by showcasing the SLEO.

iii) Role Model: to become champions and role models to other similar cities and their communities in addressing OE issues by pioneering IVOM techniques among the local community and the YG which could sustainably support the UOBG, conservation, social activities, floriculture and the tourism industry.

iv) Community Partnership: to encourage partnership with local communities throughout Sarawak through citizen science projects in order to encourage community participation in addressing the orchid extinction issue (OEI).

v) Collaboration: to invite collaboration with educational, horticultural, research, environmental, conservation, cultural, heritage botanical and other organisations to be part of the UOBG.

vi) Technology: to participate in meaningful advancement of scientific knowledge, skills, and OC activities for the benefit of the community.

vii) Revenue: to establish support facilities and amenities to generate revenue to foster and maintain a sustainable botanical institution.

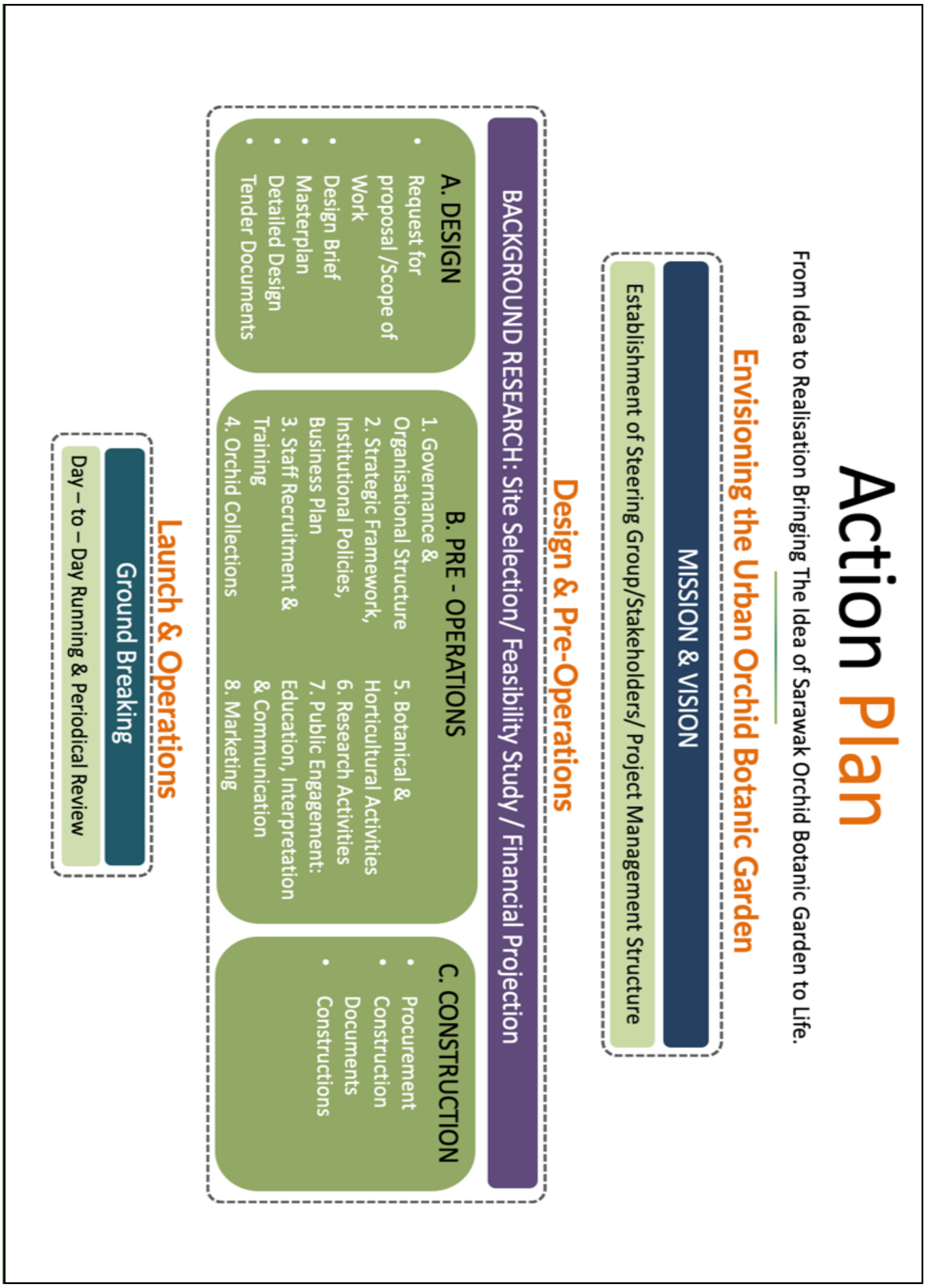
viii) Inspiration: to create an inspiring place for community learning, participation, and enjoyment.

To Grow: to include the growth and maturity of living museums or a collection of plants as well as expansion as a national institution to address the OEI.

7.4 Proposed Project Implementation

Based on the Botanic Garden Conservation International Manual – from Idea to Realisation (Gratzfield, 2016) and the earlier findings reported in Chapters 1, 2, 4, 5 and 6, the idea came to bring Sarawak Orchid Botanic Garden to Life, with the primary focus being to increase awareness among the community on issues facing critical OEI (CBDrGPSC, 2020), an action plan has been drawn up (Figure 7-3).

Figure 7-3



Action Plan: from idea to realisation in bringing the idea of Sarawak Orchid Botanic Garden to life. Planning and implementing Botanic Garden design projects. Source: BGCI Manual, 2021

7.4.1 Establishment of Steering Group/Stakeholders/Project Management Structure

It is proposed that the above plan be managed by an independent party such as the Sarawak Orchid Society (SARORSO), mentioned in Chapter 2, section 2.3, which has OC interest in their action plans as shown in their conservation efforts and activities, network activities and commitment to conserving orchids, which would ensure that the UOBG will move in the right direction with the help of other authorities (Sarawak Tribune, 2022; WSBE, 2022; Choo, 2019). In addition, the society's strong support from influential individuals (Figure 7-4) invites the participation of other government and private organisations who have both expertise and experience in OC projects, as well as the resources, to monitor and advise (Figure 7-5).

Figure 7-4

Sarawak Orchid Society (SARORSO) organisational chart; its patron is the wife of the Chief Minister of Sarawak. The Chief Minister of Sarawak (now known as Premier of Sarawak) also heads the Conservation Ministry. The Inaugural Malaysia

Conservation Conference was held in Kuching Sarawak in March 2022. In addition, the society's advisors are ministers, including the Mayor, and its mentors are directors of organisations. SARORSO's elected committee members are representatives of each division in Sarawak to ensure that any pilot projects conducted in Kuching are repeated in other divisions. Source: Tengku Auvaroza 2021

Figure 7-5

Establishment of Steering Group/Stakeholders/ Project Management Structure

The above plan will be initiated and proposed to be managed by SARORSO. SARORSO has the orchid conservation interest in their action plans, network activities and commitment in conserving orchids which would ensure that the SUOBG will move in the correct direction with the guidance and help of other authorities

The proposed stakeholders are as follows:

Advisors	Organisation	Mentors	Organization
The Mayor	Kuching City North Municipal	Assistant Director	Kuching City North Municipal
Assistant Minister	Ministry of Urban Development and Resources	Head of International Affairs	Forest Department Sarawak
Assistant Minister	Ministry of Education, Sarawak	Dean Faculty of Resource Science	University of Sarawak
Assistant Minister	Ministry of Tourism, Sarawak	Director of Tourism	Ministry of Tourism, Sarawak
Deputy State Secretary	State Secretary Officer (Smart Heritage)	Deputy Chief Scientist & Deputy Chief Advisor	Sarawak Multimedia Authority

Other Stakeholders	
Director	Kuching Water Board- KWB
Director	The Sarawak Electrical Supply Corporation- SESCO
Curator	Museum, Sarawak
Director	Public Works Department -JKR
Director	Sarawak Economic Development Corporation- SEDC

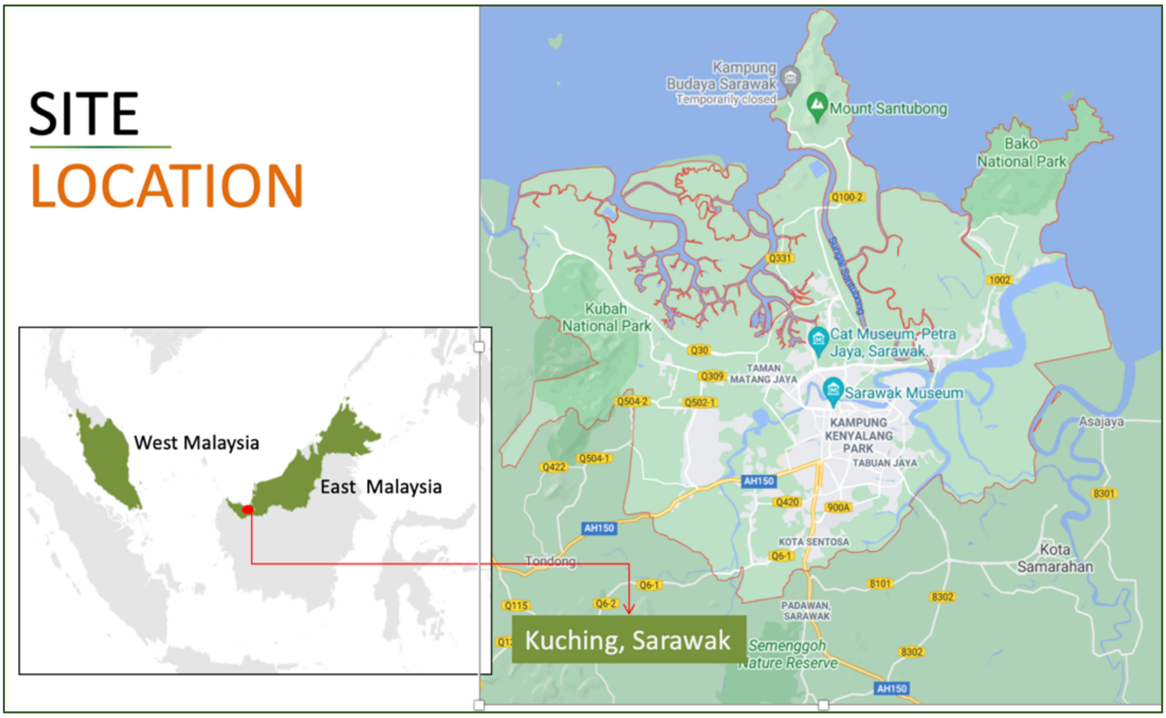
Proposed Steering Group, Stakeholders and Project Management Structure with interest and expertise in the Project. Source: Tengku Auvaroza, 2021

7.4.2 Proposed Project Location: Analysis of Existing Condition

7.4.2.1 The City

Kuching, the capital and most populous city in the state of Sarawak, Malaysia, is a strategic location and a major destination for tourists and the main gateway for travellers visiting Sarawak, East Malaysia (Figure 7-6).

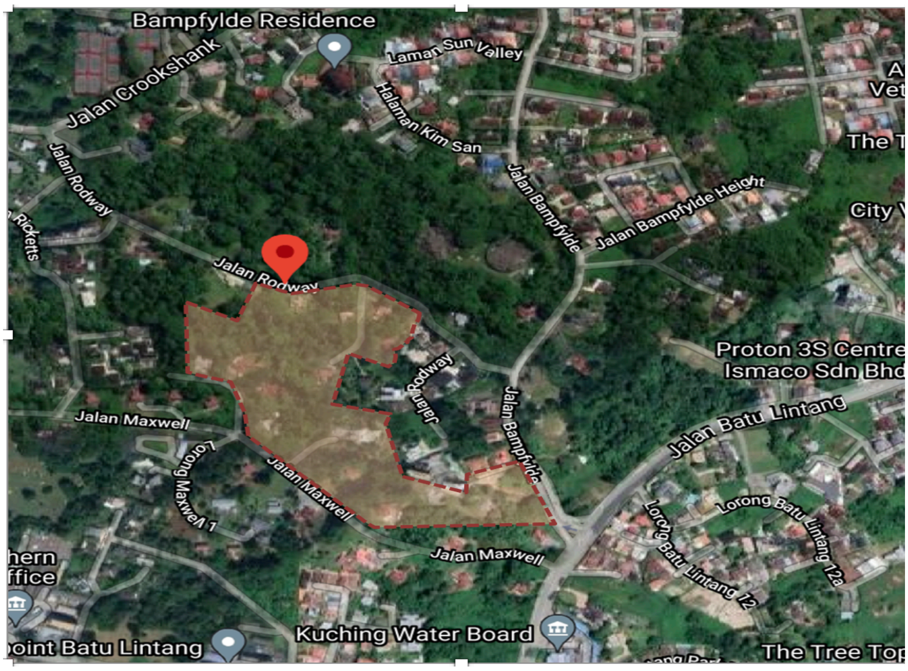
Figure 7-6



Map and location of Kuching, Sarawak. Source: Google, 2021

7.4.2.2 The Site Location

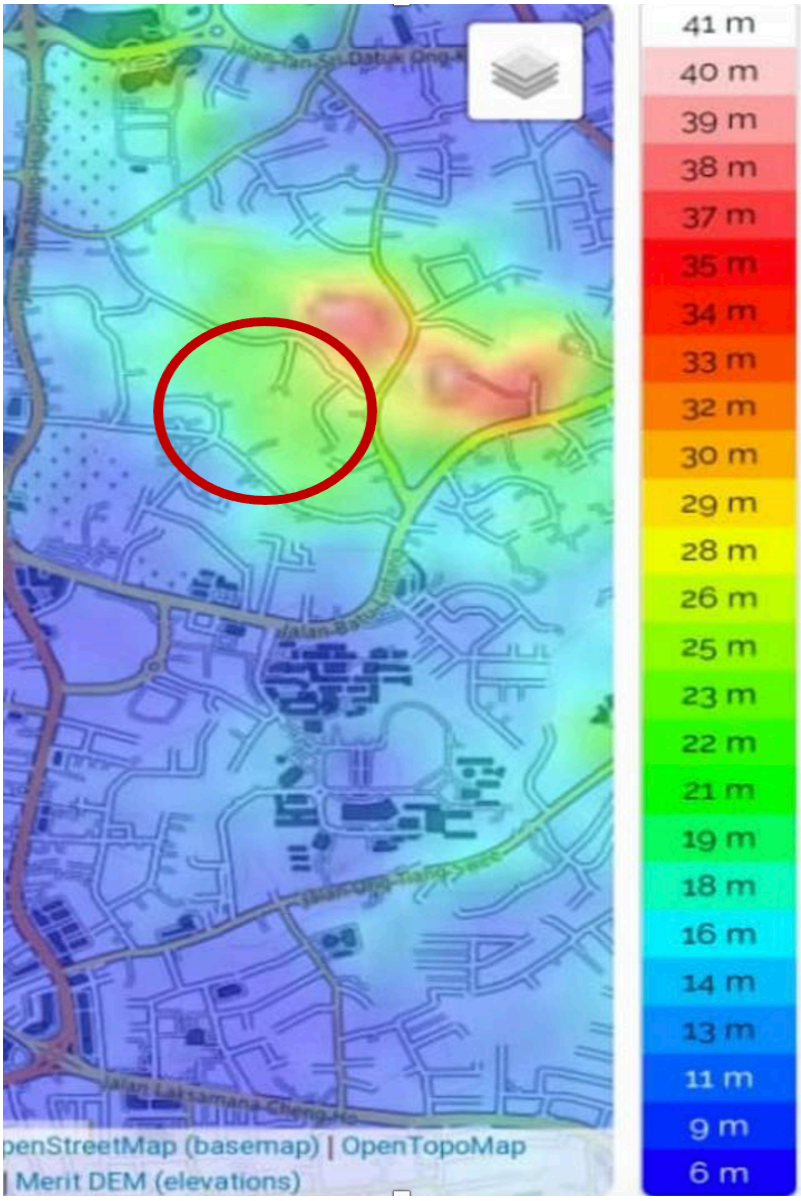
Figure 7-7



Located within the green belt of Kuching City. The land is undulating, with a small stream running across, and there are existing derelict buildings. Source: Google Maps: Tengku Auvaroza, 2019

The proposed UOBG site is located at **Grasmere** at **Jalan Rodway**, a desirable and feasible location to create a world-class, eco-cultural Sarawak UOBG (Figure 7-7), easily assessable by road. Part of the site was allocated to the Sarawak Orchid Society, SARORSO (Appendix 13), to house its headquarters. It is within the green belt of Kuching and located in a government reserve area. The site is part of a disturbed natural forest and secondary forest. There is an existing derelict building (to become the headquarters of SARORSO) located on the site. The site has an elevation ranging from 16m to 26m (Figure 7-8).

Figure 7-8



Topography Map: Area marked in the red circle. The proposed garden has an elevation ranging from 16 to 26m Source: Kuchtopo 2019

With a targeted ultimate size of **10.8 hectares**, growing more endemic and ornamental trees, it is proposed that the UOBG be developed in two phases, initially focusing development in Phase 1 on a relatively smaller four-hectare garden similar to the Chelsea Physic Garden, London CPG (Chelseaphysic, 2020) and Japanese Botanic Garden concept (Oldfiled, 2007). This initial first phase includes the footprints of its proposed facility buildings.

The remaining six hectares (Phase 2) will be a functional arboretum with minimal structure yet accessible to visitors, in line with the guideline to retain two-thirds of the land as urban green belt reserved area (Hassan & Salleh, 2019). Therefore, the proposed second phase of the UOBG consists of a sustainable arboretum to observe more OS growing naturally on more phorophytes, with minimal buildings, with perhaps a cold greenhouse for Sarawak highland OS. However, Phase 2 will not be discussed in detail in this chapter.

The proposed UOBG will include both ex-situ and in situ conservation activities in response to GSPC target 14 (CBDrGPSC, 2020) and SDG 2030, focusing on creating awareness and participation among school children (Chapter 5), the oil palm community (Chapter 6) and the general public.

7.4.2.3 The Existing Vegetation Growing in the Proposed Site

The site has a wide variety of vegetation types, with no order (Plate 7-4). The woodland is severely degraded. It has undergrowth and overly heavy invasive vines and lianas in the trees, engulfing the phorophytes, and spreading from tree to tree growing towards the canopy, which can double the probability of tree mortality if not removed (Runyon, Justin B., Negron, Jose

F., 2020; Walentowitz, A; Manthey, M, 2021). The Sarawak Forest Department has identified the existing vegetation. In addition, good quality horticultural planting with professional landscaping to improve the site from this disrepair to a state-of-the art sustainable UOBG could be a challenge (Ansari, 2008; Elmendorf & Gerhold, 2017; Luttge & Buckeridge, 2020). There are several areas with gigantic trees throughout the site that have great potential for a Canopy Walk and Canopy Web concept, similar to Singapore Botanic Garden (Nparks, 2020).

Plate 7-4

Unkempt disturbed forests, secondary forest with overgrown bushes, vines, dramatic staghorn, heliconias, common city orchid species and a profusion of ferns growing on the site would need professional landscape architects and horticulturists *to make the site into an attractive and functional UBOG which could be a model for other sites around the State. Source: Tengku Auvaroza, 2019*

7.4.2.4 Existing Built Elements and Infrastructure

There are a few 50-year-old government buildings on the proposed site and one of these is an abandoned derelict dwelling that has been assigned by the government to be the headquarters of SARORSO (Plate 7-5). As this proposed urban site is located within the heart of Kuching City (Figure 7-7 and Figure 7-8), utilities such as electricity, water and telecommunications are readily available. The transport system is also well established in the form of maintained road networks and regular public transport. As the first SLEO UBG in Sarawak, it aims to establish a prime ex-situ living collection of SLEO which will serve to complement and support in situ conservation (Oldfield & Newton, 2019). Based on the case studies presented in Chapter 4, and the Botanic Garden CI Manual for planning, developing and monitoring (BGCI, 2019), a thorough feasibility study on robust financial, legal, marketing, and environmental models as well as a social impact study need to be carried out by professionals in order to successfully develop the new venture (BGCI, 2016; BGCI, 2019).

Plate 7-5

One building is found in the location. The site has good transport infrastructure and reliable public transportation. Source: Tengku Auvaroza, 2019

7.5 Design Proposal

The proposed design is divided into:

7.5.1 Proposed Site Planning

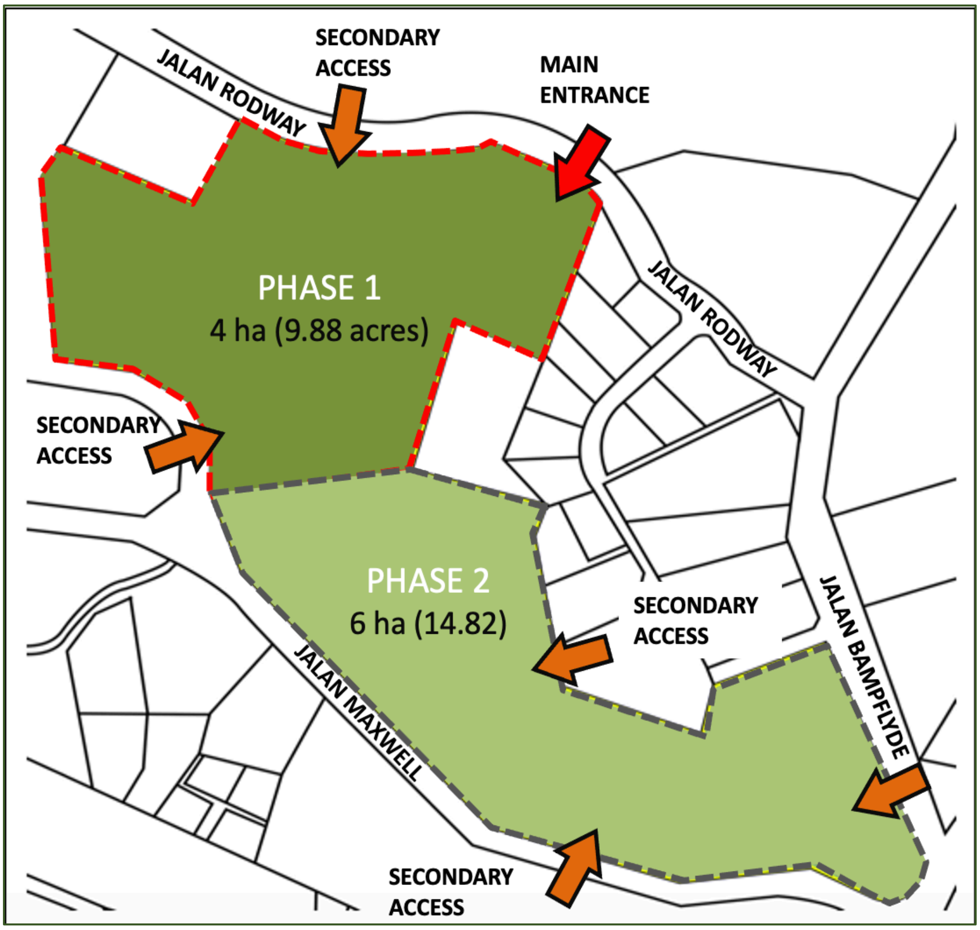
7.5.1.1 Proposed Ideas and Design Concept

7.5.1.2 Proposed Overall Plan

7.5.1.3 Images and Ideas

7.5.2 Proposed Site Planning: Phases 1 and 2

Figure 7-9



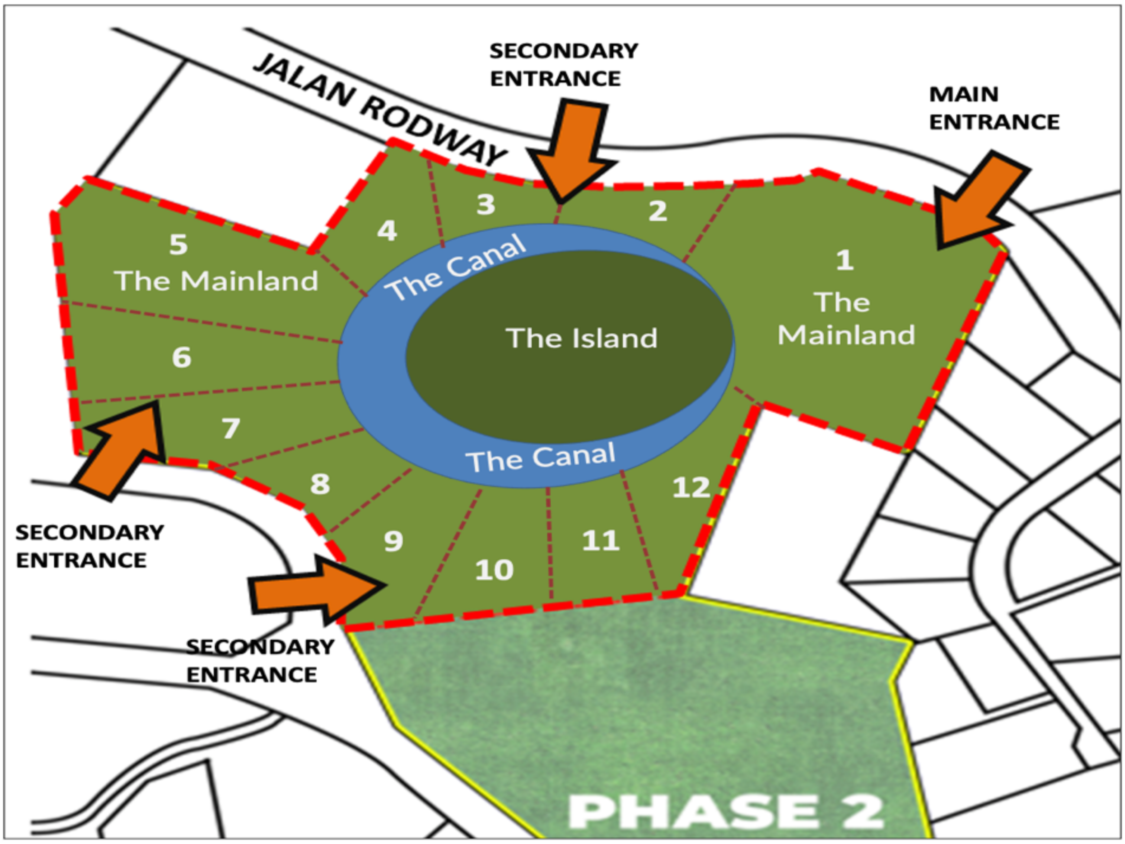
Map from Sarawak Land Survey, Jln Badaruddin. The proposed site is divided into two phases. Source: Tengku Auvaroza, 2021

For the purpose of this thesis, the research and discussion focus on Phase 1 only, as Phase 2 requires the planting of more endangered Sarawak endemic trees, as well as terrestrial orchids and other endemic plants in order to create an established, safe and mature arboretum for the benefit of visitors.

7.5.2.1 *Proposed Ideas and Design Concept for Phase 1: Creating an Attractive Educational, Functional and Relatable Outdoor Space to Create Awareness, Educate and Give Experience*

The proposed Phase 1 will consist of a four-hectare area (Figure 7-10), which is accessible from the main road, where there is existing infrastructure and fewer trees towards the front. The main entrance to the site will be from Jalan Rodway with secondary entrances from Jalan Rodway and Jalan Maxwell. This proposed setup is based on RBGK's early concept whereby the entrance and exits are important to quickly clear the queue of visitors. (RBG, 1957; BGCI, 2016; BGCI, 2019). Since the proposed area is a secondary mixed dipterocarp forest with scarce trees, additional trees need to be planted to conserve Sarawak OS of which 80% of the 2000-2500 species are epiphytic (Beaman, et al., 2001; SBFM; FRIM; SARFDM, 2000; SFC, 2018).

Figure 7-10



Proposed Design Concept of Phase 1. The proposed four-hectare Phase 1 is subdivided into three parts, the Island, the Mainland (or the Outer which is further divided into 12 sections according to the 12 administrative division of Sarawak representing different habitats found in each respective division) and the Canal separating the Island and the Mainland. This will educate visitors without their having to go to the 12 divisions to observe the orchids, their habitats and the ex situ conservation activities. Thus, these divisions will also represent the different types of OC activities being carried out by societies, government schools and agencies and other parties both local and internationally. Source: Tengku Auvaroza, 2021

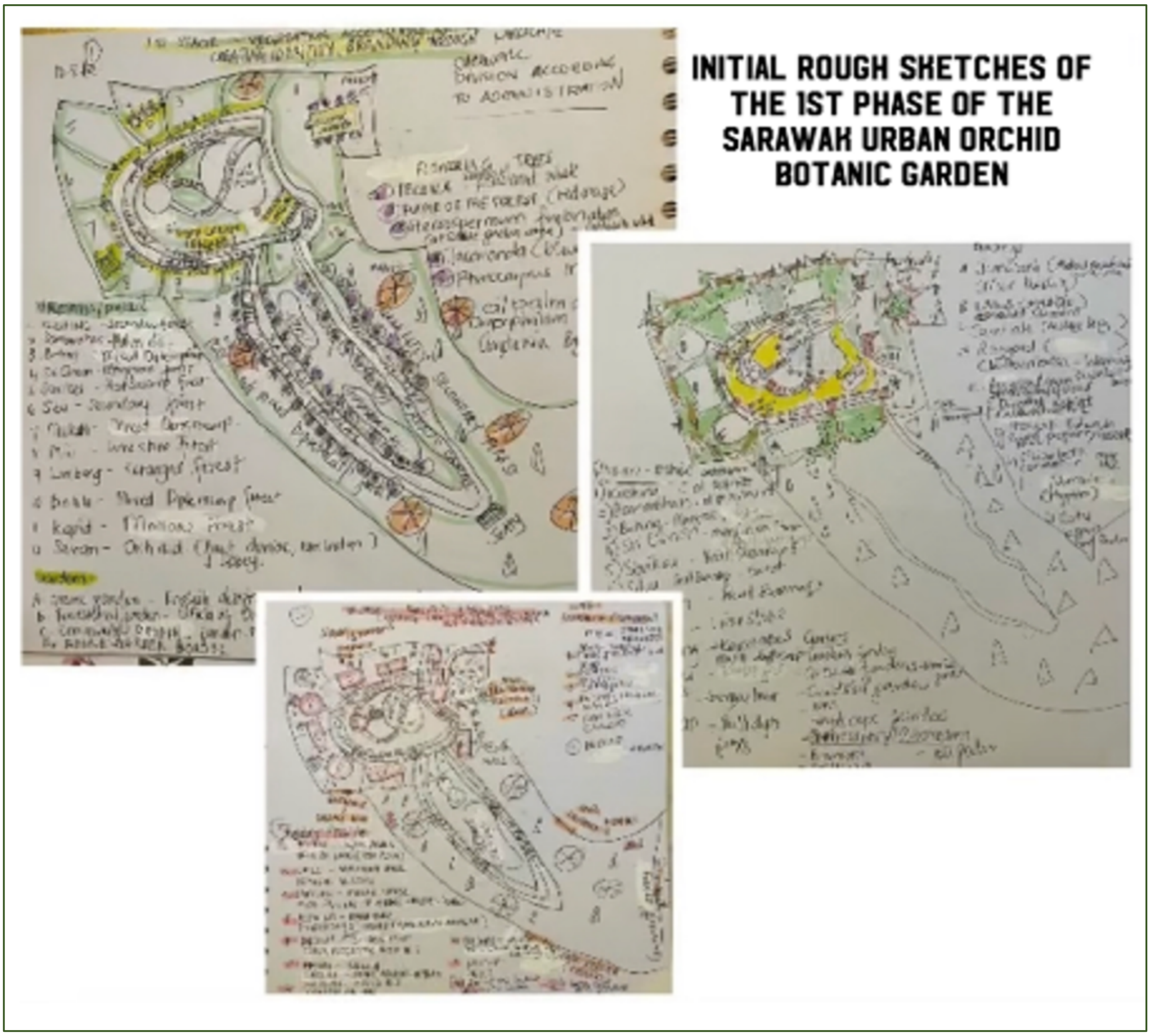
It is proposed that the four-hectare Phase 1 enclosed space is designed with a storyline, based on the history of Sarawak OS to create interest in the UOBG (Figure 7-6). The whole of Phase 1 of the UOBG has two layouts, a formal and an informal design (Bunting, et al., 2018), and is further divided into three main areas, as follows:

7.5.2.1.1 The Mainland: Outer area is further divided into 12 sections according to the 12 administrative divisions of Sarawak, imitating respective SLEO habitats. It comprises an informal permanent forestry landscape based on permaculture design with traditionally designed facility buildings which include ongoing OC activities creating experiences for visitors. **It aims to expose visitors to the threats and vulnerability of SLEO as well as the legislation and regulations protecting them. Simultaneously, it will educate visitors on how simply SLEO can be removed from their habitat to encourage them to manage and protect the SLEOs around their area, thus addressing the gaps in knowledge and practice** (Wraith, et al., 2020).

7.5.2.1.2 The Canal: A horseshoe-shaped water body that separates the Island and the Mainland, it also represents the Sarawak river which was once a functional access route for orchid collectors to hunt for orchids in the early 19th century, as mentioned in Chapter 2 section 2.5. It also has a proposed U-shaped amphitheatre with attractive details, to be engaging, educational, and inspirational. Encircling the Island, the functional canal aims to give visitors not only an enjoyable tour around the Island but also aims to expose visitors to the glorious history and international recognition and demand, and to inspire them with the adventures and achievements of the international orchid collectors as narrated in the historical accounts in their books, bringing OS to international recognition and a craze for collecting (Kingsland, 2017) – the craze which also resulted in the unsustainable illegal trade, continuing today, as reported by the scientist Amy Hinsley in conservation journals (Hinsley, et al., 2017; Hinsley, et al., 2018; Hinsley, 2018; Hinsley & Fay, 2018). This information could be presented using digital technology in a compelling, emotionally engaging, interactive format at each point the canoe passes.

7.5.2.1.3 The Island: The Central Island, with formal & informal gardens, is the main aesthetic attraction, displaying horticultural strength, with orderly formal landscape gardens and a designed natural habitat as well as a recreational pond, which has proven effective to attract visitors and animals in other BGs (Ballantyne, et al., 2008; Paiva, et al., 2020). It also elevates OS to a new perspective, opening the eyes of the visitors to appreciate native OS instead of the showy imported hybrid orchids sold at local markets. Initial rough sketches were done by the author based on research and findings as recorded in previous chapters (Figure 7-11), before using software to create the proposed plan in Figure 7-12.

Figure 7-11



Rough sketch of the layout of Sarawak Urban Orchid Botanic Garden, sketched by the author before using software to create the proposed plan. Source: Tengku Auvaroza T. Abraham, 2021

7.5.2.2 Overall Proposed Master Plan of UOBG

Figure 7-12

The proposed detailed Master Plan. Illustrated by Hakim, WA, 2022, Source: Tengku Auvaroza 2021

7.5.2.2.1 Phase 1: Four hectares comprising a mix of garden elements, arboretums and culturally designed building facilities offer state-of-the-art amenities (Figure 7-12).

7.5.2.2.2 Phase 2: Six hectares comprising only arboretums, with taller and bigger endemic trees planted around the perimeter to protect the garden from storms and strong wind, and smaller species including fruit trees in the centre. A proposed temperate greenhouse is to be built in the future to house Sarawak Highland OS which needs a lower temperature to grow and bloom, with the canal from Phase 1 extended to give visitors similar adventures highlighting global OC work and again displayed through visitor-friendly DT, presented in a compelling, emotionally engaging interactive format at each point the canoe passes. The proposed delayed opening of Phase 2 is to allow newly planted trees, OS and translocated endemic terrestrial plants such as Amorphophallus hewetti, Tacca chantreii and Begonia plants (Plate 7-5) to mature. The Phase 2 arboretum is botanically diverse, imitating the Sarawak forest as told by the orchid travellers (Low, 1968; Mjoberg, 1930; ForestSWK, 1995; Low, 2002; Beaman, et al., 2001; ForestSwk, 2019), creating a unique garden only found in Sarawak. Nevertheless, this plan could prove to be a challenge to Sarawak horticulturists and soil and water experts, as this is the first UOBG. However, it will create awareness and address OS blindness (Baldinhg & Williams, 2016), educating the community regarding OS as Sarawak's natural resource and heritage, highlighting the importance of OC as well as maintaining rich biodiversity. As mentioned previously, the UOBG should also inspire visitors to be involved in plant conservation, especially OC, which has been largely neglected compared to animal conservation (Heywood, 2017; Cowell, 2020).

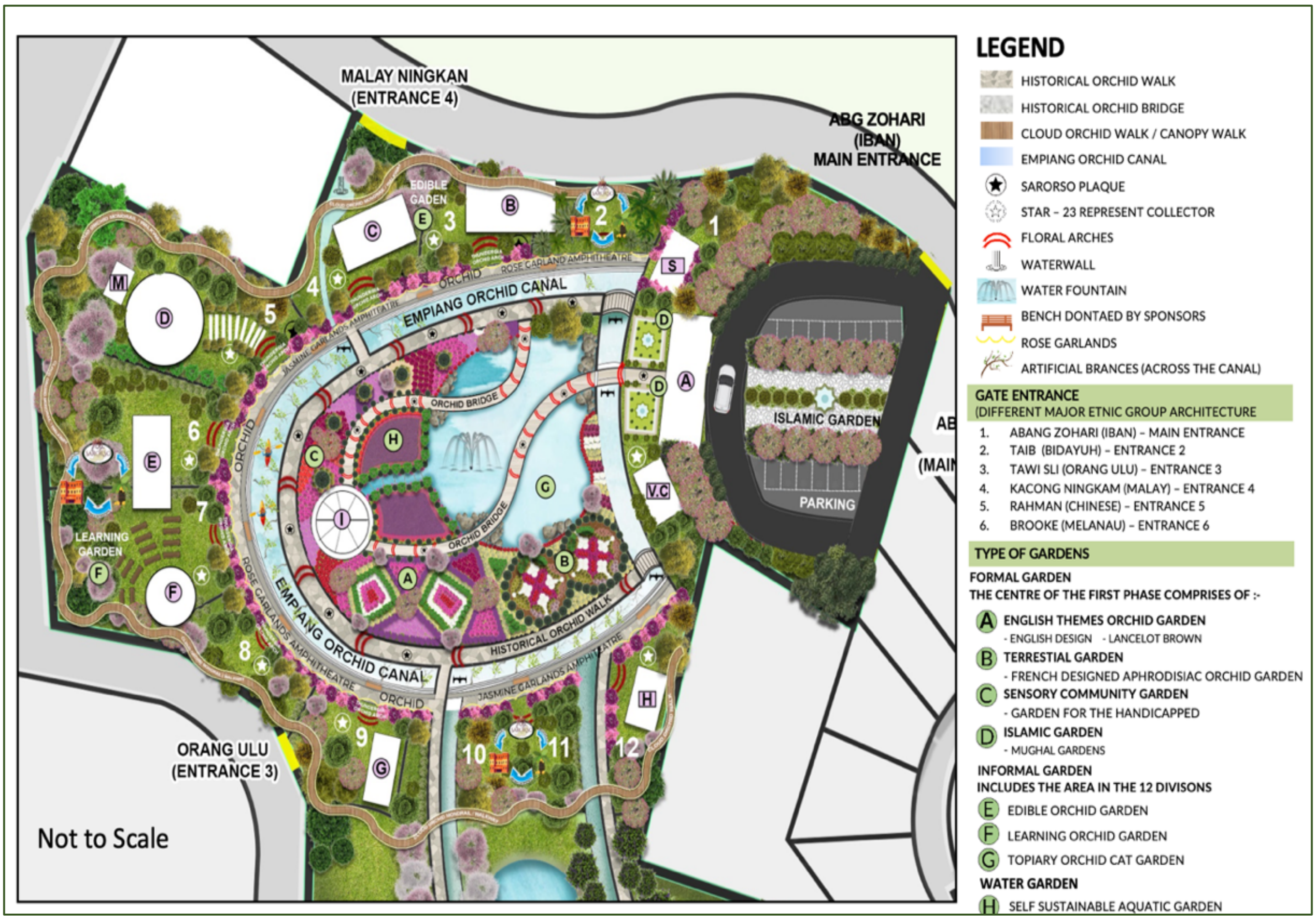
Plate 7-6

Proposed terrestrial flowering plants to be translocated into Phase 2. A. Begonia sp; B. Green Tacca chantreii (there are purple, black, white, pink and green); C to E. Colourful Amorphophallus hewetti. Source: Tengku 2018

On the other hand, awareness of the value of OS could also initially lead to an increase in illegal harvesting of OS due to the supply being unable to meet demand, since the IVOM projects in schools (Chapter 5) are still young and it will take a while for the protocorms and seedlings to mature like those in the forest. In addition, not all OS can be successfully produced in volume in schools, as the project is at a very early stage. Awareness and education are important, but there is no one standard solution to totally curb unsustainable OS trade, even though all tools are available (Fukushima, et al., 2021). An integrated multidisciplinary body is required, representing all parties including the heads of villages, government scientists and horticulturists and politicians, including mass media publicity (Hinsley, 2018; Phelps, et al., 2018).

7.6 Phase 1: Proposal Based on Permaculture Design – Garden Elements, Aboretums, Building Designs, Elements of Landscape and Vegetation

Figure 7-13



Detailed Plan of Proposed Site Plan: Phase 1, inspired by BG as in Chapter 4. Illustrated by Hakim, WA.

Source: Tengku Auvaroza, 2022

Based on the role of the UOBG and its objective, as well as the evolving function of BGs today as interesting scientific and educational establishments, functional and attractive green lungs of the earth in the Anthropocene (Cannon, 2017; BGCI, 2018), the proposed features for each of the three main areas of the UOBG (Mainland, Canal and Island as mentioned in 7.5.2) are summarised in Figure 7-13,Figure 7-14,Figure 7-15. The proposed features include:

- Both formal and informal gardens with the crowd-pulling element of landscape conservation using OS and local vegetation in order to be sustainable, directly economically beneficial to the people as well as to the environment in line with the global conservation focus, whilst inspiring visitors by seeing OS in a new way (Cannon, 2017; Giovanetti, et al., 2020; BGCI, 2021),
- natural-looking water features conveying the importance of water are major features in BGs (BGCI, 2016),
- historical elements to create pride and nationalism among locals and interest for international visitors as in other BGs (Rakow & Lee, 2015; Nparks, 2020),
- cultural heritage elements, such as the traditional/cultural character of buildings, to further enhance the identity/brand of the UOBG (Shouten, 1995; Hasan & Jobaid, 2014) as well as for both social and economic purposes as seen in RBGK, SBG and other BGs as discussed in Chapter 4, and
- a focal point that engages the visitors (BGCI, 2015).

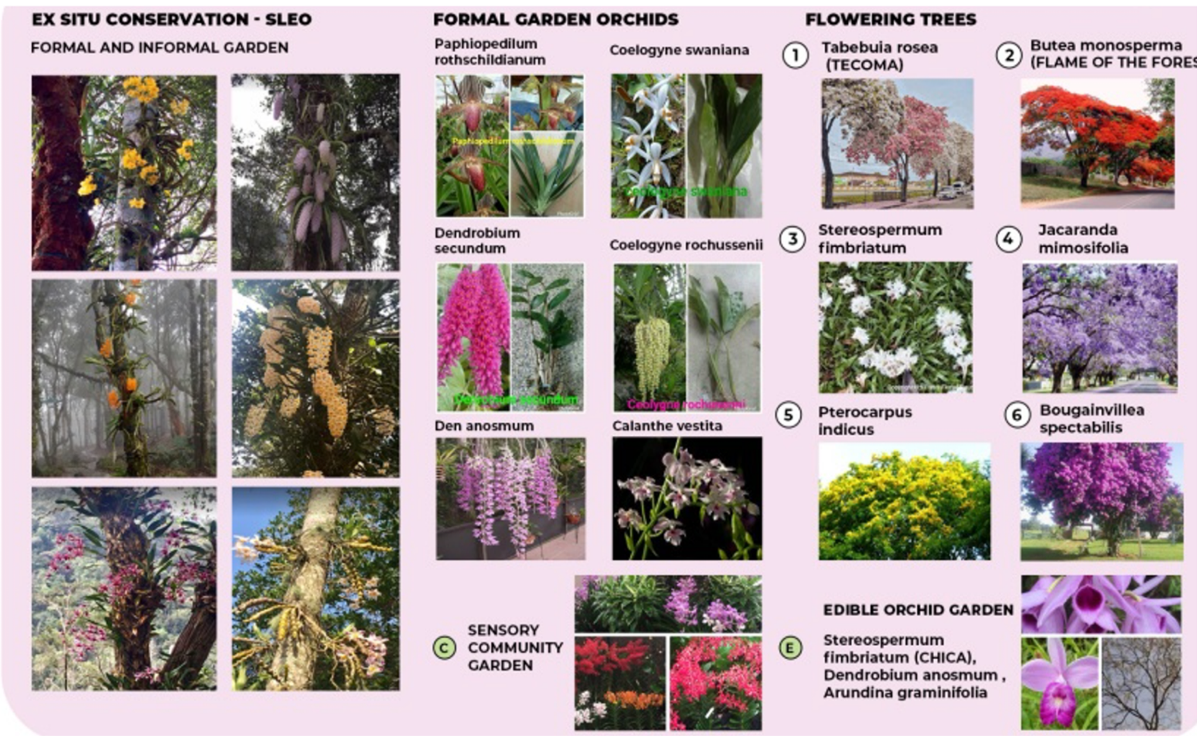
Figure 7-14

It is proposed to build a unique traditional BUILDING and naming it to create sense of belonging and to encourage participation with modern state of the art FACILITIES in Phase 1, using green technology. Source: Tengku Auvaroza, 2021

Figure 7-15

Proposed elements of the landscape based on their success and effectiveness. Source: Tengku Auvaroza, 2021

Figure 7-16

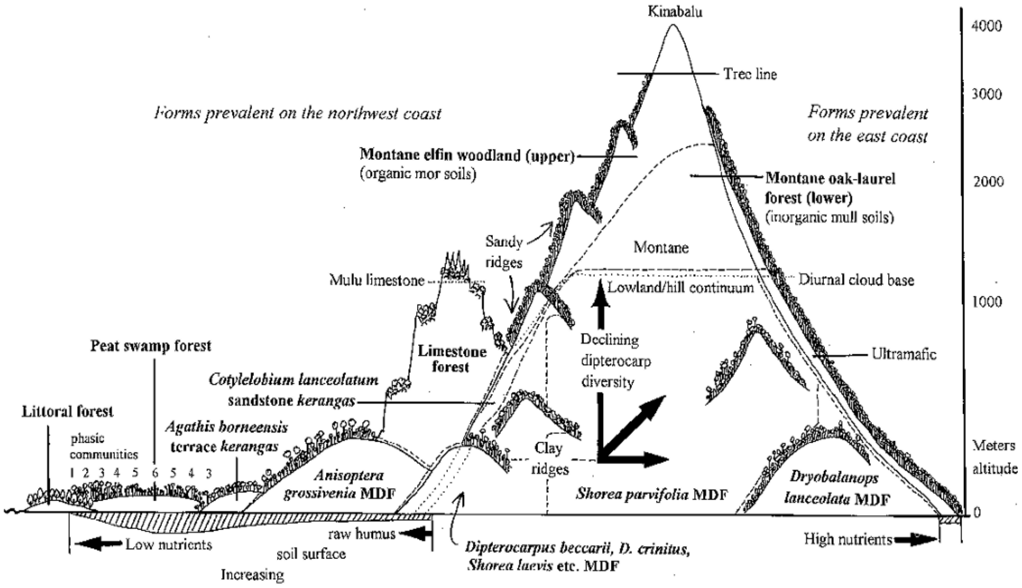


Proposed vegetation to be included in Phase 1, to create the identity and a successful impact for the UOBG, reflecting its role and objectives. Far left and centre are OS at Gunung Jerai Botanical Park which flower frequently and heavily with *potential commercial value for floriculture and horticulture purposes. Top far-right are flowering trees found in Sarawak which could act as phorophytes for epiphytic plants for splashes of colour at different times throughout the year, as well as to promote the diversity and biomass of the ecosystem. Centre bottom features recommended local plants for sensory purposes, and on the bottom row is vegetation which is used for the edible orchid garden. Source: Tengku Auvaroza, 2021*

7.7 Phase 1: The Detailed Proposed Mainland, Canal and Island Concept

Phase 1 is accessible from the main road and is a secondary mixed dipterocarp forest with scarce trees. More phorophytes need to be planted for the purpose of mounting more SLEO to imitate the various orchid natural habitats and the density of tropical forest in Sarawak (Beaman, et al., 2001; O' Bryne, 2017; Zhang & Ho, 2018). The additional types of trees to be planted will include endemic and rare endangered trees of Sarawak (SFDM, FRIM, SWFDM, 1994; Soepadmo, et al., 1996; Ling & S, 2012) including local unique fruit trees '*to die for'* as described by Swedish botanist Dr Myoberg (Mjoberg, 1930; Blancke, 2016), as well as flowering trees to encourage pollinators (Horak, 2004; Paulus, 2019) and increase the aesthetic value of the proposed UOBG by the splashes of colour when in bloom.

Figure 7-17



Diagrammatic chart of main variety of Forests against major floristics in Sarawak and Sabah. Source: (Soepadmo, et al., 1996, p. XLV)

No	Division	Landscape/vegetation
1	Kuching	Mixed Dipterocarp Forest – Richly Diversified
2	Kota Samarahan	Peat Swamp Forest
3	Sri Aman	Mixed Dipetrocap
4	Betong	Terrace Kerangas (Tropical heath forest)
5	Sarikei	Sandstone Forest
6	Sibu	Mixed Dipterocarp
7	Mukah	Littoral Forest -Coast and Caves
8	Miri	Limestones Forest
9	Limbang	Mangrove Forest
10	Bintulu	Secondary Forest Mixed Dipterocarp
11	Kapit	Montane Lower Forest
12	Serian	Monoculture Forest

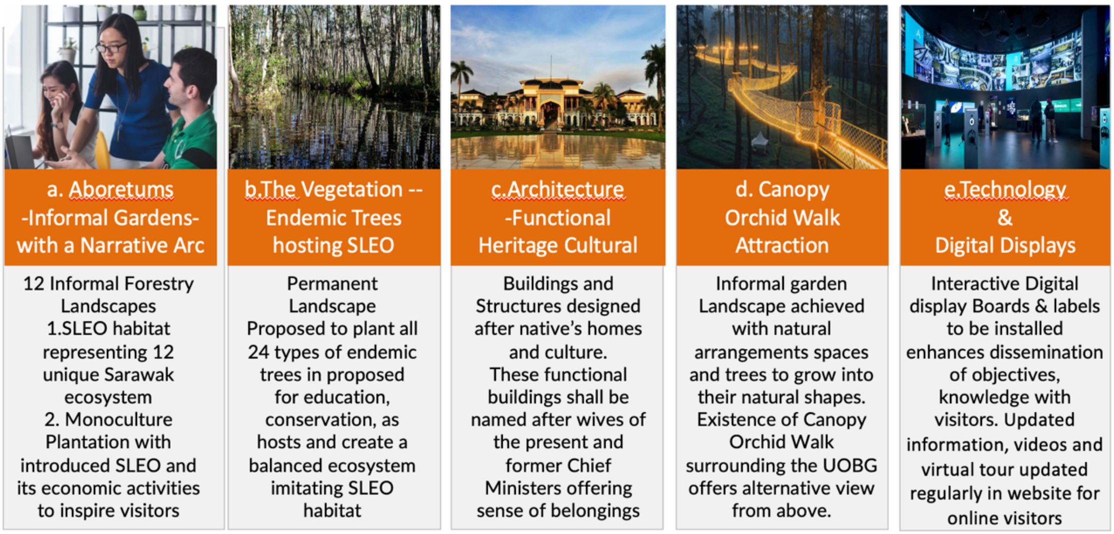
The 12 subdivision zones of SUOBG represents 12 administrative divisions with different landscape for orchid habitat

The various orchid habitats found in each Division in Sarawak. Source: Soepadmo, et al., 1996, p. XLV

7.7.1 Phase 1: The Mainland

The proposed outer area around the canal is referred to as the Mainland. The landscape is an **informal forestry garden** which is divided according to the 12 administrative **divisions which form Sarawak** (SGov, 2020). The design of **each of the divisions represents the characteristics of Sarawak forestry** which will be reflected in the landscape, building structure/design and the vegetation. The proposed main features of the mainland are as follows:

Figure 7-18



Summary of features and elements of the Mainland. Source: Tengku Auvaroza, 2021

The proposed main features of the mainland are as follows (Figure 7-19):

a. The arboretums and gardens – functional forestry landscape representing unique diverse orchid habitats found in 12 Administrative Divisions. This concept is inspired by the complex Princess of Wales Orchid Conservatory, RBGK, which supports 10 computer-controlled world climatic zones under one roof (RBGK, 2020).

b. The vegetation – an additional 24 types of endemic trees and vegetation including fruit trees and other flowering trees in order to recreate the natural environments of SLEO orchid habitats in Sarawak, and to create a sustainable ecosystem (SFDM, FRIM, SWFDM, 1994).

c. The heritage culture – functional traditional buildings, with structures to represent each major ethnic group in Sarawak, named after local charismatic leaders to add national identity, recognition, legacy and support, to develop a sense of belonging, participation and commitment from both the authorities and the community (Caiazzo, et al., 2020).

d. The Canopy Orchid Walk – elevated timber walk, allowing visitors to observe SLEO at its highest point, in the canopy of the forest, to connect one point of the UOBG to another. Inspired by the SPH Walk of Giants, Singapore (Nparks, 202) and the Amazon Peru Canopy Walkway (Lowman & Heineman, 2021).

e. Technological and digital displays – a collaborative approach to further increase effectiveness in disseminating key messages on OE issues (Postolache, et al., 2021).

Figure 7-19

The Proposed Mainland of Sarawak Urban Orchid Botanic Garden (Coloured). Outer area of site. Source: Tengku Auvaroza, 2021

7.7.1.1 The Mainland: Aboretums and Gardens with a Narrative Arc = Educational and Informative

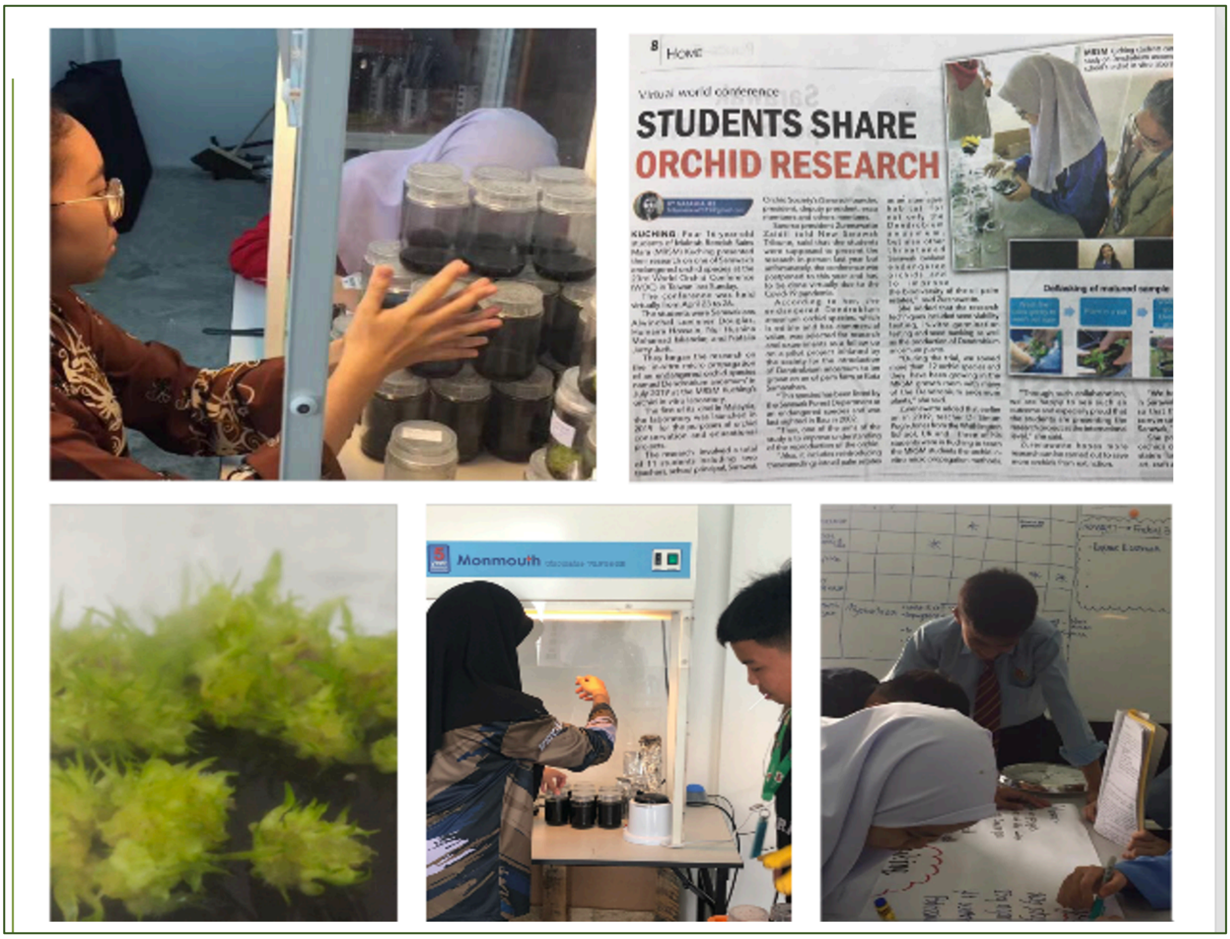
This idea of administrative divisions maximises the use for educational, informative and OC purposes. Therefore, by reconstruction of habitats for SLEO, and arboretums and gardens which include plantations (Plate 7-7), with OC activities relatable to visitors with the support of digital technology, to help them visualise how SLEO, their habitats, their contribution to the ecosystem as well as the environment and humanity must co-exist and evolve in harmony (Wraith, 2018; Zhang & Ho, 2018).

Plate 7-7

Some of the unique SLEO habitats. With the recreation of habitats, UOBG will offer a wealth of information and be a learning opportunity for understanding OC, addressing scientific, aesthetic and ecological values. Source: SFC, 2020

Activities described in Chapters 5 and 6 leading to ex-situ conservation would receive more engagement and support from the public if they could become aware that humanity is 'burning the library of orchid life' (Hogan & Hickman, 2021). In addition, **engaging youth** in UOBG as an extra-curricular activity could **encourage youth participation in OC awareness,** as shown by students of Writhington, UK and MRSM Kuching. Not only will this arboretum create a quiet sanctuary in a busy urban surrounding, but also provide environmental and pollen diversity, attracting pollinators and wildlife (Donkersley, 2019). In addition, this would reverse the decline in pollinators, improve pollinator resilience (Sutter, et al., 2017) and benefit the main attraction. Activities involving plants for pollinators also need to be included among building activities for the YG, such as identifying orchids, their hosts and pollinators, and planting. Indirectly, this will teach them about natural pollination, which would help the UOBG to become a sustainable project (Patel, et al., 2021). The presence and engagement of young visitors in the proposed UOBG are crucial as they represent the next generation and could motivate others and ensure continuous engagement (Sanders, et al., 2018).

Plate 7-8



15-year-old student from MRSM Kuching actively involved in ex situ conservation and successfully producing bottles of Dendrobium anosmums protocorms, and they presented at the 1st Virtual 23rd World Orchid Conference in Taiwan. They successfully presented a poster on in vitro micropropagation. Source: Tengku Auvaroza, 2021

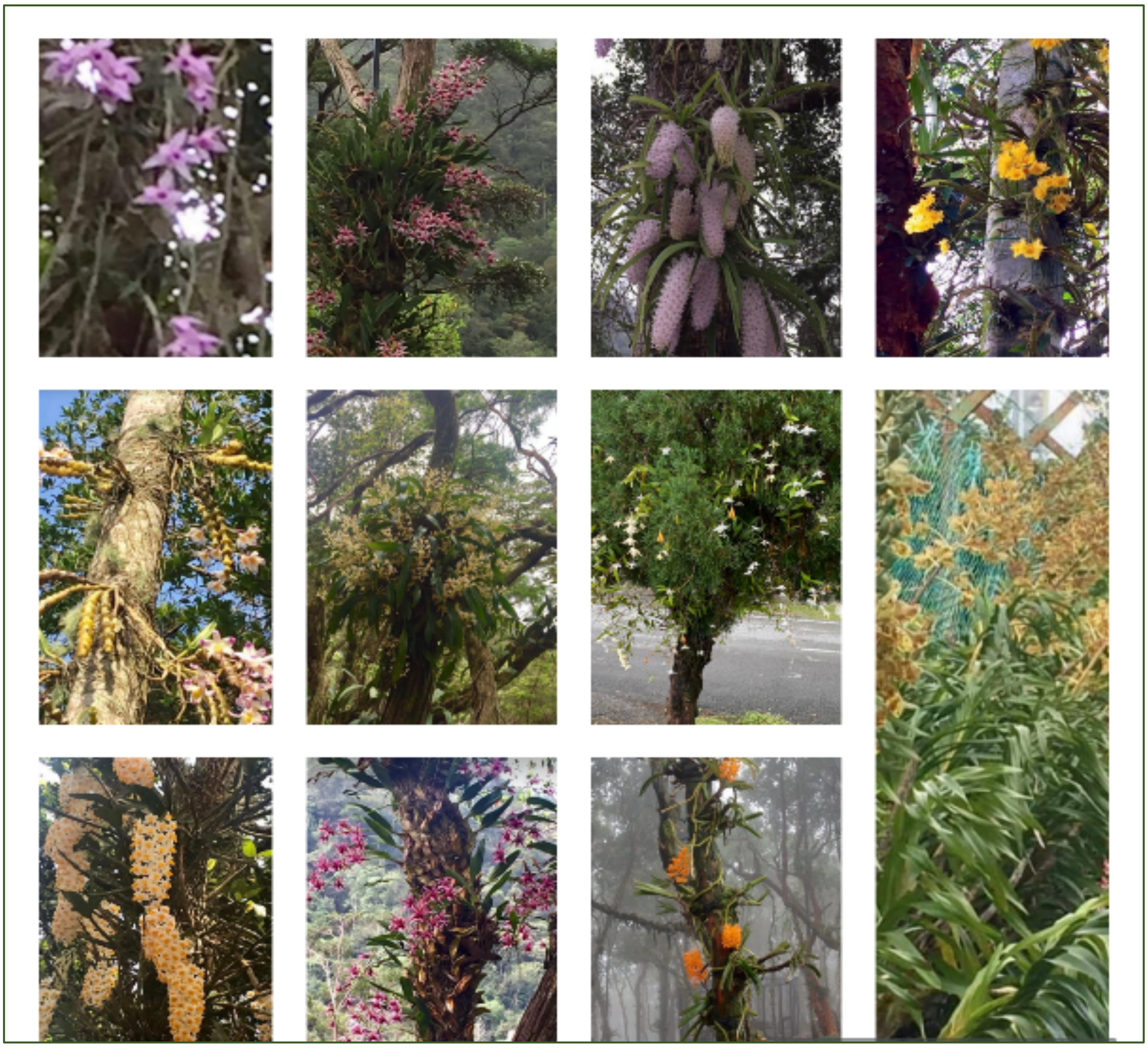
Therefore, as visitors enter different divisions with live activities, they could be guided through by volunteers or aided by technology and programmes. They will be educated on the importance of conserving SLEO, the threats to their habitats and on local legislation against illegal OS activities. The aim is that visitors develop a sense of belonging, responsibility and are inspired by nature, leading to understanding of the necessity to preserve these natural resources for the future.

7.7.2 The Mainland: Vegetation – Endemic Trees, SLEO and Activities

It is proposed to add more endemic and endangered trees to the existing secondary forest (mixed dipterocarp) in order to create an arboretum stretching around the SUOBG and the buildings. This arboretum represents the mega-rich flora of Sarawak, of 15000 different species (SFDM, FRIM, SWFDM, 1994; Soepadmo et al., 1996), and 2000 OS coexisting with the various monoculture plantations. The arboretum embraces many principles of permaculture as inspired by the arboretum in RBGK (Aranya, 2015), by using techniques and strategies modelled on natural ecosystems, creating permanent landscapes around the main buildings. Permaculture design (Bloom & Boehnlein, 2016) is said to rejuvenate the soul, restore trust among visitors and provide food (fruit, nut trees and plants) and also maintain diversification.

However, the main attraction and the unique selling point of the UOBG are the luxuriant OS (of which some are edible and medicinal) mounted on the trees (Plate 7-9) among varied mosses, covering the trunks of the phorophytes as applied in GJBG (Lucas, Manuel, 2018). The hands-on experience of going through the different OS habitats in these reconstructed habitats would allow visitors to observe terrestrial, saprophytic, epiphytic and lithophyte orchids growing and flowering, saving the forest from being visited by tourists. Visitors can also realise how simply OS can be removed from the phorophytes illegally, which could cause species extinction (Hinsley & Fay, 2018; Fay, 2018).

Plate 7-9



Orchid species mounted on trees in Gunung Jerai Botanical Garden in West Malaysia, flowering profusely. With specialised orchid horticultural skills, UOBG could also produce profusely flowering orchids as shown. Source: Ooi, 2018

In addition, the arboretum would not only be a striking landscape, a living, scientific, botanical museum, vital for fascinating SLEO research and conservation purposes, and also a place for communities to connect with the remaining public sectors that are engaged in citizen science projects, such as the introduction of rescued orchids into alternative habitats, such as the *Elaeis guieensis* and *Durio zibethinus* (Plate 7-10), saving SLEO from extinction as has been done in Turkey (Oldfiled, 2007, pp. 75-80; Ilinois, 2020), increasing the biodiversity of monocultures and being a catalyst for sustainable orchid floriculture.

The economic activities as a result of OC efforts, such as the production of orchid herbal tea by the SARORSO, together with the Malaysian Agriculture Research and Development Institute (MARDI), could inspire visitors. Through this exposure, visitors could learn and be educated by findings that will motivate participation by the public, leading to more discoveries that could help them economically, as such participation in recovery programmes could prevent SLEO from extinction, increase the biodiversity of monocultures and be a catalyst for sustainable orchid floriculture and horticulture in oil palm estates, as in Chapter 6.

Plate 7-10

Dendrobium anosmum flowering and producing seed pods in an Oil Palm Estate. Involvement of the oil palm community in Orchid Conservation projects is a new beginning for both orchids and biodiversity issues in monocultures. Source: Tengku Auvaroza, 2020

The whole arboretum and Mainland area would be a splendid field for scientific OS research, equipped with QR codes to offer practical ways for visitors to access information. As such, the UOBG is a unique proposition, as visitors will go through different experiences and witness different arboretums and gardens developed in the various divisions of the mainland. Each pathway educates and gives a different experience to visitors with a clear educational mission for each design.

7.7.3 The Mainland: Functional Heritage Culture Buildings and Structures – Architecture

Sarawak has a rich and unique history expressed in its architecture, cultural attractions, gastronomy, natural resources, logistics, local and international politics, and is renowned for her hospitality, making Sarawak a unique and competitive urban tourist destination (Motac, 2021). These attractions are identified as essential elements that appeal to tourists and need to be highlighted, developed, and packaged in order to make the destination competitive in attracting visitors (Morgan, et al., 2011; Mirabent, 2019). Thus, based on these elements and the findings of successful BGs presented in Chapter 4, it is proposed that buildings in the UOBG be designed in accordance with indigenous communities' habitats, as in Figure 7-20, to create successful branding and identity. This is also to enhance the Sarawak forest landscape which has been created as a background in the Mainland area, as well as being one of the establishment's main objectives, which is to promote its valuable SLEO heritage. In addition, heritage tourism is reported to be another USP globally, playing an impactful role in attracting people to visit a destination, stay longer and repeatedly return (Timothy & Boyd, 2008; Baker, et al., 2021). With cultural and heritage tourism, local visitors find it more relatable, engaging and memorable, which assists in promoting the preservation and protection of natural resources, and building healthy relationships with the community (Childs, 2020).

Figure 7-20

No	Building Function 'Named After CM spouses"	Sections and Hands –on Activities	Location/ Ethnic Dwellings Vegetation
A	**Main Entrance** Building Very Important Buildling ***'JUMA'ANI'***	• Reception Centre & Welcome Visitors With Interactive Multimedia Presentation Subtly guiding visitors on what to Expect from Visit subtly using screens, Video Walls, Info kiosk, inspired by Chicago and New York Museums and gardens. • Gallery of SARORSO's Patron • Auditorium 5 minute briefing to welcome visitors also used for evening orchid programs after work (inspired by Jodrell Community lectures, RBGK) • Mini Lab, Herbarium, Library, Administrative Office, Rest Room, Sarawak Orchid Society, HQ	**Division 1- Kuching** The Old Astana ***(Palace)-*** Mata Kuching Kristal T.Grammatophyllum speciose E.Dendrobium cinnbarinum L.Coelogyne echinolabium SDimorhorcis lowii/ rossii
B	**Natural Museum 'LAILA'** 6th	• History of Sarawak Orchid Species • Introduction of Orchids Into Oil Palm. Other value added activities • Gallery of Laila Taib • Rest Room/Souvenir Shop	**Division 2- Kota Samarahan** **Melanau House** E.Dendrobium lowii T.Arachnis L. Cologyne muluensis
C	**Gastronomy- Food Pavilion *'JAMILAH'*** 7th	• Restaurants and Hawker style Sarawak Cuisine to International • Child Care • Children Play Pan/ Orchid Library • Gallery of Jamilah Anu • Rest Room/Souvenir /Nursery shop (cook book)	**Division 3-Betong** **Malay Kpg House** E.Coelogyne L.Oberania snousa

List of three proposed traditional buildings, their names and functions, and the vegetation planted in their gardens. Source: Tengku, 2021

Figure 7-21

No	Building Function 'Named After CM spouses"	Sections and Hands –on Activities	Location/ Indigenous Dwellings
D	**Cultural & Art Orchid Centre 'ROSALIND'** 1st	• Gallery on History of Orchid Ethnobotany, Medicial Orchid Art and Craft Gallery • Orchid in Cultural/Tradition • Craft Short Courses for Public • Rosalind 's Gallery • Rest Room/Souvenir Shop	• **Division 4 -Sri Aman** • **Iban Long House** • 1.Vanila • 2.Ephalaenopsis lobbi(p) • 3.Ephalaenopsis anabilis (P)
E	**Youth Centre & Academy 'DOROTHY'** 2nd	• Gallery 1 History of the School Orchid Project • Dorothy's Gallery • Current School Activities • Laboratories-Mini Propagation Courses • Rest Room/Souvenir shop	• **Sarikei** • **Baba Chinese House** • All orchids which are in the Ex situ conservation conducted my school children
F	**Orchid Library & 'Herbarium HAYATI'** 3rd	• Collection of Books/ Data for Members & Public(read there) • Documenting Orchid • Hayati's Gallery • Rest Room/Souvenir shop	• **Sibu** • **Bidayuh** • E. Cymbidiums • T.Coelogyne Motleyi • L. • S
G	**Convention Hall & Exhibition Center "ELIZABETH"** 5th	• Convention Centre /Auditoriums • Halls • Orchid Botanical Art Gallery • Elizabeth's Gallery • Rest Room/Souvenir shop	• **Limbang** • **Orang Ulu House** • E.Denrochilum havilandi • E.Calanthe vistate • T. Renanthera iganteann • S.Schoenorchis buddleifora

List of four proposed contemporary traditional buildings, their names and functions, and the vegetation planted in their gardens. Source: Tengku Auvaroza, 2021

Figure 7-22

No	Building Function 'Named After CM spouses"	Sections and Hands -on Activities	Location/ Indigenous Dwellings
H	**Orchid Research Centre** Parfumes **'RAGAD'** 6th	• Scientific Laboratories- Valtombrsa • Orchid nurseries • Durian Trees	**Serian** **Collonial House** Manggo E.Bulbophyllum binnedijkii L.Vanda Drearie S. L
I	**PAGOLA** **'NORMA'** Parfume 3rd	• Speakers Corner- Holocaust • General pubic	**Island** **Roselle** E. Phal bellina (Normah Orchid0 – Parfume

List of two proposed Contemporary traditional buildings, their names and functions and the vegetation planted in their gardens. Source: Tengku Auvaroza, 2021

Applying the **circa situm conservation concept,** each building will be surrounded with mini gardens, attractively planted by the UOBG landscapists with SLEO found in each division (Harera-Cabrera et al., 2018). This would not only create awareness among visitors but encourage them to apply the same concept in their own gardens, and hence indirectly engage in circa situm conservation which has been used in other countries to preserve their almost extinct native plants. By planting these SLEO in gardens in areas where the orchids used to be found will be an effective way to participate in conserving them (Maheswarappa, et al., 2021; Mirtenda, 2021). This would not only create awareness among visitors and encourage them to be engaged in the programme but would also help scientists to collect data for their research.

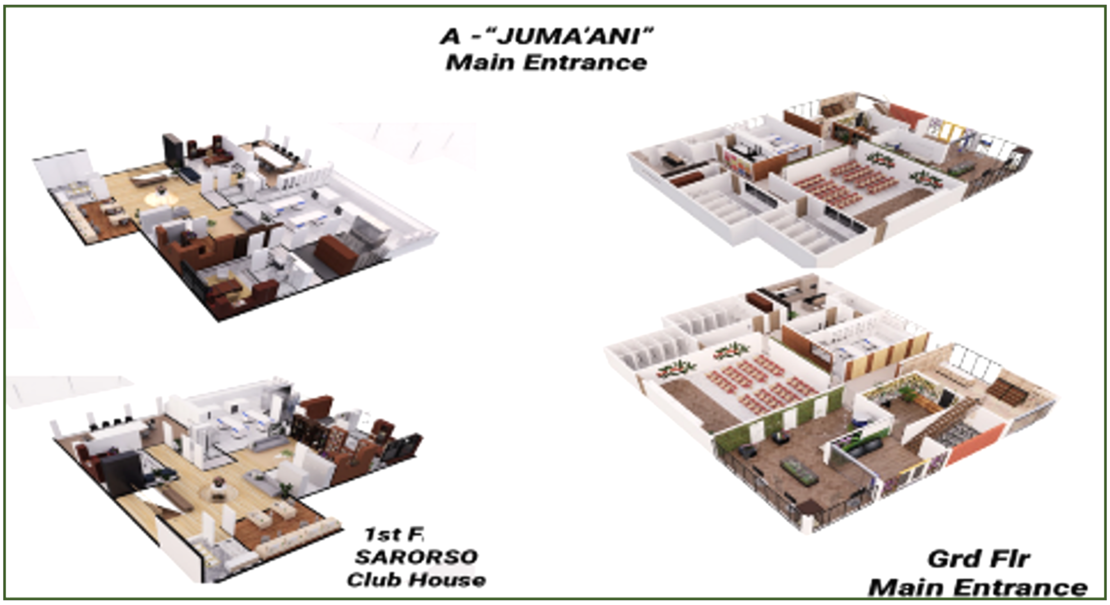
In addition, each of these buildings has its own function and programmes suitable to the OC needs of Sarawak, in order to create a sustainable and active UOBG, successfully attracting and engaging the participation of the public and NGOs. As identified in Chapter 4, the initial visitor experience is crucial. Therefore, an impactful first impression of the proposed revolutionary Main Entrance building A (Plate 7-11) in the Kuching Division is critical (Millar, 2020). An impressive, lavishly ornate, grand building with an Islamic Garden and Fountain greets visitors as they enter SUOBG, inspired by the Malay Palace in Medan designed by Dutch architect, Sumatera.

Plate 7-11

The author's impression 0f the Main Entrance Building: The Astana-Juma'ani (A) with four wings A1, A2, A3 and A4. Inspired by the Malay Palace in Medan designed by Dutch architect, Sumatera. Source: Sakura, 2021

Besides being a grand building, it will be equipped with the latest DT like that in the New York Hall of Science at Queens (NYSI, 2021), The Museum of Science and Industry, Chicago (Msichicago, 2021), and the Illinois Holocaust Museum and Education Centre (Ilholm, 2021). This effort can set the tone for the entire visit. The proposed entrance is designed in such a way that integrates technology in the form of screens and videos to present the consequences of a future with or without OS (Figure 7-23).

Figure 7-23



Proposed Ground and First Floors of the Main Building. Ground Floor (left): visitors are introduced to the role of SUOBG, the current situation and future of the orchid species, the impact orchids have on the environment and future generations. Then visitors are led to the second part about what others are doing. Visitors are shown around the herbarium and laboratory before attending a five-minute show (inspired by a digital movie shown to visitors at Az Azhaharah theatre), "Orchid Species Today". The First Floor is the Sarawak Orchid Society members' club house (only for paying members). Illustrator: Hakim. W. A., Designed by Tengku Auvaroza 2020.

7.7.4 The Mainland: Cloud/Canopy Orchid Walk – 'The Satok'

Orchids have long been sought-after for their beauty (Beaman, et al., 2001; Eng, 2019) which has caused many to brave dangerous conditions to obtain them, leading to the loss of limbs or even lives (Li, 2015). This is due to the challenging habitat and its position, high up in trees or on cliffs, making them best admired from a distance. In view of this, it is proposed to construct a long wooden suspension bridge among the trees, gently weaving through them around the perimeter of the Mainland parallel to the UOBG border (Plate 7-12). The design of the suspension bridge is inspired by a historical and famous bridge in Kuching, Sarawak called the Satok Suspension bridge. Besides orchid viewing, this feature also encourages other activities such as bird watching.

Plate 7-12

Proposed Cloud/Canopy Orchid Walk. This is the suspension bridge that was built in Lampeng Jawa, Orchid Garden.

Source: Pires, 2020

7.7.5 The Mainland: Technology and Digital Displays

In the world of BGs, DT is under-used and under-appreciated (Glam, 2021). There has been a severe failure to incorporate technology for customer/visitor interaction. However, the outbreak of Covid-19 seems to have changed how BGs communicate with visitors, as national lockdowns have limited physical interaction (Catleberry, 2021). Since the lockdown, updates on BGs have been done virtually online, and it was observed that more information could be read through the website, including conservation messages (Dhanda, et al., 2019). Globally, BGs were all affected. For example, in the middle of 2020, some BGs wrote to paying members to ask whether they wanted to be refunded for the fees which had been paid for 2020 and 2021 (Hodor, et al., 2021). New methods to generate income are required in order for BGs to evolve when physical visits are not allowed. With technology, updates on the garden can be given online through virtual events, virtual visits and other information that could be uploaded and read on the website. As such, it can be an advantage for spreading conservation messages, and beneficial for online visitors (OECD, 2020).

However, with or without Covid-19, for the public on this side of the world to understand the role of BGs, their importance and reasons for existence, digital boards, labels and displays are needed as platforms for key messages to be effectively disseminated, for OS status to be understood and for visitors to be inspired to be engaged in addressing the issue (Chen & Sun, 2018; Fay, 2018). Therefore, it is recommended that elements of DT be installed and fully utilised across the UOBG.

Plate 7-13

Interactive Digital Display in New York Museum. Source: Timeout, 2019

In the 21st century, every establishment needs technology, as it has permeated every aspect of our lives, from the way we communicate to the way we make purchases. Marketing has become an art that is primarily digital, helping organisations to generate more interest. Source: Timeout, 2019

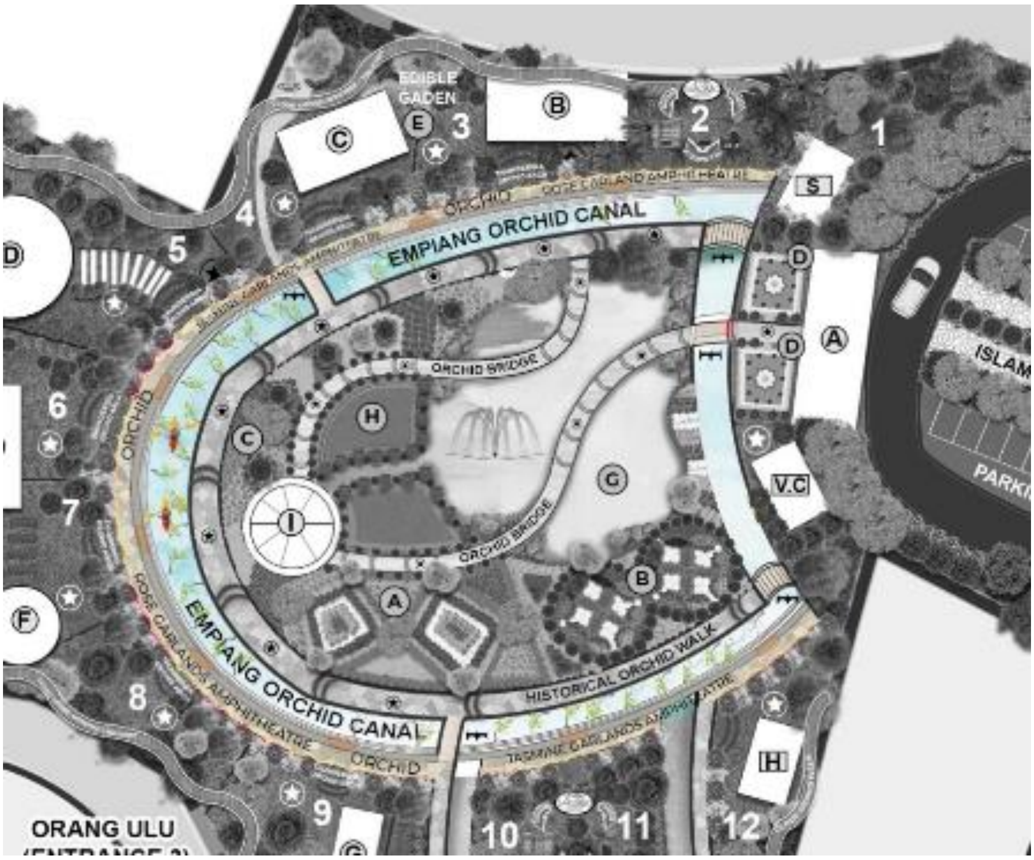
Plate 7-14

No one is spared from the use of DT in order to reach out. Here, a restaurant and educational institution devoted to spreading knowledge about Norwegian sustainable salmon farming and products. Source: Visit Oslo, 2021

7.8 Phase 1: The Proposed Canal – History

The Canal & U-Shaped Amphitheatre – Attractive, Engaging, Educational and Inspirational

Figure 7-24



Proposed canal surrounding the Island, providing an alternative mode of transport for visitors to travel around the island while enjoying the floral garden landscapes, listening to history and being educated on Sarawak Lowland Endangered orchids. Source: Tengku Auvaroza, 2021

The Canal is inspired by the Sarawak River, which has played an important role since the early 19th century in relation to the discovery and collection of OS (Burbridgre, 1880; Mjoberg, 1930; Wallace, 1962; Low, 1968; Low, 2002; Beaman, et al., 2001). Intended to serve as a way to tell the story of how orchidologists would travel along the river to identify the local flora, the canal will also serve as an attraction to visitors. Traversing the canal using '*perahu*', visitors will be able to walk in the footsteps of history, learning and appreciating how OS were discovered, their value and their habitat by the river. Visitors will also be able to hire tour guides who will add further narrative and context to the attraction, inspired by the RPK, Thailand (RPK, 2018). To further engage with modern-day visitors, the canal experience will also integrate the latest technology to provide an immersive experience.

Plate 7-15

Proposed Canal encircling the Island, with artificial stems across the canal mounted with orchid species, imitating Sarawak River during the Orchid Craze Era. With the help of technology or a tour guide history, current issues and orchid-related matters are shared. Source: RBGK, Giethoorn, Utrecht, 2021

In addition, to imitate the scenery of the river as it was in the past, as narrated by the collectors in their books, it is proposed that artificial branches be built across the canals for orchids to be mounted, grow and flower according to the season (Plate 7-16). This technique of using artificial branches instead of real trees is for the safety of employees and visitors utilising the canal, as tree branches can potentially break and cause harm (BBC, 2014).

Plate 7-16

Artificial structure being built to imitate branches of trees across the canal for safety purposes. This is an artificial trunk displayed in the orchid section of the Princess of Wales Conservatory, RBGK. Source: Tengku, 2019

Seating in the form of tiered steps is also proposed, with roses, jasmine and vanilla (Plate 7-17) garlands as seen in Queen Mary's Rose Garden (RPQM, 2019), to surround the Canal.

Plate 7-17

Proposed rose garland as inspired by Queen Mary's Garden, climbing jasmines incorporated with vanilla (climbing orchid) along the walkway around the canal to create a different ambience with mixed fragrances in order to encourage visitors to return. Source: Tengku Auvaroza 2019, DBG, 2012

A U-shaped open-air amphitheatre is built around the canal for recreational purposes, overlooking the scenery of the four formal orchid gardens on the island (section 7.9). Visitors can also appreciate the Water Garden, while doing other activities such as painting, reading or even listening to the early history of orchid appreciation and the development of OS since the early 19th century (DBG, 2012; Nparks, 2020). This open-air amphitheatre is connected to the island by colonial bridges which also have historical and conservation information in their digitalised labels.

Plate 7-18

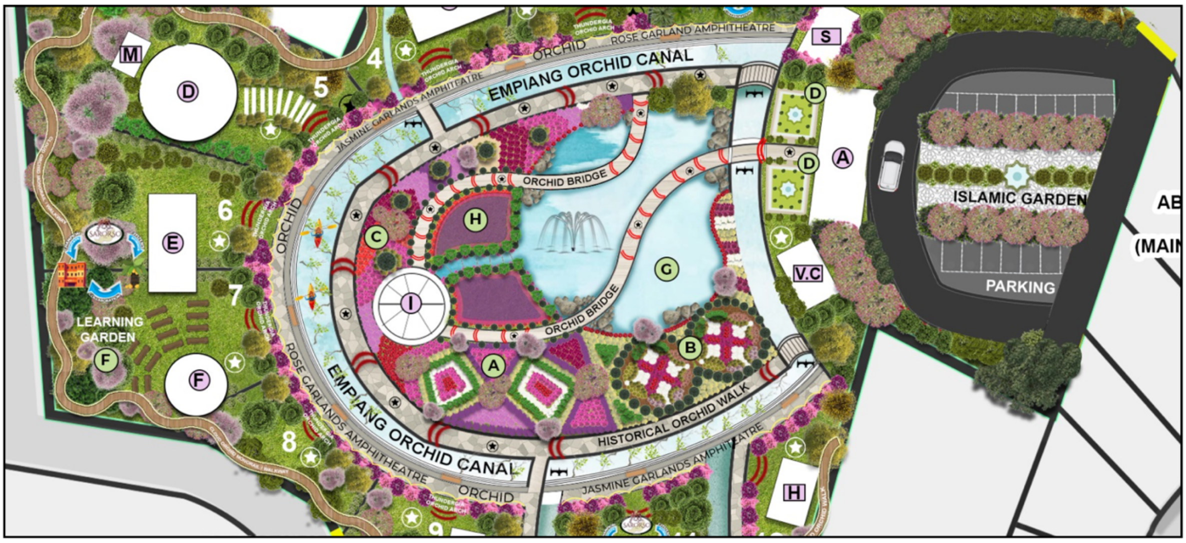
Open-air theatre built beside the Canal for visitors to enjoy the scenery of the pond and all the landscape around it. Source: Shana, 2021

Whilst the canal, amphitheatre and garlands of flora, including vanilla vine orchids (Plate 7-19), provide aesthetic value and attract pollinators (Bernhart & Meier, 2010; Hinsley & Fay, 2018), its purpose is twofold: **aesthetic and educational, to create awareness among the visitors**. UOBG's aim is to make a difference in all OC efforts and have an effective impact on visitors. As such, taking the best of older BGs and those designed today, a memorable and informative trip along the canal should ensure that the message, clear and with innovation, will last in visitors' minds, and even after they leave the gardens, they will be inspired to participate in the UOBG OC programmes or simply contribute to OC in their own ways (Kaufman, 2011). As Thrash and Elliot note, the height of human motivation springs from the beauty and goodness that precedes us and awakens us to better possibilities (Buheji, et al., 2014).

Plate 7-19

One of the proposed climbing plants – flowering vanilla (an orchid) vine with seed pods planted in a farm in Kuching. There are three species of vanilla present in Sarawak. Source: Borneo Post, 2017

Plate 7-20

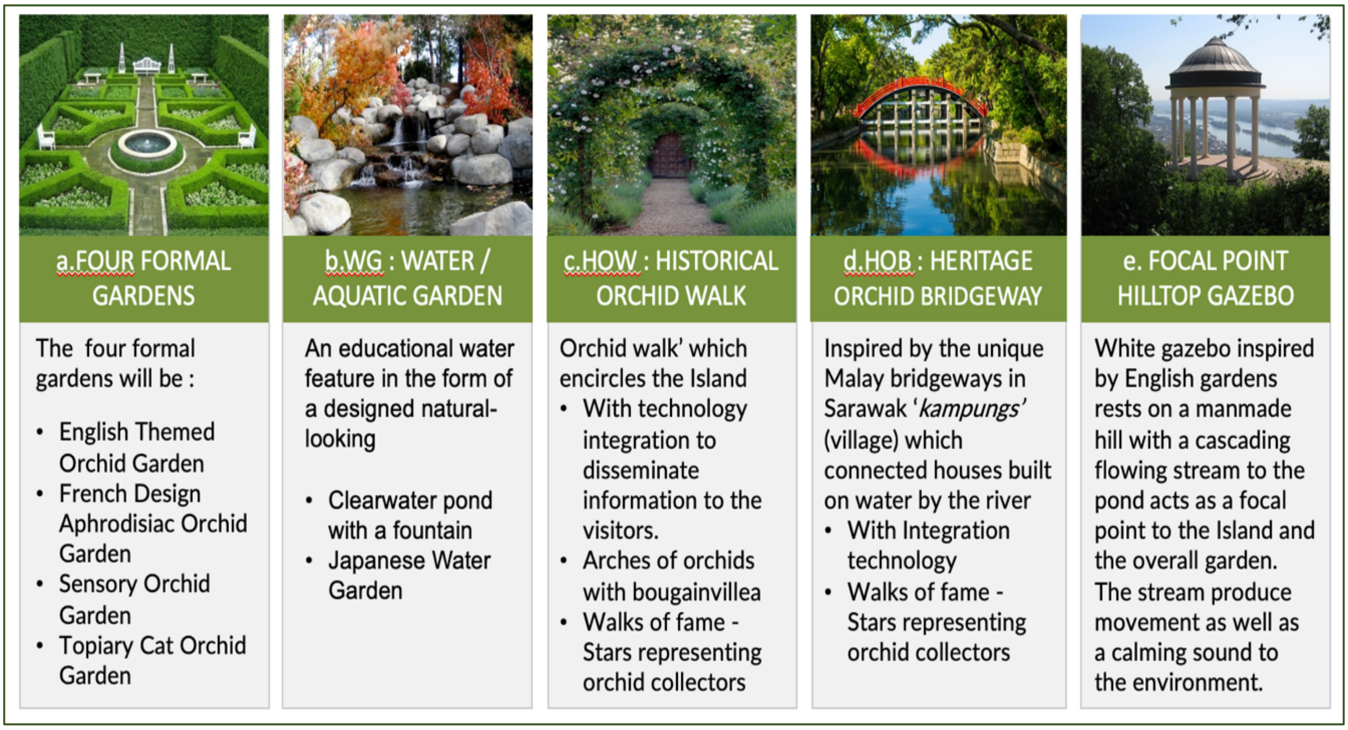


The Canal. Source: Tengku, 2021

7.9 The Island

The proposed Island is located at the centre of the total land area (Figure 7-13). The Island is to have the following popular formal and informal garden features, incorporating both terrestrial orchids and epiphytic orchids mounted on ornamental flowering trees and artificial tree structures and arches, as seen below.

Figure 7-25



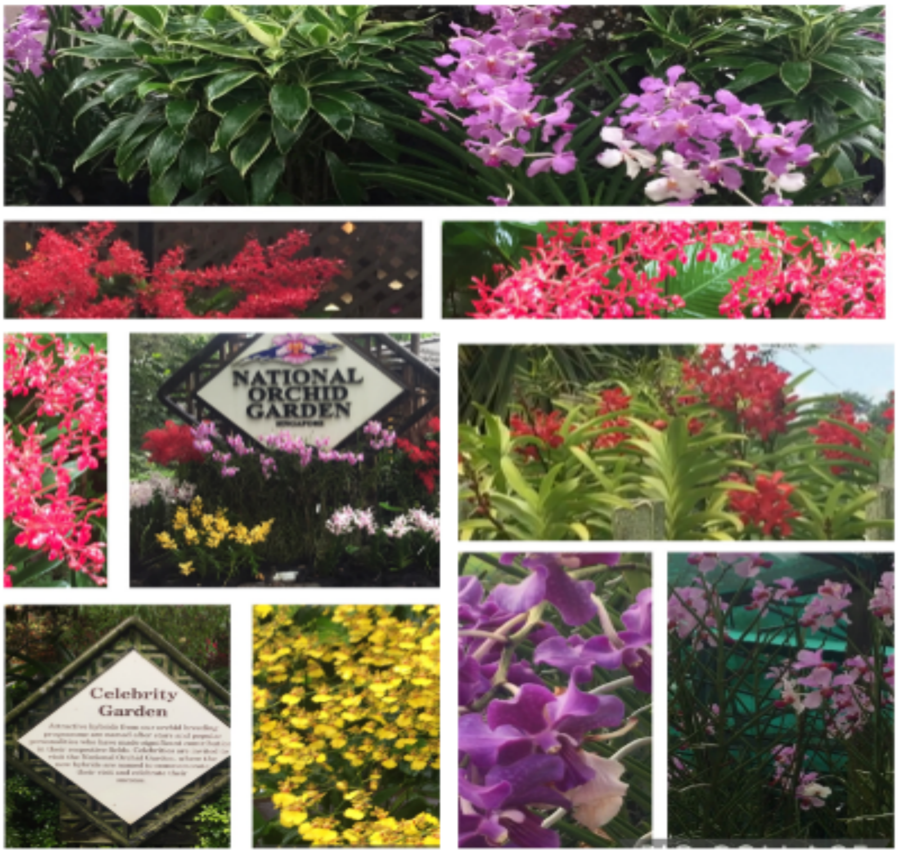
Proposed sustainable garden features divided into gardens, water features and historical features based on popular BGs visited and the BGCI Manual 2016. Picture Source: Google, 2021

7.9.1 The Island: The Four Formal Gardens

7.9.1.1 English Themed Orchid Garden

Based on English landscape design (Rutherford, 2016; Williams & Silva, 2017) displaying a vibrant and orderly collection of terrestrial OS (Plate 7-21), including showy hybrid orchids which are crossbreeds of Sarawak OS, it provides a glimpse of the potential of a Sarawak orchid hybrid floriculture industry to visitors contributing to the long-term planning for both the UOBG and the orchid floriculture industry. In addition, the proposed inclusion of a lake, bridges and picturesque architecture fits the design of the popular and picturesque landscape and English garden, and also connects the historical part of the UOBG, relating Sarawak and OS history, with the British Rajah and botanists, as well as collectors (Low, 1968; Low, 2002; Mjoberg, 1930; Russan & Boyle, 1893; Spenser, 2018).

Plate 7-21



Proposed use of continuously flowering terrestrial orchids (as above) to create the three formal gardens on the Island, giving opportunities to visitors to be educated about the importance of SLEO, their conservation and commercial and medicinal potential, as well as encouraging participation in conserving and understanding the success of a sustainable floriculture industry. Source: Tengku Auvaroza, 2018

7.9.1.2 French Design Aphrodisiac Orchid Garden

Based on French classic garden (*jardin à la française*) landscape architecture which exhibits true feelings for natural materials including earth, trees, water and the sky (Marriage, 2015), the design of the garden uses diversified SLEO which have varying medicinal properties, e.g. *Arundina graminifolia* (Eng, 2019) in an application not typically found locally; this will not only attract visitors' interest but also educate them on the herbal properties of the SLEO. The application of the sustainably sourced SLEO (usually neglected) as an attractive landscape material could also increase demand by landscape architects, which helps conservation (Dilaver, 2013; Westwood, 2020; Hogan & Hickman, 2021).

Plate 7-22

Chateaux of the Loire Valley Gardens. The application in garden design of common aphrodisiac, medicinal orchids and plants into a harmonious interplay of colours would encourage visitors to seek to know more about the SLEOs and thus make it a priority to improve the situation the orchids are in. Source: Chateaux de Villandry, 2019

In other words, this effort also encourages *circa situm* conservation, the special circumstances of conservation within an altered agricultural landscape (Boshier, et al., 2004; Mirtenda, 2021), which could inspire visitors from different backgrounds to visualise the OS laid out in such novel settings in their own gardens, differentiating them from how they would typically be found in fields, which locals have taken for granted and allowed to be cleared for development (SG, 2016; Harera- Cabrera, et al., 2018; Cabrera, et al., 2021). In addition, the use of SLEO with medicinal properties in these formal gardens could help locals want to source sustainable seedlings with the benefit of the introduction of an in vitro orchid micropropagation technology programme in schools and other communities (Chapter 5), as well as the existing economic opportunities for the development of sustainable orchid horticulture, floriculture, herbal and pharmaceutical industries, which the state government has been promoting (Noriezam, 2019).

7.9.1.3 Sensory Orchid Garden

As SLEO habitats are being damaged and threatened by anthropogenic activities, and plants are facing severe consequences due to unsustainable development, all groups of people must be encouraged to benefit and be part of the UOBG (Wraith, 2018; Dominoni, et al., 2020). This could take place under the community science project to encourage inclusion and the interactive participation of all backgrounds and abilities (Sacare, 2018).

This section of the garden will utilise specialised equipment that encourages sensory experience (Hussein, 2010; Gonzalez & Kirkevold, 2014; Zajadacz, 2019). Besides promoting the aesthetic value, this part of the UOBG promotes other characteristics of SLEO such as varied textures, smells, tastes and even the sounds of pollinators, combined with other available facilities, hard & soft landscapes, garden furniture and accessible pathways (Plate 7-23). It would also serve as a basis to gather and encourage new responses, feedback, and opportunities to be used for future projects or expansion. This would increase the understanding of threats, the need for monitoring and protecting SLEO populations and their habitat and ex-situ conservation by a wider subset of the community (Weaver, 2020; NGA, 2017). However, there will be some issues and challenges that would need to be fleshed out further as highlighted by Hussein saying that "…challenges in terms of long-term maintenance should also be addressed in the design plan (Hussein, 2009).

Plate 7-23

A sensory orchid gardens is an educational way to encourage participation of special ability guests to interact with the environment through touch/texture. Source: Google, 2021

7.9.1.4 Topiary Cat Orchid Garden

Topiary is a sustainable ancient horticultural practice originating from the Romans, related to Renaissance gardens and Italy (Way, 2010). It has been proven to create an attractive living ornamental garden which would definitely encourage engagement for all visitors (Kelleher, 2018), as well as the YG; this is shown by how Walt Disney uses topiary in various studios to tell stories effectively to the YG (Kiddle, 2021; Brooks, 2019).

Kuching is a derivative of *'kucing',* meaning 'cat', which is thus a brand for Kuching city. It is believed that the city obtained its name because of the endemic fruit tree *Euphoria malaiense* (the 'cat's eye tree', which locals call 'Isau', has medicinal properties), which grows in abundance by the riverbanks (Holtum, 1953; SFDM, FRIM, SWFDM, 1994; Said, 2021). This information can be featured in the UOBG. Creating topiaries of an established brand, in this case, cats, and incorporating orchids as part of the creation contributes to an additional potential USP to the SUOBG (Morgan, et al., 2011; The Economic Times, 2020) which could be used as an effective means to create awareness and educate the young, as it generates powerful attraction and interest in OC among visitors.

Plate 7-24

Topiary of Mickey Mouse at Disneyland

Topiary cat , creation by Richard Saunders

Topiary of elephants and orchid as part of Kew Gardens Annual Show

Left: Topiary of Mickey and Minnie, Walt Disney. Top right: a creation by Richard Saunders. Bottom right: Topiary of elephants and orchid as part of Kew Annual Show. As Kuching means cat, incorporating OS alongside the design of plant-based cats could be the mascot and a USP for the UOBG. Source: Disney, (2020); Saunders, (2021), Kew (2020).

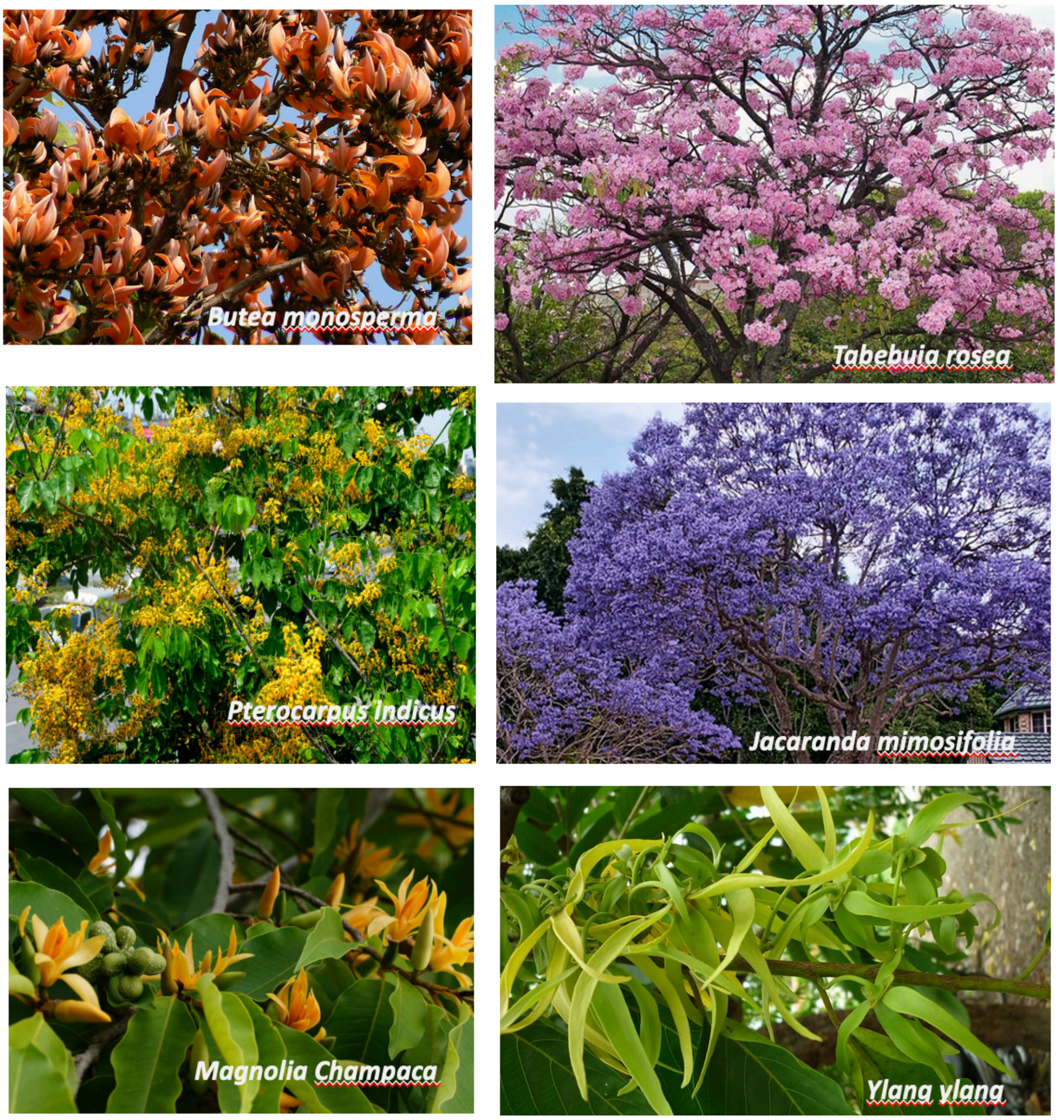
To further encourage the engagement and participation of visitors, it is proposed that periodical classes or lessons be held in the garden for members of the UOBG to learn topiary techniques, how to incorporate orchids into the topiary designs, and information on OE at the same time. Doing this will undoubtedly increase visitors’ appreciation of OS, and returning visitors will be more invested in conservation. These formal floral landscapes are intended to be crowdpullers with their aesthetic appeal; their symmetry, balance and colours using SLEO and a mixture of other vegetation. This bright, floral formal design is further enhanced by flowering phorophytes to create depth, as well as the epiphyte orchids included in the gardens. The spring display in RBGK (Plate 7-25) inspired the idea of the floral trees for the UOBG.

Plate 7-25

Scenery at Royal Botanic Garden, Kew, in bloom. Sarawak UOBG has another advantage in that not only the trees (phorophytes) and the terrestrial orchids on the grounds would flower, covering the grounds and the crown of the trees but epiphytes mounted on the trunks and branches would produce flowers when in season; see Figure 7-15. Gunung Jerai OS. Source: RBGKew, 2022.

Some of the flowering phorophytes used on the island (Plate 7-26) have fragrance, adding colour, depth, interest and scent, which is something different from the evergreens that are commonly seen in the landscape of tropical Sarawak. Most importantly, the flowering trees **benefit from pollinating insects** (Rollings & Goulson, 2019). The abundance of flowering SLEO on the ground and flowering phorophytes whenever in season increases the frequency of pollinators (Paulus, 2019; Rollings & Goulson, 2019). The garden presents a unique scientific opportunity where scientists and visitors, including students, can observe and collect data for further scientific research related to the symbiotic relationship between SLEO, its pollinators and fungi (Neves, 2009; Selosse, 2014). However, this ambitious plan will need professional horticulturists, experienced landscape designers and arboriculturists (BGCI, 2016; BGCI, 2020) in order to be successful.

Plate 7-26



Proposed Ornamental/Scented/Edible Flowering trees for the 'Island'. 1. Butea monosperma, 2 Pterocarpus indicus, 3. Stereopersmum fibriatum; 4. Jacaranda mimosifolia; 5. Cempaka; 6. Bougainville spectabilis; 7. Ylang ylang and 8. Tabebuia rosea. These trees will act as phorophytes to Sarawak's epiphytic orchids. Source: Amazon, 2019.

In addition, for educational and awareness purposes, visitors are able to gain more knowledge on the SLEO, their habitat (including caring for and maintaining it), their pollinators and conservation efforts, through scanning QR codes/labels or sensors using the latest technology available in the garden, inspired by other commercial sectors (Gordon, 2015; Gligoric & Krco, 2019; White, 2020). This would address the issue of unwanted bulky labels/signage in natural settings and encourage interaction. The availability of facilities for the public, such as libraries, herbariums, an IVOM laboratory, workshops and so forth, would be able to support visitors' observations and findings, as well as provide hands-on education so that UOBG would be an educational establishment that meets human needs and enhances well-being (Razak, et al., 2015; Chen & Sun, 2018).

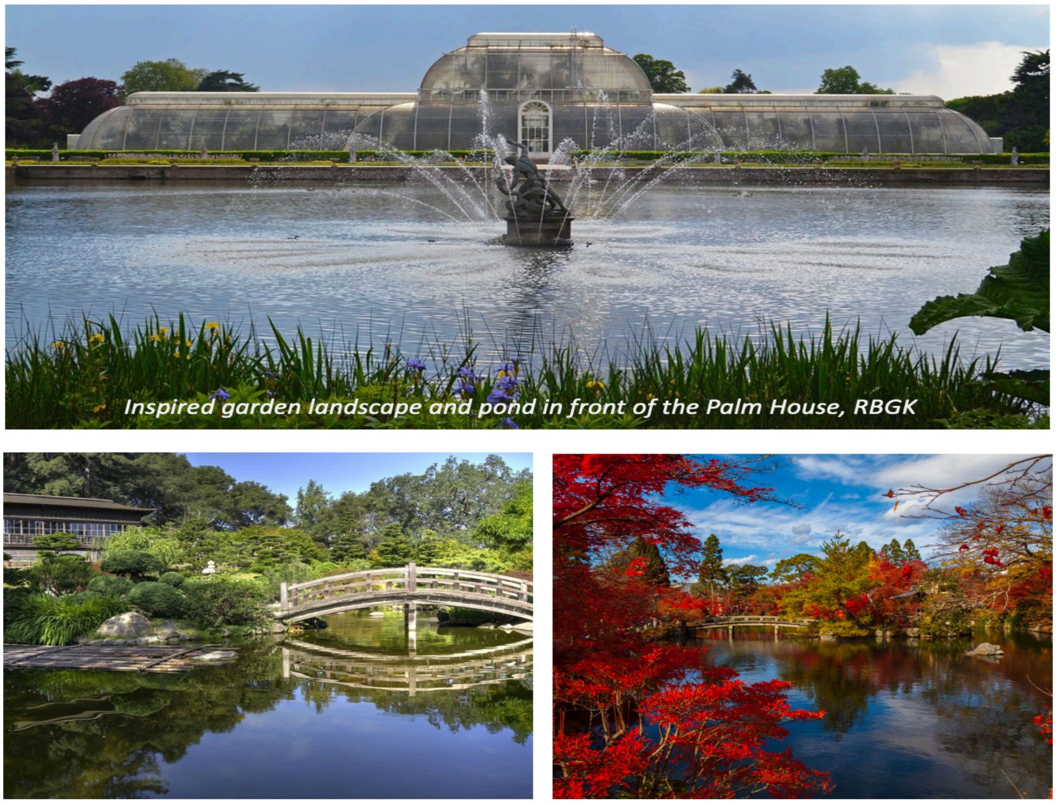
7.9.2 The Island: Water Feature – Water Gardens or Aquatic Garden (WG)

Another visitor attraction would be a water feature in the form of a natural-looking clearwater pond with a fountain, inspired by the garden landscapes and ponds in front of the Palm House, RBGK (Plate 7-27) and Japanese Water Garden (Plumptre, 1993; Lane, 2020). In addition to efforts to increase biodiversity on land, the presence of a lentic ecosystem in an urban space is expected to add aesthetic value, peace and tranquillity. It could also make a vital contribution to freshwater life conservation (Oertii & Parris, 2019). A pond also provides resources and habitats for both terrestrial and aquatic organisms (Cereghino, et al., 2014).

This natural-looking pond with trees growing around it makes a necessary contribution to ex-situ conservation for SLEO. *Vanda drearie* and *Vanda helvola* (Beaman, et al., 2001; Puccio, 2003) are proposed to be displayed in this part of the garden imitating their natural which require high humidity (Beaman, et al., 2001). Similar to other sections of the UOBG, it is proposed that supplementary information can be found when visitors scan labels/QR Codes

(Gordon, 2015; Gligoric & Krco, 2019; White, 2020) around the WG so as to achieve the role and objective of the UOBG as an education establishment (Willison, 2006).

Plate 7-27



Self-sustainable natural-looking clear water ponds for the Island. The bottom two are Japanese Water Gardens; OS could be anchored on the phorophytes and artificial structures around the pond, inspired by the pond by the RBGK Palm House, and Japanese Water gardens. The vegetation around the pond creates an attractive natural scene every season, creating interest and excitement among visitors, encouraging them to return. OS whose habitat is the mangrove forest would survive well by the pond. Source: MotherEarthNews, 2020

7.9.3 The Island: A Historical Element – The Historical Orchid Walk – HOW (accessible)

The proposed orchid walk which encircles the Island is another feature equipped with frontier technology for disseminating information in relation to OS for the convenience of the visitors, making the UOBG more interesting and interactive for today's needs and today's generation. For example, the integration of technology in the form of sensors or mobile application scanners installed at each embedded star on the walkway allows visitors to trigger these tags through their mobile devices or information poles, in order to access the history and achievements of the collectors and the OS they collected. This technology is inspired by the UiO Natural History Museum (UiO, 2020).

The proposed design also includes arches of brightly coloured, continuously flowering plants, such as bougainvillea, which act as a shade for a suitable OS mounted on the arches. The arches provide shade for the visitors as well. These arches were inspired by the arches in RGBK, SGB, New York and Dubai Miracle Garden- DMG (Plate 7-28).

Plate 7-28

Proposed floral arches over the Historical Orchid Walk. Inspired by floral and orchid arches in RBGK, SGB, New York Botanic Garden and Dubai Miracle Garden. Source: Gardens, 2019

The embedded stars on walkways represent 23 prominent orchid collectors since the early 19th century, and their contribution to the orchid industry (Appendix 14). The embedded stars (Plate 7-29) in the HOW are inspired by the acknowledgment and recognition given by Hollywood and Disneyland to reputable actors and actresses through their Walk of Fame. It is hoped that the HOW stars can educate, engage and inspire visitors to appreciate, value and protect SLEO, and be aware of the potential of both the floriculture and horticulture industries.

Plate 7-29

It is proposed to embed stars in the Historical Orchid Walk, to represent the early orchid collectors in the early 19th century. It is proposed that the stars be linked to a post with a screen that displays information (inspired by displays in the UIO Natural History Museum, Oslo) or perhaps to the visitor's phone as they pass the stars, whichever method they wish to choose. Source: Tengku Auvaroza 2018 and Hollywood, 2021.

HOW also serves as an alternative way for visitors to stroll around the Island to enjoy the SLEO formal gardens and other attractive areas. Most importantly, visitors will be guided around the various information points on the Island giving the history of OS, as well as information about the SLEO, ongoing OC efforts and other OS economic potential.

It is further proposed that HOW be connected to the outer mainland by five different types of ornamental colonial stone/brick bridges (Plate 7-30).

Plate 7-30

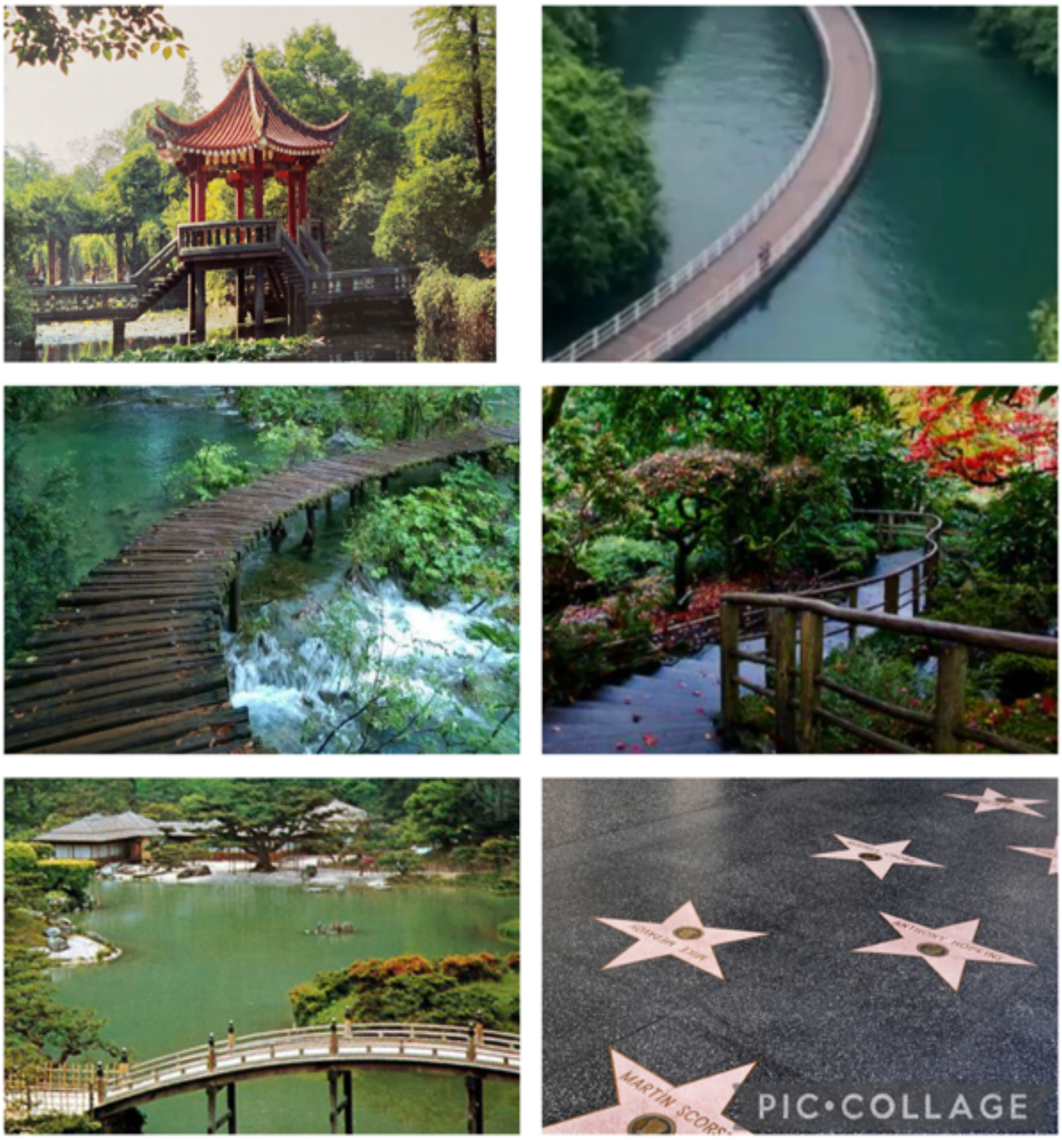
Colonial-style ornate bridges of various forms reflecting early 19th-century British architecture to recreate the ambience of early 19th century England, relating to the history being told as visitors stroll on the HOW. Source: Whiltonmarina.com, 2019

7.9.4 The Island: A Heritage Culture Element – Heritage Orchid Bridgeway (HOB) – (accessible)

Bridgeways create depth to the overall landscape design (Bell, 2019), inspired by the unique Malay bridgeways in quaint little '*kampungs*' (villages) in Kuching, Sarawak (Kampung

Masjid and Kampung Bintangor), connecting houses which were built by the river, and also by the bridgeways in Japanese UBGs. The HOB seeks to be a heritage culture element that local people (especially the older generation) can relate to, as these villages have mostly been subject to modern development. Aside from its aesthetic appeal, it is an important element for both practical and spiritual reasons (Stedman, 2018). This proposed pedestrian bridgeway that meanders over the garden allows visitors to appreciate the four formal landscape designs and the peaceful water feature below, and to engage in a meditative experience (Brown, 2020).

Plate 7-31



Beautifully designed bridges in Japanese and Chinese gardens are important elements that provide aesthetic appeal and a relaxing atmosphere to the gardens to inspire reflection and meditation. Source: Stedman, 2018

Secondly, it is also proposed to embed HOB with stars, with names representing 'new historical figures'. Hence, while visitors are enjoying the scenery and the horticulture, listening or reading information being shared about the past, present and future of SLEO, they are able to submit questions or remarks online which would be addressed by UOBG personnel. In this way, data are automatically being collected, and the UOBG management is continuously updated about visitors' expectations. In addition, while exploring the garden, visitors are subtly being educated through high technology facilities or personal tour guides, if they choose to have one, at their convenience. Tour guide services are inspired by a similar service offered at the RRP, Chiang Mai, mainly offered by university students who are well informed about the relevant history and can convey it in an educational and interesting manner.

Similar to the HOW, floral arches are mounted with SLEO along the bridgeways, not only to provide shade but to enhance the beauty of the bridge and showcase the SLEO which are all labelled with detailed information to educate visitors.

7.9.5 The Island: The Focal Point – A Hilltop Gazebo/Pergola

A gazebo/pergola is a garden feature built by Egyptians approximately 5000 years ago near water, usually on a high point to act as a focus with an extensive and attractive view (Lancaster Barns, 2020). The proposed white gazebo/pergola (Plate 7-32) on a manmade hill with a flowing stream cascading into the pond acts as a focal point to the Island and the overall garden to achieve a far-reaching effect as soon as a visitor enters the garden; the stream provides movement as well as a sound effect contributing to the sonic environment of the gardens (Gerwen, 2017).

In addition, in order to include the element of cultural heritage, it is proposed that the gazebo/pergola be named after the previous Governor's wife, after whom an internationally known Sarawak endemic orchid (EO) *Phallaenopsis belina* (the State's official flower) was also named; the local name of *P. bellina* was Orkid Lundu or Kambang Alu, but it was renamed Orkid Normah after her. The beautiful *P. bellina* is found only in Sarawak and is commercially known for continuous blooms, tricolour waxy star-shaped flowers up to 5cm across and attractive shiny broad green foliage, and is highly fragrant (Hsiao & Tsai, 2006; Ramya, et al., 2020); it is so well known for its citrus fragrance that studies have been conducted in Taiwan for the chemical components to be extracted and infused into new Taiwanese non-scented hybrid orchids, creating a new scented cultivar (Chuang, et al., 2018). Whether this is an act of biopiracy, the illegally gaining of exclusive monopoly rights over a Sarawak endemic orchid, is not clear (C.L.Akurugoda, 2013). Thus public awareness and education in this area are just as important as the need for legislation and provisions to be strengthened to protect indigenous/endemic orchids against biopiracy. This UOBG could serve as the main platform for action where all matters relating to this area could be shared with the public to create awareness.

Plate 7-32

Sarawak's official flower, Phalaenopsis bellina (locals call it Norma orchid), fragrant and endemic to Sarawak, mounted around the proposed White Pergola with a terrestrial orchid, e.g., Calanthe visanthe, along the cascading stream flowing towards the pond. Information on these orchids and horticultural skills could be downloaded using a QR code. This is an area for activities such as skill demonstrations and talks. Inspired by Speaker's corner, Hyde Park Corner. Source L-R: Tengku Auvaroza, 2019 & Suttons, 2020

7.10 Discussion

Despite the popularity of Urban Botanical Gardens (UBGs) globally, their contribution to ex-situ Orchid Conservation (OC) remains under scrutiny, especially concerning unmet Sustainable Development Goals (SDG) and Global Strategy for Plant Conservation (GPSC) targets (CBD, 2020). This chapter advocates for a tailored UOBG framework for Kuching, Sarawak, addressing OC needs through case studies (Chapter 4), BGCI manuals, and scientific journals (Chen & Sun, 2018; Gale, et al., 2018; Wraith, et al., 2020). In the absence of a Botanical Garden (BG) in Sarawak, the proposed UOBG emerges as a vital opportunity (IUCN, 2019; Wraith, et al., 2019).Emphasizing the context-specific nature of UOBGs, the proposed garden aims to attract local visitors of all ages, fostering awareness of local natural resources, particularly Orchid Species (OS). Leveraging digital technology, the UOBG intends to transform traditional perspectives on OS, bridging knowledge gaps and engaging the community (IUCN, 2019; Wraith, et al., 2019).

While existing BGs contribute significantly to ex-situ actions, including education and recovery programs, there is a call for UOBGs to enhance their impact on community knowledge, attitudes, and engagement with OC. The proposed UOBG emphasizes relatability and community-centric efforts, integrating aesthetic, educational attractions, and interactive technology. The success of a modern UOBG lies in groundwork, prioritizing community and conservation at its core. The UOBG is positioned as a platform for Sarawak's Sarawak Lowland Endangered Orchids (SLEO) conservation, but OC efforts extend beyond the UOBG (Chapters 4, 5, and 6). The UOBG's success hinges on creating an authentic experience that fosters an emotional bond with Sarawak OS, addressing the Orchid Extinction Crisis (OEI) (Williams, et al., 2015; BGCI, 2020)."

7.11 Conclusion

"Adapting Successful Botanical Garden Practices for Orchid Conservation in Sarawak: Experimental Community Projects (See Chapters 5 and 6) as Catalysts for Rapid and Significant Impact.

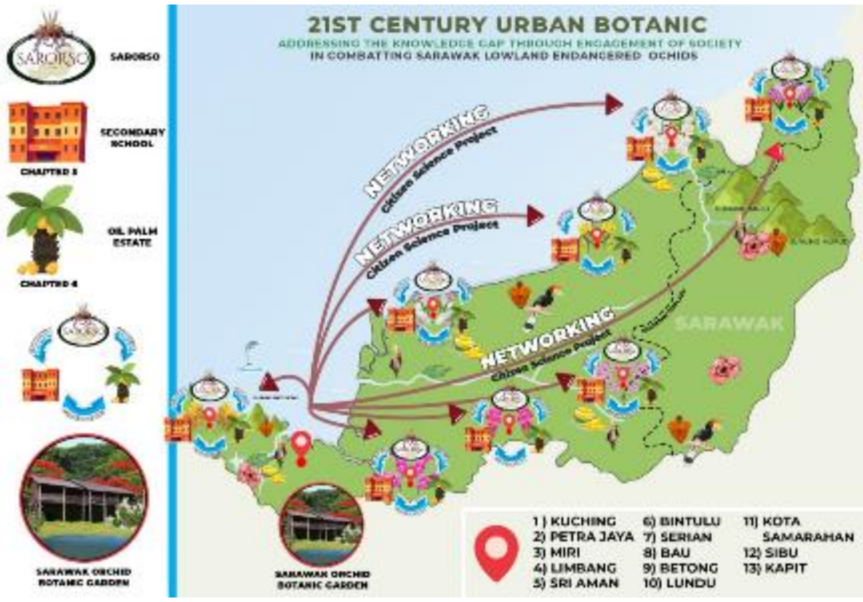
The recommendations for Orchid Conservation (OC) draw from successful Botanical Gardens (BGs) worldwide, tailored to Sarawak's OC needs. Two ex-situ conservation community projects, discussed in Chapters 5 and 6, yielded unexpectedly positive results with considerable social and economic benefits. Despite being a thesis concept, these projects demonstrated remarkable success within a short timeframe, offering potential benefits for OC, the environment, and society in just three years (discounting pandemic years).

The urgency of Sarawak's Orchid Species (OS) preservation raises questions about the viability of waiting for the proposed Urban Orchid Botanical Garden (UOBG) to materialize. The experimental projects, presented in Chapters 5 and 6, prove highly valuable and could be more impactful if embraced by secondary schools and oil palm communities in Sarawak. This decentralized approach, involving schools in OC, has the potential to rapidly address Orchid Conservation Issues (OCI) without relying on a single bureaucratic establishment, offering a proactive alternative to waiting for UOBG development (RBG, 2019; Chapters 5 and 6)."

7.12 The Future

Although the high cost will be one of the major challenges in developing an UOBG, time is of the essence and proves to be a bigger challenge. Therefore, it is hoped that the proposed UOBG will trigger the development of more UOBGs in all parts of Sarawak, and on a smaller scale in schools, universities and colleges. An increase in UOBG development in the state would address orchid extinction issues and eventually put them to rest (Dhanda, et al., 2019).

Figure 7-26



The proposed concept of the UOBG is to inspire and encourage schools and monoculture plantation owners to participate in conserving orchids in their green spaces through micropropagation and planting of OS, which will not only increase the percentage of OC in keeping with target 8, but will also benefit them socially and economically in the long run. Source: Tengku, 2021

CHAPTER 8

8 Conclusion

In researching the framework for a modern SUOBG which functions effectively and constantly enriches itself to continuously draw and engage its visitors in increasing awareness, knowledge and skill in OC and then apply it in their daily lives, the first component of this thesis (Chapter 2) investigated the relationship between the deterioration in the mega-rich orchid biodiversity and the loss of habitat of 2000 Sarawak lowland endangered orchid (SLEO) species throughout the lowland area (Mjoberg, 1930; Low, 2002; Beaman, et al., 2001; Schuiteman, 2017; Sarawak Forest Corporation, 2019). Further investigation was carried out on current measures and conservation efforts to prevent further deterioration, as found in the National Policy on Biological Diversity (NPBD) 2016-2025 (KETSA, 2021) and Laws of Sarawak Chapter 26, Wildlife Protection Ordinance, 1998. This included in situ conservation programmes by the government, as well as efforts by local scientists who for decades have not only been doing their research but also performing orchid rescue work at the logging sites (Go, et al., 2019).

However, it was found that there is a stark contrast between the abovementioned national policy and law enforcement and current conservation goals on preventing the loss of orchid biodiversity. Whilst orchidologists such as Dr Sillbam Allare state that ex-situ conservation is of great importance in saving genetic information and diversity, both national policy and wildlife laws prevent the public not only from performing ex situ conservation through laboratories but also from rescuing orchids without a licence which, from experience, is almost impossible to secure. Chapter 2 also discussed how this led to the inability to legally access OS in any form without paying a high price to licensed orchid nursery owners who have monopolised the business for almost a decade and have kept knowledge and skills to themselves. Empirically, for Sarawak, this may have contributed to the illegal extraction of orchids from their habitat nearby, illegal trading, diminishing interest and the extinction of knowledge of OS among the public, leading to the loss of ethnobotany and the lack of participation of the general public in OC. In further investigating the effect of conservation efforts on keeping Sarawakians aware of the deteriorating orchid situation, it was found that local government scientists have been highlighting the matter through decades of participation in both national and international orchid conferences as speakers who recognise the importance of and dire need for OC (Go, et al., 2020). Yet evidence showed that Sarawak is losing its orchid biodiversity, and awareness among the general public is low (SARORSO, 2019).

Chapter 2 investigated the impact of public response in a survey conducted by the Sarawak Orchid Society (SARORSO, 2018) and the results were found to be contrary to expectations. Despite confirming a low level of awareness and knowledge of OS, the survey showed that the public has a significantly positive response and interest in receiving education to increase this knowledge, including the rich historical background, taxonomy, economic importance, propagation of OS and their conservation as well as commercial horticulture for aesthetic purposes. In developed countries, despite having significantly fewer OS, awareness and knowledge of them and their value is significantly greater (as proven in the number of BGs, CSPs, plant-related NGOs and books), where conservation efforts are much more robust to the point that OS is acknowledged as a heritage, which indirectly promotes conservation. However, through our investigation, we found that in Sarawak the situation is the opposite. Unless this level of awareness, knowledge and passion reaches this part of the world, the situation will not improve significantly. In the process of preparing a proposal for the UOBG, the community and individuals who have been involved have shown much excitement and commitment (e.g., volunteering in scientific activities which could assist in obtaining new data for scientists to analyse) and progress in OS awareness and knowledge. Based on the response to discussions with the community about a UOBG, it is clear that efforts targeted on the grassroots are impactful, and thus need to be further focused in this way to reach out to the masses who have direct contact with the various orchid habitats.

SARORSO's innovation in the form of pioneering Malaysia's first ex situ orchid conservation programme in a secondary school (which is discussed in Chapter 5), providing the local YG with an opportunity to become invested in OS and their conservation, as well as the potential of an entrepreneurship experience based on the model of a successful school orchid project in the United Kingdom, is a great example of an effective historic conservation effort which can be a feature of the proposed UOBG. This serves as the beginning of efforts whose impacts continue to grow; the efforts start with a single lab in a school, the effects (as from the one ongoing case study) were that it developed into the formation of interschool networks of micro-BGs serving as a growing and powerful tool for scientists to further utilise, gather data and analyse. The implication of the involvement of school children and their contribution cannot be underestimated.

Chapter 6 further demonstrated the strengths of community involvement through CSP, this time in the form of the oil palm industry. A step beyond the involvement of schools, radical innovation can take place within the oil palm community following the translocation of OS projects, where each community acts as an echo chamber amplifying individual awareness and knowledge. The effect of this is not limited to the oil palm industry, but with collaboration with orchidologists and other organisations, a platform is formed where each may contribute and benefit. The success of the experiment could lead to the inclusion of oil palm trees in the proposed UOBG as a 'functional arboretum reflecting a story', which could be practical and relatable to visitors. This unique ex-situ conservation trial hosted by SARORSO was further investigated in Chapter 6, exploring the possibilities of translocation of OS into a potential alternative habitat – a monoculture forest which has a global reputation as a green desert. This chapter further discussed the potential of the innovation as a game-changer in the battle to combat orchid biodiversity loss, orchid extinction, as well as potential biodiversity reclamation in oil palm estates. The investigation also assessed the potential impact of the translocation on the socio-economic landscape of the palm oil industry. Although both of these potential innovations (experiments in Chapters 5 and 6) have some important challenges in the form of uncertainty, the need for many trials and attempts to prematurely assess 'progress' by authorities, scientists and competitors, both have great potential for changing the landscape and perspective of OC, as well as the local education syllabus and the image of the region's palm oil industry, and which could lead to a new sustainable 'Orchidelirium' (Grienfield, 2021).

Chapter 2 also found that having strong support and involvement from the government and other key stakeholders on the establishment of the UOBG has benefits, especially financially, but it can be a surprisingly complex issue when there is a change in leadership as well as a complex mechanism for fostering dialogue and information exchange, which leads to red tape. The outcome of the investigation helped to highlight deficiencies and strengths in justifying the development of a UOBG on a valuable piece of land in Kuching, Sarawak, with the enforced need to effectively communicate, educate and create awareness of critically threatened OS, enhancing local knowledge to conserve OS sustainably within their own territories and address the rapidly approaching orchid extinction. This would all need to be done without losing sight of the 'big picture' that Sarawak is a developing state (CBD, 2020; CBD, 2021).

All the above investigations led to the exploration of the possibility of incorporating them into unique engaging features of the proposed UOBG. Focusing on the conservation aspect of a 21st century BG, Chapter 4 investigated the features of existing BGs that successfully attracted visitors and were also popular tourist destinations; this research identified six highly visited international Urban Botanic Gardens (UBGs) and four unique OC organisation models. Through documenting the inherent strengths and weaknesses of these organisations, this chapter analysed their unique features, successes, challenges and focused roles, and the barriers to creating public awareness and establishing education focusing mainly on cultural knowledge of biodiversity conservation and sustainable development (mainly for those visitors who do not come from a background of botany or conservation) as well as the UBGs' contribution to the economy within their communities and in their respective countries (Koopowitz, 2001; Fay, 2018). Further deliberation is presented on how and in which areas these popular UBGs did not effectively relate to their visitors, let alone generate an environment for visitors to address the issue of OC after visiting the BG.

Chapter 7 details a concept drawn up for the proposed UOBG which focuses closely on OC based on the discussions and findings from Chapters 2, 3, 4, 5, and 6, with features that show dynamism and utilise cutting-edge technology which are relatable to local visitors and demonstrate continuity for both now and the future, with the purpose of preventing orchid extinction. In line with the call by Dr Paul P Smith (Secretary General of BGCI) for BGs to carry out effective plant conservation in their own geographic and taxonomic spheres (Smith, 2020), Chapter 7 proposed a sustainable UOBG concept, whose design included a novel community-based setting tailored to Sarawak's available resources and the needs of local communities, and acting as an agent to popularise scientific knowledge among local people as well as providing access to research results and conservation concerns. The proposed infrastructure differed from that of world leading BGs which, when paired with history, makes them distinctly unique crowds pullers. For example, glasshouses would pose a challenge for the proposed UOBG if not properly explained to local people to avoid wrong expectations. The proposed sustainable UOBG instead offers creative regional characteristics, introducing concepts and designs displaying diverse natural orchid habitats as well as the culture of various ethnicities through architectural forms, tourism formats, and both physical and cultural landscapes with enriched function, economic benefits, attractive horticulture and education (Gratzfeld, 2016). These biomes would represent Sarawak's identity, creating not only effective conservation but also providing the visitors with a unique and different travel experience from that in other BGs, fully exploiting modern technology.

8.1 The Overview of the Research Aim and Objectives

The goal of this study was to create a 21st century sustainable, functional and relatable UOBG (focusing on Sarawak Lowland Orchids) in Kuching, Sarawak, which would educate and improve visitors' experiences in awareness of and interest in SLEO, their conservation, importance to the ecosystem and biodiversity, and their socio-economic contribution, through a unique and interactive educational and relatable experience when visiting the UOBG, and the inspiration it provides to visitors after the trip.

8.1.1 Research Drivers

Sarawak has been well known to Kew scientists and orchid collectors since the 1840s as having a diverse range of valuable endemic orchids (Holtum, 1953; Low, 2002; Wallace, 1962; Beaman, et al., 2001). The majority of Sarawakians are ignorant of the above powerful and valuable history, a heritage that could be an effective tool to understand and preserve the orchids. It is now known to harbour at least 10% of total orchids in the world, which have been facing the threat of extinction since the early 19th century due to over-collection by foreign collectors (of which some held government positions under Rajah Brooke's rule at the time); illegal extraction is still being carried out today, but instead by local people (Emmor, 2019). Additional threats such as habitat loss, fragmentation and illegal trading have become increasingly common. Despite efforts in OC being made through laws, policies, conferences and conventions by the authorities and local and international scientists (Go, et al., 2020), the following aims further drive this research:

a. To address the absence of a BG despite the presence of botanists from Kew since the early 19th century (Holtum, 1953; Wallace, 1962; Low, 2002; Beaman, et al., 2001). From the author's experience and through the questionnaire conducted by SARORSO in 2018-2019, other than the orchidologists and botanists, local people were not aware of the importance of OS to the ecosystem and their social-economic potential nor the fact that Sarawak OS are classified as critically endangered, endangered or vulnerable.
b. To rectify the absence of an orchid society in Sarawak. Despite being one of the most 'megadiverse' places on earth, Sarawak still did not have an orchid society until 2018 to ensure that OS diversity and its situation are made known to the public through activities to meet human needs and raise awareness of both cultivation to relieve pressure from wild orchid collecting, and conservation to prevent orchid extinction.
c. To protect Sarawak OS from loss of habitat. The ongoing massive deforestation in Sarawak due to development by the state has led to the clearing of 50% of Sarawak's primary forests over the past 50 years. Thus, there is a dire need for artificial assistance in providing alternative habitats such as monoculture plantations before OS suffers a large-scale extinction event. The challenge faced by scientists when rescuing orchids is to find new habitats large enough to cater to these rescued orchids (Go, et al., 2019).
d. To halt the illegal trading and monopoly of OS that have become the norm in Sarawak. Despite being highlighted by local scientists in conference, both activities are still

taking place (Go, 2019). The research identified that in order to curb illegal trading and poaching of Sarawak OS, micropropagation of orchids can increase the supply sustainably and flood the market by producing a great number of seedlings in the near future, preventing a monopoly and the exorbitant prices which encourage the illegal trade. However, despite this, and the fact that the micropropagation of orchids is well known globally and widely practised among scientists, established nurseries and hobbyists as an invaluable tool for conserving the maximum amount of genetic diversity in minimum space and time, and has the potential to enable the conservation of valuable orchids in this 21st century, as proven in other countries, this simple skill is still not known to the majority of the general public in Sarawak.

e. To drive the increase of knowledge and awareness regarding OS and their extinction status among local people, as the survey by SARORSO showed that the level of knowledge and awareness of OS was minimal (SARORSO, 2018). In addition, despite local scientists reporting on living in the Anthropocene era through books, journals, social media and conferences, Sarawak's local community seems to be completely ignorant or insensitive about the importance of OS to the community and environment. Forests are being cleared but only a minimum and selected few of the orchids were collected (SARORSO, 2018; Go, et al., 2019).

f. To develop a strategy that will consistently meet the deferred targets of the Global Strategy for Plant Conservation (GSPC) within Sarawak. It has been well documented that despite the presence of popular BGs worldwide, the GSPC targets have continued to be unmet (CBD, 2019; Miller, et al., 2020). The BGCI technical report, dated April 2020, discussed the increasing impact of education and public engagement with BGs in influencing visitors' behavioural change in actions such water saving, food, energy and carbon recycling, meaning that BGs need to play an active role in society. Whilst the author would prefer to be in a position to assist countries in achieving the GSPC targets worldwide, efforts can only be directed to Sarawak. Thus, the first step should begin with the state's own action in identifying best practice aimed at influencing local visitor behavioural change according to the immediate needs of the state. This is to ensure that BGs are better deployed to effectively meet the new deadline in 2050, which in this context is to prevent orchid extinction.

To emulate the impact made by the Writhlington School Orchid Project Team on young people. The author was inspired by this 30-year-old orchid project implemented by a school in the UK. Despite the UK having only 52 terrestrial orchids, the Year 8-12 students of Writhlington are more knowledgeable, skilled and passionate about not only their UK terrestrial orchids but also epiphyte orchids from Sarawak than school children in Sarawak who have lived surrounded by orchids (Coles, 2021; WOP, 2021). The project served as an eye-opener and an effective model to address reaching out to and educating the younger generation in engaging with OC and garnering interest in BGs.

8.1.2 Research Approach

Three primary research questions were stated in Chapter 1, which acted as a guide providing a clear focus to the study, with a literature review, trials and experiments in Chapters 2, 4, 5 and 6. The questions and hypotheses were as follows.

RQ1. What factors contribute to the successful collaboration between an urban botanic garden and SLEO orchid conservation with the intention to improve visitors' experiences in relation to awareness and interest acquirement about SLEO, its conservation and its importance to ecosystem and biodiversity while visiting the UBG.

Hypothesis – The collaboration of a cutting-edge UBG with the mega-rich unique orchid biodiversity of Sarawak that is under significant extinction pressure due to diminishing orchid habitats especially as no other BGs have specifically concentrated efforts on conserving Sarawak orchidaceous species in various natural manmade habitats without the use glasshouses would successfully attract visitors as the UOBG is not disconnected from their daily lives and this will create awareness, educate on the importance of orchid conservation as well encourage local visitors to be engaged in orchid conservation activities in their respective areas.

RQ2. Would an unexpected and unique experience while visiting the proposed UOBG educate visitors (both local and foreign) to create awareness and update their knowledge, learning interest and commitment to SLEOs, its conservation technologies and actions which could lead to a positive impact on conservation efforts knowing that today public EDUCATION is not the primary and initial objective of most existing BG visitors (Ballantyne, et al., 2007)?

Hypothesis – The unexpected and unique experience which is beneficial and relatable to local visitors of all generations and of different groups would be able to increase learning interest thus educate, create awareness, update knowledge, drive commitment to various conservation technologies and consequently lead towards positive impact on local conservation efforts while enjoying the recreational aspect of the proposed UOBG.

RQ3. Could the Monoculture Plantations be part of a successful ex situ conservation model in the cultivation of orchids in living collections in a botanic garden?

> *Hypothesis* - The monoculture plantation (in this case Oil Palm Plantation) could be a successful functional arboretum demonstrating the application of orchid ex-situ conservation representing a model in the proposed UOBG which could be repeated by visitors belonging to the oil palm community.

The discussion in respective chapters, resulting in the collection of data, findings and results, has helped to further develop the concept of the Proposed Sustainable UOBG in Chapter 7.

8.1.3 Research Outcome

This section details findings in support of the three research questions.

8.1.3.1 What factors contribute to the successful collaboration between an urban botanic garden and SLEO orchid conservation to improve visitors' experiences in relation to awareness and interest acquirement about SLEO, its conservation and its importance to ecosystem and biodiversity while visiting the UOBG?

Chapter 4 explored the strengths and weaknesses of the identified BGs that had clear roles, (Smith & Harvey-Brown, 2018), including enhancing their relevance to hard-to-reach communities of people who are still clearing trees, replacing them with monoculture plantations or for other development purposes without rescuing the OS (Go, 2019). It was found that with their awareness and engagement, they could play a major role in effectively addressing OS extinction issues (UoL-UK, 2010; Smith & Harvey-Brown, 2018). There is a need to work in partnership with local communities by translating and incorporating these findings into the features and activities in the proposed UOBG. The investigations found that, in order to address these important issues, the public must be exposed to various species of SLEO in a familiar environment, with relatable scientific activities available such as research, conservation, culture and public education, allowing the community to feel that they could benefit (UoL-UK, 2010; Smith & Harvey-Brown, 2018; Westwood, et al., 2020).

Therefore, in addressing the first aspect, which is education, awareness and communication through a BG, as mentioned in Chapter 1 (IUCN, 2019; Wraith, et al., 2019), in order to fill in the top three knowledge gaps in conservation priorities as identified by IUCN (IUCN, 2019), action needs to be in line with the current needs of the local people in Sarawak as per the findings mentioned earlier. Thus, to effectively conserve orchids in Sarawak, the first step is that the BG needs to be tailored to extending awareness and education, as well as communication focusing only on the OS of Sarawak, since Sarawak is home to 8% of the world's OS. In line with the critical biodiversity loss the world is experiencing, BGs need to have a greater emphasis on conserving local species threatened with extinction, and the restoration of local knowledge, as stressed by the director of Kew Gardens, Dr Alexandre Antonelle (Antonelle, 2020) and Dr Paul Smith, the Secretary General of BGCI (Smith, 2020).

Results of investigations show that scientists and conservationists alone will not be successful in conserving orchids, as shown by the unmet CBD goals and GSPC targets (CBD.int, 2020), despite 20 years of concerted efforts by scientists (UoL-UK, 2010; Smith & Harvey-Brown, 2018; Westwood, et al., 2020). Research findings also show that despite scientists from leading BG organisation such as Dr David Bramwell (a leading plant conservationist) and Dr Paul Smith claiming that ex-situ conservation would ease the pressure on in situ conservation, including due to the effects of illegal collection of orchids and unsuccessful natural propagation in the forest (the original habitat of OS), Sarawak law limits ex situ conservation by local people. But the investigation of the participation of SARORSO and its citizen science projects (CSP) (Cohn, 2008; Conrad & Hilchey, 2011; Gao, 2018) found that they have caused a change towards effective conservation activities, as seen in the success of other CSP conducted in different fields (Jones, et al., 2018).

In reflecting on SARORSO's achievement in creating CSP (as in Chapters 5 and 6), they have had a significant impact on reaching out and educating and inspiring others to participate, as well as making a significant contribution to awareness and an increase in knowledge through the participation of students in national and international OC conferences, which received wide coverage in the media (WOC, 2021; Jee, 2021; Abdullah, 2021; TVS, 2021). As in Chapters 5 and 6, the success in translocating OS to oil palm estates, and all the other economic potential, has attracted others from those communities to be interested, and this too has attracted the attention of the mass media (TVS, 2021). CSP has become the link that allows communication between the authorities and conservationists. In addition, with CSP, SARORSO became the silent voice speaking to policymakers, advocating for the possibility of communities being engaged with OC and helping researchers integrate scientific and local knowledge which could help secure a future for OS (Gao, 2018; Turrini & Bonn, 2018). However, there is one disadvantage in contrast to the above positive findings; it was reported that in addressing the challenge of educating the public on the value of these orchids and their habitat, there is a risk of OS being stolen from sites, whether from the proposed UOBG, school compound or alternative habitats (Sutherland, 2021; Greenfield, 2021).

8.1.3.2 Would an unexpected and unique experience while visiting in the proposed SUOBG educate visitors (both local and foreign) to create awareness and update their knowledge, learning interest and commitment on SLEOs, its conservation technologies and actions which could lead to a positive impact on conservation efforts knowing that today public EDUCATION is not the primary and initial objective of most existing BG visitors (Ballantyne, et al., 2007)?

The successful engagement of the MRSM school orchid project team in this pioneer project has not only helped the children to understand the importance of taking care and conserving orchids, but also to develop a School mini orchid BG within the school compound, a new extracurricular activity based on the rich untapped local resources, a platform for new ideas, new insights and a new database and findings for scientists to analyse, creating an early relationship with scientists from higher institutions and organisations. This development encourages maturity of thought as they have participated in world conferences (WOC, 2021), giving the school children the experience, confidence and opportunities available to others of their age and interest from other countries, where they have been able to cross-check ideas and findings first hand, communicating with each other and building relationships. They have inspired other school children to be interested in what they have achieved, specialising in the SO of their particular area, focusing on rare, endemic, and endangered orchids, including the rich historical background, paintings, and drawings for those who are more interested in history and the arts. This creates a potential natural network with others having the same interest, strengthening relationships. In addition, with the participation of other schools, it is hoped that over time Sarawak will be able to slow down the extinction of SO more than any scientific institution could on their own in the same period of time.

Investigation also found that by including conservation activities for schools in the UOBG as proposed in Chapter 7, where schools are given the opportunity by the SUOBG to have a permanent space for displays, demonstrating their skills through field trips or participating in orchid exhibitions, others could be inspired to do the same (Pugh-Jones, 2021). For example, presenting the experience of a field trip could assist in enabling continuity, allowing others to learn from and avoid common pitfalls which others have experienced before them. At the same time, the opportunities gained from the visit could be and shared with others in the school and the community. Similarly, SUOBG visitors who are parents or students from other schools who have been inspired would have a positive impact on conservation. By participating in the SUOBG, a wider reach can be developed, establishing connections, and presenting opportunities that would attract feedback and responses from other parties.

However, this is constrained by the fact that it involves the collaboration of school children with other stakeholders (such as zoo and museum stakeholders) (Whitaker, 2016; Frejd, 2019), meaning that as they are school children under parental care, the parents may be positive or negative; they may cause pressure on schools and curriculum changes, costs and funding, as well as poor collaboration with the UOBG management. If encouraged, these schools could become constant suppliers of protocorms and seedlings to the UOBG and the community around them, responding to demand, which in return would curb illegal extraction and trade in the long term. The participation of school children in BGs at a very young age could be the start of a healthy relationship with the BG, understanding its role and the importance of OC; this could produce more conservationists, botanists and orchidologists for Sarawak, who in turn may be able to make positive changes to laws and policies with regard to OC. School children also have influence over their parents and will be able to indirectly educate their families and those around them. As such, the presence of relatable experiments and trials at the

UOBG would attract returning visitors who would then bring others and expose them to new opportunities to be involved. School children or young people's involvement in research is normally underestimated in terms of their capacity to participate. However, in this case, it is proven that they are able to perform as any adult would, given the right opportunity and circumstances.

8.1.3.3 Could the monoculture plantations be part of a successful ex situ conservation model in the cultivation of orchids in living collections in a botanic garden?

The findings from the investigations offer not only the possible integration of SLEO and the UOBG, creating an alternative habitat for ex-situ SLEO conservation, to not only potentially improve the biodiversity of OPE, but also to create an aesthetically pleasing sight in the plantations for visitors to appreciate and potentially apply in their own lives. In the SUOBG, the plantations will be displayed as a functional arboretum incorporating OC, which would be relatable to many potential visitors who are part of the oil palm community, or the general public who live among oil palm estates and trees. This enhances citizen science knowledge and participation (Turrini & Bonn, 2018), resulting in effective and wide-reaching benefits from visiting the UOBG (Smith, 2017; Fay, 2018; Chen, et al., 2018) which attracts repeated visits. In addition, innovations implemented in the proposed SUOBG, representing ongoing conservation projects in oil palm estates and schools, act as models for those interested and will also encourage practical research for natural ecosystems, meaning that the UOBG will not just be a living museum collection, as suggested by Sara Oldfield, Secretary-General of Botanic Gardens Conservation International (BGCI) (Oldfield, 2010). However, in contrast to the above positive findings, since oil palm trees do not have branches (Srivaro, et al., 2018), SLEOs which can only grow on a horizontal surface cannot be translocated and attached to the trunk. Further, since this experiment is only two years old, and despite the farmers' confirmation that the orchid translocation does not affect the productivity of oil palm or the tree trunk itself, the long-term impact is yet to be observed. As the experiments and displays are based on living specimens, every day there will be new findings and data which will help scientists to move forward in OC.

However, this two-year-old experiment has suggested that *Da* were rarely naturally pollinated, perhaps due to the small number of its pollinators. Nevertheless, even with successful hand pollination, the seed pods disappeared after two months, with no evidence to show where they had gone, though squirrels and mice were sighted on the estate. Thus, with the above finding, with the SUOBG organising educational projects, hand pollination could be an attraction for visitors (similar to an activity on a vanilla farm) (Gigant & Besse, 2016; Gallant, 2018), conducted at certain times and places to encourage improved skills and knowledge for conservation purposes. On the other hand, hand pollination is high maintenance and labour intensive, and could be costly as a long term or permanent activity if pollinators still fail to be present in greater numbers.

8.2 Research Limitations

It is inevitable that throughout a research project, limitations exist that may compromise or affect the quality and efficiency of the project. This project was no different. This section details 'out of the ordinary' limitations and hurdles faced when undertaking the research.

a. Innovation in this paradigm is mostly conceptualised as effective conservation and inherently good (Schoberg & Blok, 2018). Yet, the study and innovations do not automatically lead to a societally desirable and ethically acceptable combination of cost-effective welfare for the community and environmental sustainability in the long term.
b. The researcher's proposal for the SUOBG is a concept based on analysis of novel networks and practices of biodiversity conservation at existing BGs.

However, it seeks to focus on the conservation and landscape aspects, in order to generate the right impact with regard to the serious challenge of orchid extinction in the 21st century. It does not take into consideration the technical aspects of land or architecture.

c. The development of the proposal for the SUOBG was contingent on various parties coming together to achieve the same goal. This does not necessarily mean that differences among the stakeholders are easily reconcilable, meaning that progress may be slow due to disputes on the location of land, classification of the land and the jurisdiction of the different stakeholders, among others.

d. Innovation depended heavily on the availability of equipment and materials. As many of the concepts and activities were very new for the state, equipment such as Lamina flow cabinets and agar need to be imported. As all this was ongoing during a worldwide pandemic, import costs and times were vastly inflated, making value almost non-existent.

e. The research depended greatly on interviews and surveys created by SARORSO. The planned personal interviews with the community and other BGs (such as Bristol Botanic Garden, which is a newer, volunteer-based BG) would have been ideal for this proposal. In addition, interviews with potential UOBG stakeholders in Sarawak could not take place due to the unexpectedly prolonged pandemic.

f. The project required communication over two widely different time zones. With the author operating in the UK and experiments ongoing in Sarawak, communication became a challenge due to the seven to eight-hour time difference. Connectivity was also an issue in Sarawak as the experiments were carried out in a school and on an oil palm estate outside of Kuching. In addition, the researcher was not able to travel to Malaysia to visit experiment sites. This affected the obtaining of consistent results. Thus, with the pandemic and lockdowns going on all over the world, data collection was heavily impaired.

g. During the UK Covid-19 pandemic lockdown from March 16, 2020 until May 18, 2021 (14 months), the researcher experienced slow progress and had her resilience tested with the unavailability of libraries, botanic gardens (as they were rarely open) and communication, and being unable to be with her spouse and family for 16 months, as well as receiving consistent bad news regarding Covid in the UK and in Malaysia.

8.3 Future Direction and Recommendations for Further Research

Sarawak is a biodiversity hot spot among 17 such regions worldwide, but habitat deterioration and mass change in land use are causing a significant threat to SLEO. The solution to this demands the presence of a SUOBG. With increased public awareness, government policies, revised legislation and laws on orchid micropropagation, ex situ conservation carried out at every corner and on every tree of Sarawak, SLEO will not be depleted, and enough supply will be made available to meet demand. The following are recommended areas for future research:

8.3.1 Conservation of indigenous and local knowledge, with ex-situ conservation of SLEO to be conducted in every district of Sarawak according to the number of secondary schools present. This could rekindle the memories of the mature community of an area, encouraging the sustainable use of plant resources for the benefit of all as part of sustainable development.

8.3.2 Incorporation of OS in the curriculum in both Primary and Lower Secondary Schools in Malaysia.

8.3.3 Ex-situ conservation on other monoculture plantations such as sago and fruit trees for the purpose of conserving the SLEO which cannot survive on the trunks of oil palm trees.

8.3.4 Ex-situ conservation of SLEO in housing estates, offices, streets, parks, and government building compounds according to their natural geographic condition and distribution.

8.3.5 Review of existing laws and legal framework relating to wild orchids to adjust Malaysia's policies, laws and strategies to the needs of the current orchid extinction scenario.

8.3.6 Ex situ conservation of the Sarawak Highland Orchid through CSP.

8.3.7 Value-added activities such as the sale of orchid protocorms in jars to encourage purchase from sustainable sources.

8.3.8 Development of a Sarawak floriculture industry of local orchids through oil palm estates.

8.4 Conclusion

Living in the Anthropocene, the era in which the activities of mankind have caused a high level of threat to plants (Fay, 2018), there is a need to remedy the effects of this activity. In this context, the UOBG, primarily focusing on SLEO, seeks to offset the effect of a high rate of urbanisation in Sarawak, which has come at the price of her green cover (habitat for orchids) due to low awareness of OC. Thus, Sarawak needs to develop a sustainable UOBG focusing on biodiversity conservation which includes the following:

1. A garden which is dedicated to only SLEO collection, cultivation, preservation and display, which can at the same time inspire other institutions to collaborate with the UOBG. Collaboration is crucial due to Sarawak's geography being complex (Beaman, et al., 2001; Schuiteman, 2017), and the proposed SUOBG will require a constant supply of orchids for replenishment or sale to meet demand (Nparks, 2018).
2. A garden that displays and holds activities which are relatable and demonstrate synergistic coexistence with communities, portraying various economic benefits to

the local community (Mirenda, 2021) as well as other visitors, of preserving and promoting their orchid biodiversity and value-added products/services. This facilitates returning visitors and attracts new visitors, engaging them with conservation strategies that the proposed SUOBG has laid out.

3. Innovative approaches through CSP, enabling the creation of a network throughout Sarawak preserving specific orchids within their natural distribution without pressure to adapt to a new environment. This network can act as a nursery for the proposed SUOBG, duplicating the SUOBG's ex-situ conservation efforts on a much smaller scale specialising in their own local OS, which would inspire participation from audiences of all generations and communities. In turn, this will lead to an increase in public awareness, education and communication on orchids, their current situation, conservation and the potential socio-economic benefits for the community, at the same time protecting the orchids from poaching.

With the above factors in mind (whilst acknowledging that they have their own potential challenges) and based on the strengths and weaknesses of existing established BGs around the globe, it is important that steps begin with positivity. Thus, a SUOBG is proposed based on the above concepts in order to address the loss of OS in Sarawak, and to also ensure that the GPSC targets are met. As depicted in Chapter 7, the research culminates in the concept of a SUOBG that understands its role as a BG and how it can engage the community as a whole, even though there would be tough challenges. The sketch and outline proposed are an indication of what the SUOBG comprises – it serves as a visual layout, to be used as a structure according to the researcher's recommendations and findings in order to effectively address the issues that Sarawak's OS are currently facing. The sketch and proposal will require technical refinement by industry experts who will be better placed to understand how each component can work together to form a coherent organisation. The key here is to understand that there is a gap that can be filled using innovative approaches and that there is scope for community engagement to take centre stage. On its own, the proposed SUOBG will be insufficient to address the current conservation challenges faced by the 2500 OS in Sarawak. Therefore, to protect orchid biocultural diversity and address the extinction issue, not only does Sarawak need more than one SUOBG, but at this critical point, from the investigations, it is more important to establish a network of schools and monoculture plantations immediately across the 26 sub-districts. These will serve as powerful tools for ex-situ conservation of orchids that effectively create awareness, educate and communicate, while waiting for the SUOBG to mature.

It is hoped that this study can provide insight for the orchid conservation stakeholders in Sarawak and that it will be used for the betterment of orchidaceae in Sarawak, whilst at the same appreciating that this also has implications for the broader conservation community.

I have appended the most recent progress of my work as an outcome of the thesis to the appendix.

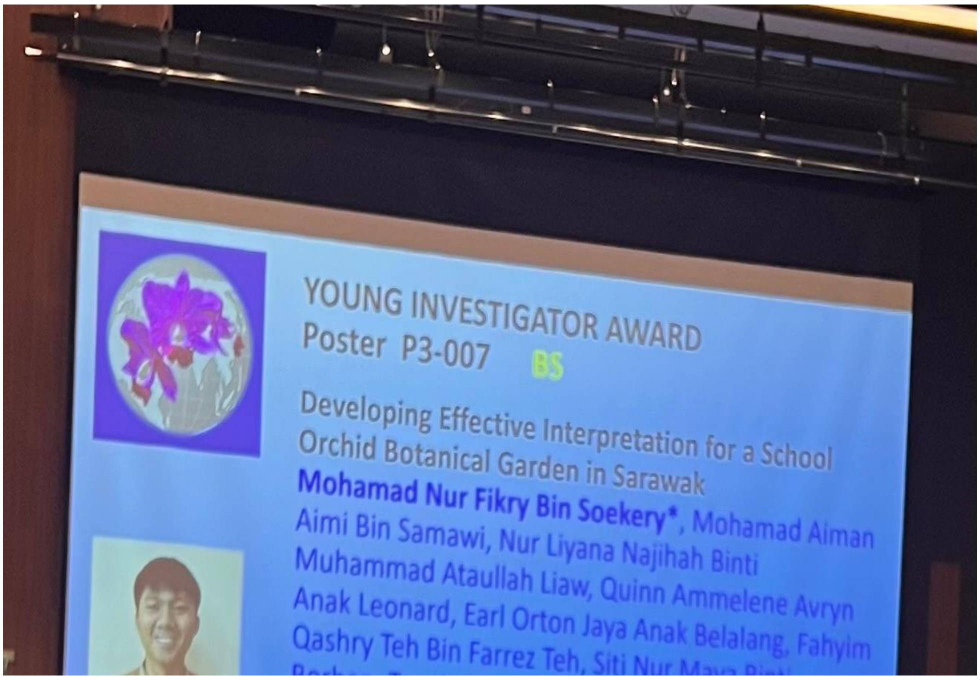


*Figure 27"Latest Achievement - Students affiliated with the MRSM JIVOM Laboratory have garnered acclaim by clinching the Junior Investigator Award at the esteemed 23rd World Orchid Conference held in Tainan, **Taiwan in 2024**. Their research poster titled 'Developing Effective Interpretation for a School Orchid Botanical Garden in Sarawak' stands as a testament to their unwavering commitment and noteworthy contributions to the field, a trajectory unforeseen prior to 2019. Additionally, they are slated to present at the upcoming BCGI 8th Global Botanic Garden Congress in Singapore in August 2024, where they will present a poster titled 'Challenges in Establishing & Sustaining a School Mini Orchid Botanical Garden in Sarawak Amidst Leadership Transitions Source: SARORSO,2024'"*

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10 Appendices

10.1 Appendix 1

No	List of Early Foreign Orchid Collectors of Sarawak Orchids				
	tanist/ Collectors	Publication	Date	Location	Remarks
2	Sir Hugh Low Resident of Labuan,Sarawak Resident of Perak,Pen Msia	Orchids of Sarawak	1845	Labuan and throughout Sarawak Labuan Forest was cleared	Hispaintings of orchids and other subjects kept at Kew. Numerous orchids were collected but not systematically recorded
3	Thomas Lobb	Orchids of Sarawak	1857	Lawas	Worked for firm of nurserymen Messrs. Veitch & Sons
4	Odoardo Beccari	Orchids of Sarawak	1965-1868	Kuching, Matang, Mount Santubong	Built lodging and laboratory called Vallombrosa near Mount Matang
5	Frederick W. Burbridge	Orchids of Sarawak	1877-1878	Lawas, Meropok River	Curator of Botanic Gardens of Trinity College, Dublin from 1879 to death
6	Ignatz F. Förstermann	Tree Flora of Sabah and Sarawak Vol.1	1886	Sarawak	Employed by English horticulture firm Sander & Sons
7	Charles Hose	Orchids of Sarawak	1891-1894	Mount Dulit, Mount Lambia	26 orchid taxa collected
8	George D. Haviland	Orchids of Sarawak	1892	Kuching, Mount Barang, Mount Penrissen, Limbang, Ulu Tawaran, Rajang, Mount Lambia	Sarawak medical officer and Curator of the Sarawak Museum
9	Henry N. Ridley	Orchids of Sarawak	1894, 1897, 1903, 1905, 1915	Bau, Matang, Lundu	Made about 50,000 collections in his lifetime

10	Johannes Waterstradt	Tree Flora of Sabah and Sarawak Vol.1	1891	Padas River	Danish zoological collector. Much of his orchid collections went to the firm of Hugh Low in London
		Tree Flora of Sabah and Sarawak Vol.1	1892-1893	Lawas River & Kinabalu	
		Tree Flora of Sabah and Sarawak Vol.1	1894	Kudat, Banggi, Balambbangan, Labuan, Kinabalu, Lawas River, Limbang River	
		Tree Flora of Sabah and Sarawak Vol.1	1895	Kinabalu	
		Tree Flora of Sabah and Sarawak Vol.1	1902	Brunei	
		Tree Flora of Sabah and Sarawak Vol.1	1903, 1908, 1912	Kinabalu	
11	Friedrich R. R. Schlechter	Tree Flora of Sabah and Sarawak Vol.1	1901	Labuan, Kudat, Sandakan, Banjarmasin, Balikpapan, Samarinda, Kutei	German orchid specialist
		Tree Flora of Sabah and Sarawak Vol.1	1906-1907	Kuching	

12	John Hewitt	Orchids of Sarawak	1905	Kuching, Limbang	Curator of Sarawak Museum in 1905-1908
			1907	Baram	
			1908	Bungo Range, Mount Matang, Saribas, Mount Pueh	
13	Cecil J. Brooks	Orchids of Sarawak	1907-1910	Bungo Range, Mount Penrissen, Mount Santubong, Mount Pueh, Bau, Mount Senggi, Mount Kapor, Tringos	Collected 85 orchid taxa
14	John C. Moulton	Orchids of Sarawak	1909	Lawas	Founded Sarawak Museum Journal in 1911. Curator of Sarawak Museum 1905-1915 and returned to Sarawak as Chief Secretary of the Government
			1910	Limbang River	
			1911	Batu Lawi	
			1913	Mount Pueh, Mount BBeumput	
			1914	Mount Murud	
15	James W. Anderson	Orchids of Sarawak	1912	Bau, Mount Pueh, Mount Berumput, Mount Pensaung	39 orchid taxa collected
16	Eric P. Mjöberg	Orchids of Sarawak	1922	Mount Murud, Mount Dulit, Bidi Caves, Mount Pueh, Mount Matang, Mount Penrissen, Lundu, Sadong, Santubong	95 orchid taxa collected
			1925	Batu Tibang	
17	Mary Strong Clemens and Joseph Clemens	Orchids of Sarawak	1929	Kuching, Lundu, Mount Pueh, Mount Gading, Bidi Caves, Mount Matang	49 orchid taxa collected
18	Richard Eric Holttum	Tree Flora of Sabah and Sarawak Vol.1	1931	Kinabalu	Director of Singapore Botanic Garden together with Joseph Clemens and wife Mary Strong Clemens
19	Paul W. Richards	Orchids of Sarawak	1932	Marudi, Dulit, Bidi, Bau, Santubong	Botanist on Oxford University Expedition

20	Patrick M. Synge	Tree Flora of Sabah and Sarawak Vol.1 and Orchids of Sarawak	1932-1933	Miri, Baram, Marudi, Bidi, Bau, Santubong	Assisted Paul Westmacott Richards of Oxford University Expedition
21	Winifred M. A. Brooke	Orchids of Sarawak	1954-1956	Kuching	Collected approximately 3000 number which are in the herbaria of Leiden, Natural History Museum, London, Geneva and Sarawak
22	John W. Purseglove	Orchids of Sarawak	1955-1956	Kuching, Batu Kitang, Setapok, Mile 6 Penrissen Road, Semanggoh Forest Reserve, Bau, Lundu, Mount Gading, Sematan, Mount Pueh, Bako, Tau River, Mayeng River, Bukit Mersing, Tatau	Collected 64 orchid taxa and are in Singapore Botanic Gardens Herbarium with duplicates at Kew, Leiden, Sarawak and Arnold Arboretum
23	Eduardo Quisumbing	Tree Flora of Sabah and Sarawak Vol.1	1963	Bako, Santubong, Semengoh, Bau, Brunei, Mt Kinabalu	Filipino orchidologist
24	Jim B. Comber	Tree Flora of Sabah and Sarawak Vol.1	1967-1968	Tenom and Crocker Range, Sabah	Collections given to Kew
25	J.C Nielson	Orchid of Sarawak	1978	55 Collection, 49 taxa	
26	Anthony Lamb	Tree Flora of Sabah and Sarawak Vol.1	1974, 1977-1981, 1990s		Collections sent to Kew or Leiden. Used Sandakan herbarium collecting numbers although did not always lodged there

27	C. Hansen	Orchids od sarawak	1978-1991	Unavailable	Collected 56 , 47 taxa
28	E.F de Vogel	Orchids of Sarawak	1988-1991	Unavailable	Collected 418, 251 taxa
29	T. Roelfoesema	Orchids of Sarawak	1997-1998	Unavailable	Collected 171, 134 taxa
30	A. Schuiteman	Orchid of Sarawak	1993	Unavailable	Collected 121, 104 taxa

(SFDM,FRIM,SWFDM, 1994; Beaman, et al., 2001)

Note:Foreign Interest on Sarawak Orchids Since 1847

Sir Hugh Low, son of a Scottish horticulturist, was earlier a naturalist sent by his father at the age of 20 to collect orchids and other flora in 1847 and he stayed in Labuan, Sarawak as Governor of Rajah Brooke administration until 1877 before he left for Perak, West of Malaysia to become a Resident (Low, 2002). As mentioned by Sir Hugh Low in his book (Low, 1968), the colourful history of the serpentine Sarawak River (74.56 mile) was the main transportation for the early inhabitants who were Malays and inhabitants of the sea-coasts in southwestern Sarawak (Low, 1968; Low, 2002). The river is also where history begins long before the appointment of the white Rajah by the Sultan of Brunei in 1840 (Hahn, 1953; Maddison, 1967). Fleets ascended the river carrying explorers who were botanists and some in modern science referred to as orchidologists hunting for the beautiful and majestic floras of Sarawak (Beaman, et al., 2001). The Orchidaceace described by botanist Hugh Low as profusion and beauty; were seen on the open banks of the Sarawak rivers; the epiphytes delightfully decorated the forest trees by the rivers (Low, 1968) gave a glimpse how Kuching was 174 years ago. These orchids were collected and brought back to England during the Orchidilerium (Swinson, 1970). Orchidilerium is the name given to the Victorian era of Orchid madness between1837-1901 (Chase, et al., 2017). It is when collecting and discovering orchids reached extraordinarily high levels due to the price they were paid for by the Royalties and elite societies in the United

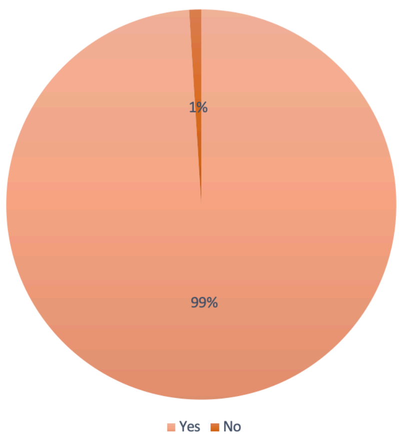
Kingdom which spread to the European and America then (Mjoberg, 1930). Wealthy orchid fanatics of the 19th century sent explorers which included botanist Sir Hugh Low (Arnold, 1932) i and other collectors (Russan & Boyle, 1893; Mjoberg, 1930; Beccari, 1904) to almost every part of the world in search of new varieties of orchids. Orchidelirium was also known to be synonym to Dutch tulip mania. However, despite being ruled by British Rajahs and later colonised by the British, the presence of famous botanists since 150 years ago and despite having about 7% of the total recorded species orchid of the world, Kuching never enjoyed a development of a Botanical Garden by its British colonise.

10.2 Appendix 2

SARORSO Community Questionnaire

Question 1

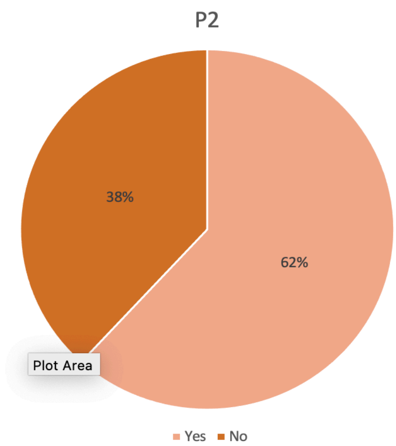
What type of flower shown in diagram? (correct answer: orchid)



The survey was known by public made by a Sarawak orchid Society. The picture shown was Sarawak State Flower *Phalaenopsis bellina* which is locally known as Normah orkid (previously known as Orkid Lundu (named by the Malays) or Kembang Alo (by the Bidayuh)

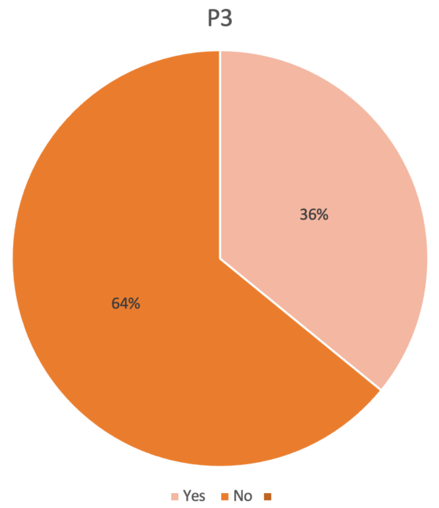
Question 2

Is the state flower of Sarawak an orchid?



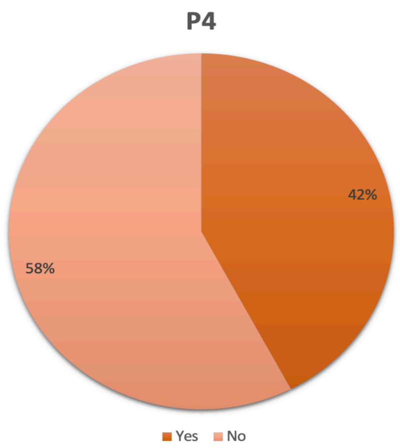
Question 3,4

Do you know the name of the state flower of Sarawak?



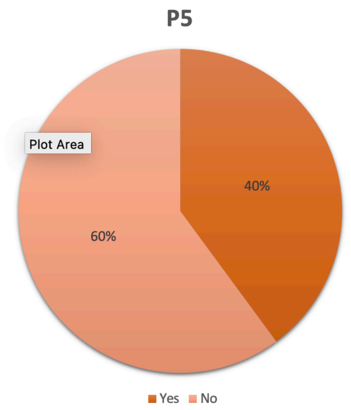
Question 5

Have you seen the Oleaner Hawk Moth Caterpillar before in Sarawak?



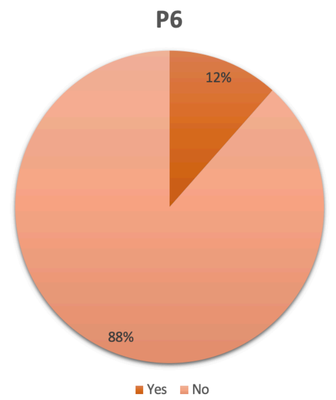
Question 6

Did you know that there are more than 31000 species of orchids and 110000 hybrids and orchids are the largest family of flowering plants which comprise approximately 8% percentage of flowering plants?



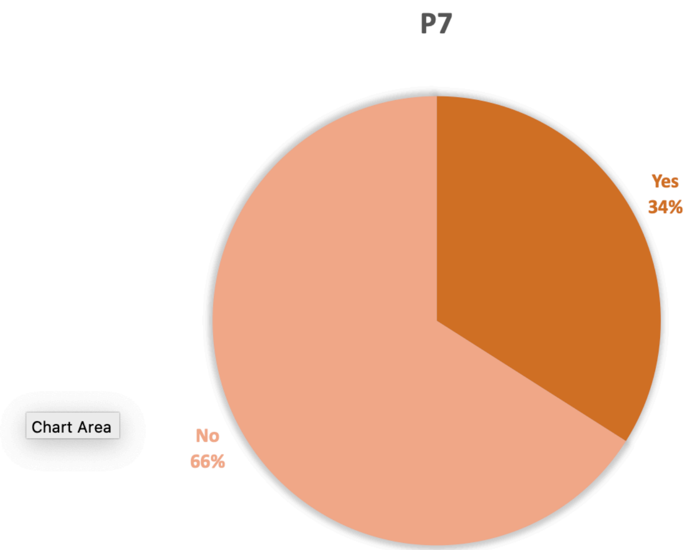
Question 9

Do you know Sarawak has not less than 2000 species of orchids?



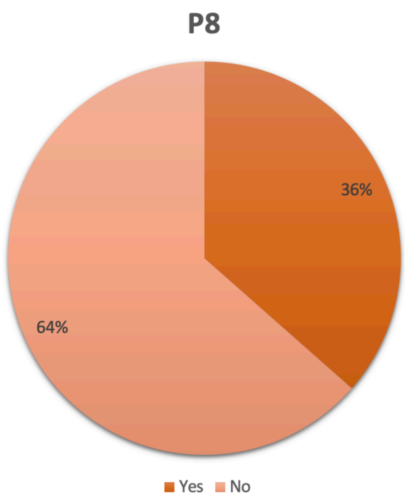
Question 10

Have you noticed Dendrobium Crumenatum?



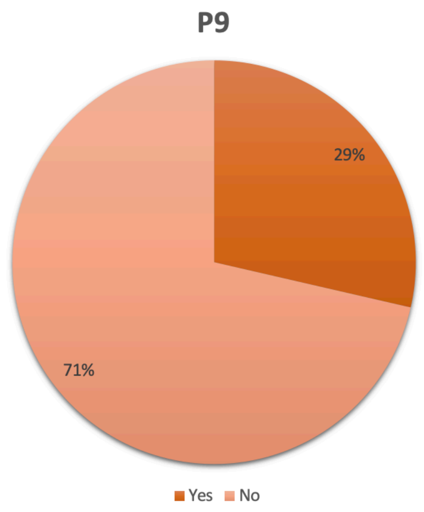
Question 11

Orchids are parasites



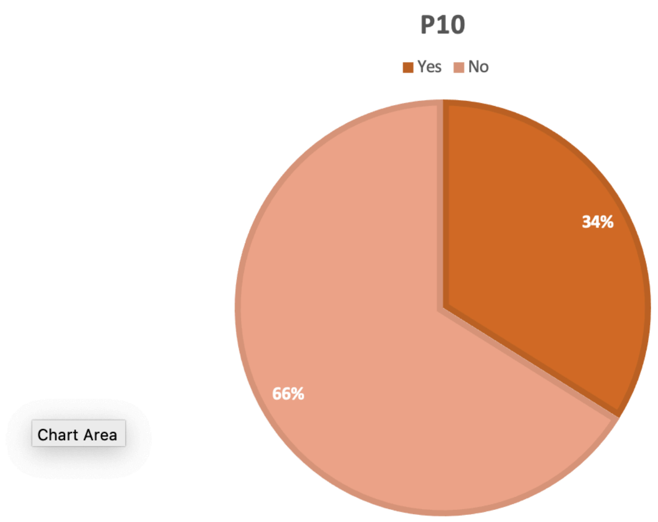
Question 12

Have you sighted Arundina Graminifolia around areas where you have lived?



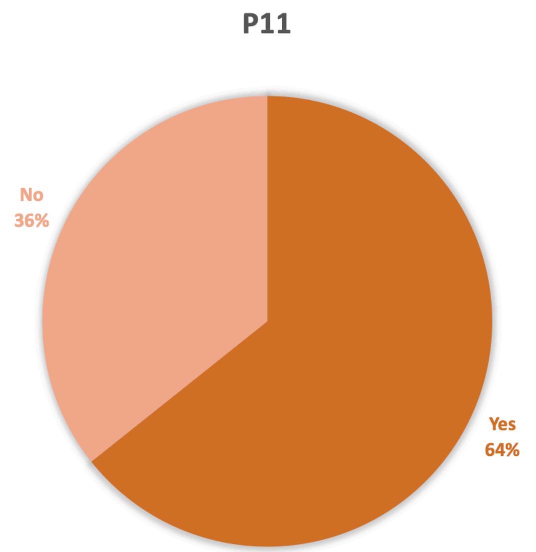
Question 13

Have you heard about orchid conservation



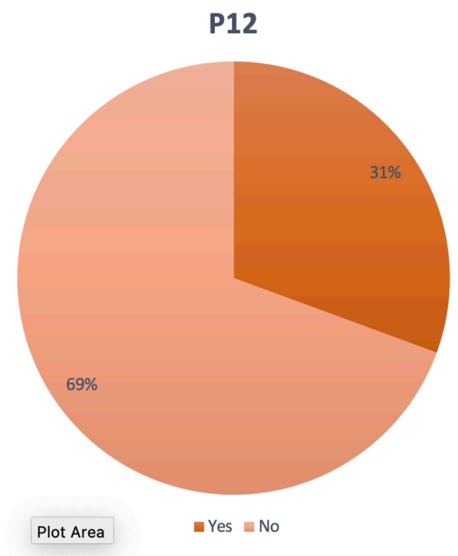
Question 14

Is conservation of orchids an important issue



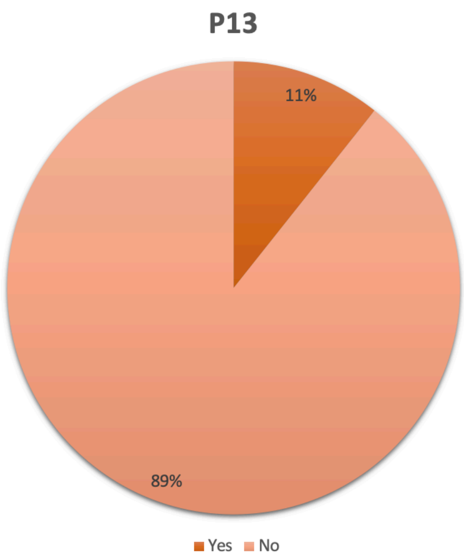
Question 15

Do you know what a flask orchid is?



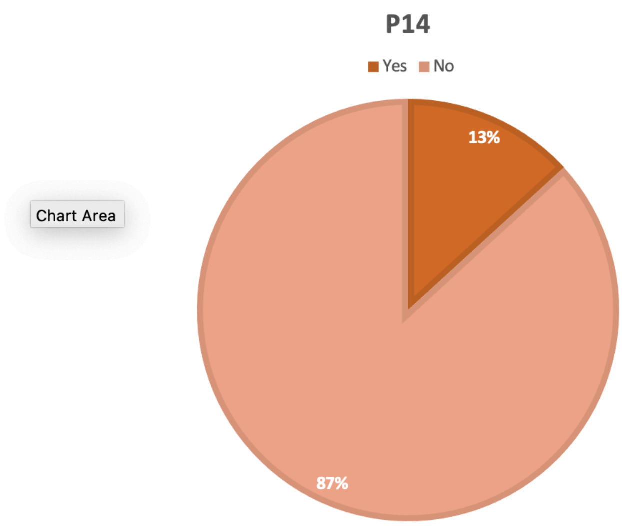
Question 16

Did you know MRSM students are studying on orchid micropropagation for conservation purposes?



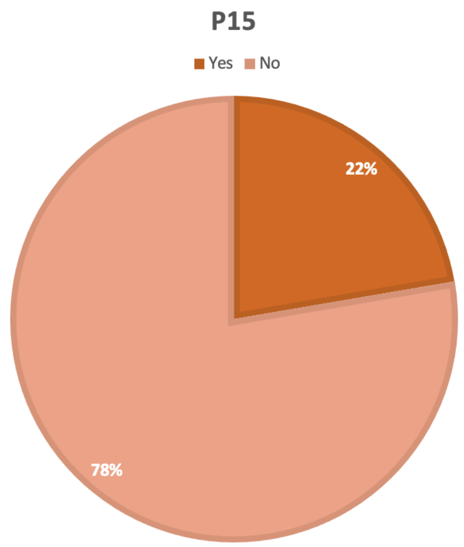
Question 17

Do you know roughly the meaning of rescuing species orchids?



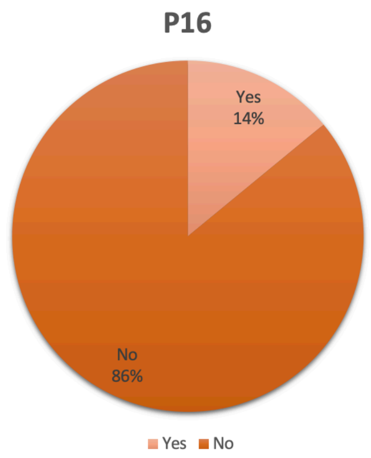
Question 18

Have u been to any orchid park or garden in Sarawak?



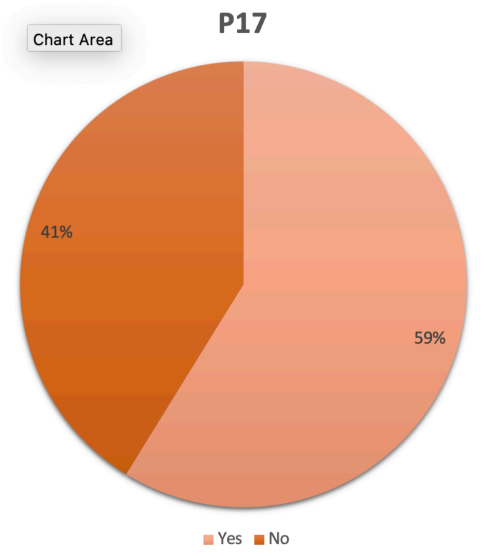
Question 19

Do you know that SARORSO has started to introduce rescued orchids into oil palm and they are the first to to do it the world?



Question 20

Do you think Kuching needs a Species Orchid Botanical Garden?



Medicinal Purposes of Orchids Species

Page	Name	Location	Purpose (Southeast Asia) (Eng, 2019)	Purpose (Pant & Raskoti, 2013)
79	***Dendrobium subulatum***	Sarawak	- Applied to relieve headache	
(12)	***Dendobrium speciosum***	Australia		- Emergency food
	Dendrobium cremenatum	Malaysia or Singapore	- Flowers gregariously several days after thunderstorm - Juice from fresh, crushed, boiled, or roasted pseudobulbs, dropped into ear to relieve headache o *Malays in Kelantan,* stuffed orchid stems with onion and jintan manis before roasting preparation in hot ashes - Pre-war Malaya, pigeon orchid highly regarded as magical plant, employed in ceremonies to induce return of beneficent spirits	
(42)	***Dendrobium amoenum***	Nepal, Burma, India		- Stem is used for tonic
(43)	***Dendrobium crepidatum***	Nepal, Bhutan, China, India, Laos, Myanmar, Thailand, Vietnam		- Stem is used in fracture
(43)	***Dendrobium densiflorum***	Nepal, Bhutan, Burma, China, India, Laos, Myanmar, Thailand		- Pulps of the pseudobulbs are used in boils and pimples
81	Malays referred to orchid as anggreks			
81	***Dendrobium purpureum***	More common in East Malaysia	- Substitute to *Dendrobium Cremenatum* - Stems; used to treat whitlow	
81	***Dendrobium planibulbe***	More common in West Malaysia	- Substitute to *Dendrobium Cremenatum* Before modern medicine and antibiotics in Malaysia; pounded into a poultice and applied to sores and infected wounds in Peninsular Malaysia	
81	***Dendrobium subulatum***	Perak	- Substitute to *Dendrobium Cremenatum*	
(44)	***Dendrobium eriaeflorum***	*Nepal, Bhutan, Burma, India, Malaysi, Myanmar*		- Whole plant is used in tonic

(44)	***Dendrobium fimbriatum*:**	Nepal, Bhutan, China, India, Myanmar, Thailand, Vietnam		- Whole plant used in liver upset and nervous debility
(45)	***Dendrobium heterocarpum***	Nepal, Bhutan, China, India, Indonesia, Laos, Philippines, Sri Lanka, Thailand		- Paste from stem is used in fracture and dislocated bone
82	***Dendrobium crumenatum***	Malays	- Malays thought nothing to be its equal for affections of the brain and nerves that a conserve of its flowers and leaves was used for cholera	
82	***Dendrobium quadrangulare and D. pumilum***	Malaya	- Treat Dropsy	
(45)	***Dendrobium longicornu***	Nepal, Bhutan, China, India, Myanmar		- Plant juice is used to relieve fever, boiled roots are used to feed livestock suffering from cough
(46)	***Dendrobium macraei***	Nepal, India		- Stem is used in asthma, bronchitis, throat trouble, fever and aphridisiac
117	***Vanilla planifolia and Vanilla pompano***	Singapore Botanic Garden	- Flowered and bore fruit	
117	***Vanilla***	Malay Peninsula	- Vanilla only successfully grown in the drier parts, heavy rainfall in many parts militates against it	
203	***Eulophia nuda* (commonly referred by *Eulophia spectabilis*)**	Distributed throughout southern China, India, Myanmar, Thailand, Indochina, *Malaysia,* Sumatra	- Terrestrial orchid	
(12 & 13)	***Eulophia***	Africa	-	- Prevent Miscarriage
(12 & 13)	***Eulophia flaccida***	Africa		- Powdered to incisions made on skin to relieve pain
(12 & 13)	***Eulophia cucullata***	Africa		- Treat diabetes or skin infections, prevent epilepsy
(50)	***Eulophia dabia*:**	Nepal, Afghanistan, Bangladesh, Bhutan, China, India, Pakistan, Tajikistan, Turkmenistan, Uzbekistan	- Rhizome is used in appetizer, tonic and aphrodisiac, purulent cough and heart trouble. Tubers are given to infants in cough and cold	
(50)	***Eulophia spectabilis***	Nepal, Bhutan, China, Cambodia, India, Laos,		- Tubers are used in appetizer, used for tuberculosis, tumors and bronchitis

		Myanmar, New Guinea		
206	***Crepidium resupinatum***	Malaysia	- Occurs in mountain forests at the forest floor Clear bile, relieve fever, control infantile fits, treat measles and promote sweating	
210	***Hetaeria obliqua***	Malaysia	- Prepare a poultice for sores	
259	***Angraecum furvum*** Malay; Angrek Kitsjil		Yellow on the outside, dark inside, russet, or smoky colour, yellow at the edges, faint scent	
259	***Dendrobeum purpureum*** 2 Malay Names; Angrek Jambu / Angrek Cassamba		- Growing on host plants, *Waringin* (Ficus Benjamina), *Sumaria*, (Casuarina Equisetifolia) and *Clove* (Szygium aromaticum) - Used to treat matta icaro (whitlow) – stems were crushed, heated, and then smeared on affected parts of the fingers – heat caused whitlow abscesses to rupture, releasing pus and accelerating healing	
(46)	***Dendrobiumm monticola***	Nepal, China, India, Thailand		- Pulps of the pseudobulbs are used in boils and pimples and other skin eruptions
260	***Luisia confusa* (labelled; *Angraecum* decimum / *angustifolium*)**	Widespread in Indonesia	- Javanese used conserved leaves to treat disorders of the brain and nerves, bloody diarrhoea and poisoned wounds inflicted by krisses and pikes	
260	***Dendrobium anosnum*** - Other Names. o *Dog Orchid* o *Angraecum caninum* - *Malay Angrek Andjing*		- Grew on trees with short, thick, mossy trunks like kinar (Kleinhovia hospita) near beaches an in the low land	
260	***Dendrobium ephemerum***	Lowlands of Sulawesi and the Moluccas		
(47)	***Dendrobium moschatum***	Nepal, Bhutan, China, India, Laos, Myanmar, Thailand, Vietnam		- Pseudoblb is used in fracture and dislocated bone
264	***Phalaenopsis amabilis*** o Malay – *Anggrek putih besar*		- No mention of medicinal usage, leaves were eaten as food	
265	***Renanthera matutina***	Distributed from Sumatra to Malaysia,	- Grew by the beach and along riverbanks in the valley	

		Kalimantan, and Java	- Deep yellow and densely overlaid with red lines and dots Used to be pickled	
(11)	***Vanilla planifolia andrew***	America		- Treatment of hysteria, fever, impotence, rheumatism - To increase energy of muscular system
270	***Vanilla planifolia andrew***	Indonesia	- Important cash crop	
270	***Vanilla abundiflora J.J. Sm.***	Indonesia	- Obtain vanilla like fragrance from ripe pods	
270	***Liparis treubi J.J. Sm.***	East Coast of Celebes, Indonesia	- For Constipation - Chew on plant (Angraecum Gajang) and swallow the juice while simultaneously rubbing their abdomen with its heated leaves	
(56)	***Liparis nervosa***	Nepal, India, Japan, Malaysia, Thailand		- Tuber is used to treat stomachache, malignant ulcers
271	***Calanthe rubens ridl.***	Indonesia	- Employed in native medicine, no specific mention on its usage	
271	***Calanthe veratrifolia***	East Coast of Sumatra, Indonesia	- Crushed flowers were employed to relieve pain from dental caries	
271	***Dendrobium crumenatum***	Batavia, Indonesia	- Treat earache	
(31)	***Calanthe plantaginea***	Nepal, Bhutan, China, India		- Dry powder from rhizome with milk is taken as tonic and as an aphrodisiac
(31)	***Calanthe puberula***:	Nepal, Bhutan, China, Japan, Vietnam		- Ehizome is used as antipyretic
(32)	***Calanthe sylvatica***:	Nepal, Bhutan, China, India, Indonesia, Japan, Sri Lanka, Thailand, Vietnam		- Pseudobulb is used to stop bleeding from nose
(32)	***Calanthe tricarinata***	Nepal, Bhutan, China, India, Japan		- Leaves and pseudobulbs are aphrodisiac and leaf paste is also applied on sores and eczema
272	***Dendrobium faciferum***	Indonesia	- Wickerwork	
272	***Dendrobium utile***	Indonesia	- Yellow green stems to make baskets and mats for royalty	
272	***Dendrobium salaccense***	Indonesia	- Leaves to impart liquorice-like fragrance to cooked rice and to perfume women's hair	
272	***Renanthera moluccana***	Indonesia	Make pickles which tasted like capers	

276	***Corymborkis veratifolia***	Kelantan	- Used as a febrifuge to treat fever in children - Sap from leaves and stem was rubbed into hair to stimulate hair growth	
276	***Vanilla graffithii***	Kelantan	- Used to treat fever; but only lasts a day	
276	***Apostasia wallichi***	Peninsular Malaysia	- Employed as antidiabetic herb in Peninsular Malaysia	
279	***Nervilia aragoana***		- Used as ubat meroyan	
279	***Acriopsis javanica (Acriopsis lilifolio)*** - Other Names: *Sakat Bawang / Onion Orchid*	Malacca	- Unremitting high fever	
279	***Anoectochilus***	Cultivated in a Chinese plantation in Parit Buntar (northwest Malay Peninsula)	- Use as medicine (could not discover exact use)	
279	***Anoectochilus reinwardtii***	Iban and Kelabit (Borneo)	- Used to treat infertility	
279	***Aplostellis flabelliformis*** - Malay Name; Daun sa-helai sa-tahun	Malays	- A decoction of the leaf was consumed, and the remainder poured into bathwater for use by the parturient during the first 3 days of puerperium as a preventative preparation against complications	
(8)	**Anoectochilus formosanus. Anoectochilus koshunensis,** ***Anoectochilus roxburghii***	China		- Used in Chinese folk medicine
(27)	***Anoectochilus roxburghii***	Nepal, Bangladesh, Bhutan, China, India, Japan, Laos, Thailand		- While plant used to cure tuberculosis
280	***Bromheadia finlaysoniama*** - Malay Name: *Seraman*	Malacca, Sarawak	- Malacca – treat rheumatism - Sarawak – flower stalks are chewed to extract the juice which is thought to be effective for treating asthma and toothache	
280	***Bulbophyllum vaginatum***	Malacca	- Roasted fruit is dropped into ear to treat earache	
(11)	***Bulbophyllum kwangtungense***	Chinese		- Yin tonic (traditional Chinese medicine)
(12)	***Bulbophyllum maximum***	Africa		- Protect against sorcery
(29)	***Bulbophyllum careyanum***	Nepal, Bhutan, Burma, Myanmar, Thailand		- Paste from pseudobulb and leaves used for skin urn
(29)	***Bulbophyllum leopardinum***	Nepal, Bhutan, China, India, Thailand		- Paste from pseudobulb used in skin burn
(30)	***Bulbophyllum odoratissi***	Nepal, Bhutan, Burma, China,		- Whole plant is to treat tuberculosis and fracture

		India, Laos, Myanmar, Thailand		
(30)	***Bulbophyllum umbellatum*:**	Nepal, Bhutan, China, India, Myanmar, Thailand, Vietnam		- Whole Plant is used to enhance congenity
281	***Cymbidium***		- One unidentified species was an emetic	
281	***Cymbidium finalaysonianum*** **Malay Name*: Sepuleh***		- Ward off evil spirits - Chewed roots were spat on sick elephant following recitation of a mantra (Matra Gajah)	
281	***Dendrobium xrumenatum*** - Other Names: ○ Malay Name: *Daun sepuleh tulang* *Anggerik merpati*	Malay Peninsula, Singapore	- Used by Malays to treat boils and pimples - Treat earache - Plant was used to sprinkle magic rice to ward off evil influences alleged to be the cause of ill fortune, illness, or demise	
(12)	***Cymbidum madidam***	Australia		- Chewed for dysentery and seeds were used as an oral contraceptive
(12)	***Cymbidium canaliculatum***	Australia		- Treating different ailments such as dysentery, to relieve pain and in control of ringworm
(38)	***Cymbidium aloifolium***	Nepal, Bhutan, China, India, Indonesia, Malaysia,Myanmar, Sri Lanka, Vietnam		- Paste from rhizome and root used for fracture and dislocated bones
(39)	***Cymbidium devonianum***	Nepal, Bhutan, China, Thailand, Vietnam		- Root paste is appled to treat boils, concentrated decoction is taken in cough and cold
(39)	***Cymbidium iridioides***	Nepal, Bhutan, China, India and Myanmar		- Fresh juice from leaf is applied is applied to deep wound
(40)	***Cymbidium longifolium***	Nepal, Bhutan, China, India, Myanmar		- Leaves are used in demulcent
(12)	***D. teratifolium, D. discolor***	Australia		- Treating different ailments such as dysentery, to relieve pain and in control of ringworm
282	***Dendrobium planibulbe*** Malay Name: *Miga*		- Treat dermatological lesions affecting back of the neck - Poultice made by pounding the plant	

(48)	***Dendrobium trnasparens***	Nepal, Bangladesh, Bhutan, India, Myanmar		- Paste from pseudobulb and stem is used in fracture and dislocated bone
282	***Dendrobium pachyphyllum***	Malacca	- A decoction of this lowland orchid was used for dropsy	
282	***Dendrobium subulatum***	Perak	- Applied to forehead to relieve headache - Pounding the leaves of this orchid	
282	***Desmotrichum pallidiflorum*** Malay Name: *Susu kubong*	Taiping, Perak		
282	***Eria pannea***		- Medicinal Bath made by addition potion of boiled Eria Pannea to treat ague (malaria or any severe fever)	
(49)	***Eria spicata***	Nepal, China, India, Myanmar, Thailand		- Paste from stem is taken internally to reduce stomachache and applied externally to reduce headache
282	***Hippeophyllum scortechinii***	Penjom, Pahang	- Treat earache	
283	***Spathoglottis plicata***	Tapah, Perak	- Treat Rheumatism	
283	***Tropidia curculigoides***	Telok Anson, Bentong	- Telok Anson – Serugat – Drank to treat diarrhoea - Bentong – Ranchang Hantu – Treat malaria (A decoction prepared using the entire orchid plant and leaves of Ardisia was administered during cold stage of fever	
283	***Papilionanthe hookeriana*** - Other names: o Malay: *Tulan* o Common: *Kinta weed*	Kinta Valley, Telok Anson	- A decoction of the plant was used as a foment to treat joint pains in Telok Anson	
(61)	***Papilonthe teres***	Nepal, Bangladeshm Burma, Myanmar, Thailand, Vietnam		- Paste from whole plant is applied to treat dislocated bones
284	***Heataeria olbiqua***	Borneo, the Malay Peninsula, Sumatra	- Poulticing sores	
284	***Oberonia anceps***	Malay Peninsula to Java	- Leaves were used	
(59)	***Oberonia Caulescens***	Nepal, China, India, Vietnam		- Tuber is used in liver ailments
284	***Vanilla graffithii***	Malay Peninsula and Karimun Islands	- Leaves and Stem were pounded and applied to hair to promote hair growth - Flowers were rubbed on the body to relieve fever	
285	3 orchids present in collection of substances collected by I.H. Burkll from Chinese herbalist in Malaya	Malay Peninsula	***Bletia hyacinthina*** - Used as a demulcent for children with dyspepsia and	

	(B***letia hyacinthina, Dendorbium nobile, Nervilia fordii schltr***)		given for dysentery, haemorrhoids, and ague ***Dendorbium nobile*** - *Lithophytic* ***Nervilia fordii schltr***	
(9)	***Dendorbium Nobile***	Imported to Malaysia by Chinese Herbalist (Dendorbium Nobile)		- Impart longevity and serve as an aphrodisiac. Stems are used to alleviate thirst, calm restlessness, accelerate convalescence, reduce dryness of mouth. Treat rheumatism, excessive perspiration. Weakness from thirst, impotence and menstrual pain.
(47)	***Dendrobium Nobile***	Nepal, Bhutan, China, India, Laos, Myanmar, Thailand, Vietnam		- Stem is used in tonic, used in thirst and dryness of tongue. It is also used in
(11)	**B*letia catelunate***	America		- Dysentery
285	***Arachnis flosaeris or bromheadia Finlaysoniana***	Iban and Borneo	- Applied the sap on the tooth and gum to relieve toothache - Shoots of *Calanthe* or *Phaius* were softened by heating over a fire and eaten to cure swollen parts of the body.	
285	***Cymbidium***	Borneo	- Kelabit eat as vegetable	
285	**Dendrobium Species** a) *Dendrobium crumenatum* (Malay Name: *Sepulah tulang*) *b)* *Sepulah rumah* c) *Plocoglottis lowii* (*porphyrophylla*, Malay Name: *Sepuleh dudok* or *Sepuleh dudor*) d) *Cymbidium finlaysonianum* (Malay Name: Sepuleh)	Perak	- Used to sprinkle water in the house after a recent demise to prevent the departed spirits from haunting it - Dendrobium crumenatum - Sprinkle rice paste about a house to invite a return of beneficent spirit	
(9)	**Dendrobium Species**	China,Taiwan, Korea, Japan		- Important in Chinese medicine to cure a variety of disease - Taiwan, Korea, Japan; treat stomach ache, night sweats, strengthen kidney, cure impotence and also as a tonic
286	***Agrostophyllum bicuspidatum* or *Appendicula cornuta***	Sarawak	- Kelabit, Worn as protective charm against curses	
286	***Anoectochilus reinwardtii***	Sarawak	- Predict sex of baby	
286	***Corymborkis veratrifolia***	Java	- Planted in sacred burial places	
294	***Ceratostylis latifolia***	South Sukami, West Java	- Locals ate young leaves either raw as salad or cooked	

294	***Habenaria multipartite***	Central Java	- Eaten	
(53)	***Habenaria commelinifolia***	Nepal, China, India, Myanmar, Thailand, Vietnam		- Whole plant is used as Salep (A starchy prepation of the dried tubers of various orchids, used in cookery and medicinally)
(53)	***Habenaria intermedia***	Nepal, China, India		- Tuber paste is used in hyperdipsia, fever cough, asthma leprosy skin diseases
(54)	***Habenaria marginata***	Nepal, Bhutan, China, India, Myanmar, Thailand		- Thoroughly boiled plant extract taken in flatulence, wound, tonic
(54)	***Habenaria pectinata***	Nepal, China, India, Pakistan		- Leaf Juice is applied in snake bites. Tuber is used against arthritis

10.3 Appendix 3

Objectives and targets of the Global Strategy for Plant Conservation (2011-2020)
It refers to the Updated Plant Conservation Report 2020, September and the progress made in the Global Strategy for Plant Conservation 2011-2020 (CBD.int, 2020)

Target 1	An online flora record of all known plants
Target 2	An assessment of the conservation status of all known plant species, as far as possible, to guide conservation action
Target 3	Information, research and associated outputs and methods necessary to implement the developed strategy
Objective II: Plant diversity is urgently and effectively required	
Target 4	At least 15 per cent of each ecological region or vegetation type secured through effective management and/or restoration
Target 5	At least 75 per cent of the most important areas for plant diversity of each ecological region protected with effective management in place for conserving plants and their genetic diversity
Target 6	At least 75 per cent of production lands in each sector managed sustainably, consistent with the conservation of plant diversity
Target 7	At least 75 per cent of known threatened plant species conserved in situ
Target 8	At least 75 per cent of threatened plant species in ex-situ collections, preferably in the country of origin, and at least 20 per cent available for recovery and restoration programmes
Target 9	70 per cent of the genetic diversity of crops, including their wild relatives and other socio-economically valuable plant species, conserved while respecting, preserving and maintaining associated indigenous and local knowledge
Target 10	Effective management plans in place to prevent new biological invasions and to manage important areas for plant diversity that have been invaded
Objective III: Plant diversity is used in a sustainable and equitable manner	
Target 11	No species of wild flora to be endangered by international trade
Target 12	All wild-harvested plant-based products sourced sustainably
Target 13	Indigenous and local knowledge innovations and practices associated with plant resources maintained or increased, as appropriate, to support customary use, sustainable livelihoods, local food security and health care
Objective IV: The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programmes	
Target 14	The importance of plant diversity and the need for its conservation incorporated into communication, education and public awareness programmes
Objective V: The capacities and public engagement necessary to implement the strategy have been developed	
Target 15	The number of trained people working with appropriate facilities to be sufficient according to national needs in order to achieve the targets of this strategy
Target 16	Institutions, networks and partnerships for plant conservation established or strengthened at national, regional and international levels to achieve the targets of this strategy

10.4 Appendix 4

IUCN/SSC Orchid Specialist Group – Orchid Action Plan:
To advocates dual strategies to conserve orchid diversity: establishing in situ protection of natural habitats and promoting trade of artificially propagated plants and cut flowers

A. First Half of the Plan discusses the following:	
1	the unique biology of the orchid family;
2	threats posed by habitat loss and over collecting
3	in situ strategies of habitat conservation and management
4	ex situ strategies of artificial propagation and seed banking
5	the desperate need for more research and education from the international level down to the local orchid society
B. Second half of the plan details the present status of countries richest in orchid species	
1. Mexico 2. Costa Rica 3. Panama 4. Ecuador and 5. neighbouring countries, 6. the Guayana region 7. The United States 8. Canada, 9. Caribbean Islands 10. Europe 11. North Africa 12. the Near East 13.North Asia and 14. Japan15. India 16. Africa 17.Madagascar and 18. surrounding islands 19.Australia 20. Southeast Asia – Malaysia Indonesia, Brunei, the Philippines, Thailand, and the south-west Pacific islands	
6.	Knowledge
7..	Diversity
8.	Threats
9.	Case histories

IUCN SCC-Global Checklist: Priority Actions recommended

1.	Preparation of global checklists of orchid species and identification of areas of high biodiversity
2.	Legislation and funding to protect, research, and properly manage and monitor such areas
3.	Availability of propagation material of rare and new species for commercial development, preferably in those countries where the species are native, thereby reducing demand for wild-collected plants
4	Responsible salvage of orchid plants from areas of deforestation where appropriate, followed by artificial propagation and distribution
5	**Preparation of educational programmes on orchids and their role in biodiversity by orchid societies and botanical gardens for the public**
6	More active registration of bona fide herbaria and scientific institutions belonging to CITES party countries to enable freer movement of pressed and liquid-preserved plant materials for scientific purposes
7	Sharing of plants, seeds and pollen among orchid growers and botanical gardens

10.5 Appendix 5

	Features/Characteristics	Detail	SCORE= (Y/Y+N x10)
A	**A Clearly Defined Mission**		1 2 3 4 5 6 7 8 9 10
	1	Mission	Y N
B	**The Experience Upon Arrival**		1 2 3 4 5 6 7 8 9 10
	2	Virtual Presentation – Discover What To Expect from Visit (Climate Change /Conservation)?	Y N
	3	Personal Interactive Questions & Answers	Y N
C	**Aesthetics: Brand, personality, character**		1 2 3 4 5 6 7 8 9 10
	4	Architecture landscape-Identity/Branding	Y N
	5	Landscape – Frequently changed?	Y N
	6	Theme/Image/Logo	Y N
	7	Conservatories/Living museums	Y N
D	**Location: Accessibility & Facility**		1 2 3 4 5 6 7 8 9 10
	8	Urban	Y N
	9	Transportation	Y N
	10	Herbarium, Library	Y N
	11	Laboratory	Y N
	12	IT facilities – WiFi	Y N
	13	Disabled facilities	Y N
E	**Public Education Programme**		1 2 3 4 5 6 7 8 9 10
	14	Interactive technology display	Y N
	15	Labelled Plants	Y N
	16	Brochures OR Interpretative Panels	Y N
	17	Ongoing Short/Long Exhibits	Y N

		18	Community programme	Y N
		19	Collaboration with Schools programmes	Y N
		20	Youth camps	Y N
		21	Undergraduate/graduate education	Y N
		22	Internships	Y N
		23	Agriculture Extension resources	Y N
		24	Professional training courses	Y N
F	**Research Programmes**			1 2 3 4 5 6 7 8 9 10
		25	Twinning with local universities/higher institutions	Y N
		26	Horticulture techniques	Y N
		27	Propagation	Y N
		28	Botany: taxonomy, systematic and evolution	Y N
		29	Conservation and/or ecological restoration	Y N
		30	Education & Visitor Service	Y N
		31	Invasive Species Control	Y N
		32	Pollinators	Y N
		33	Fungi	Y N
		34	Ethnobotany	Y N
G	**Conservation programme**			1 2 3 4 5 6 7 8 9 10
		35	Biology (ex-situ)	Y N
		36	Ecological conservation/restoration (in situ)	Y N
		37	Ethnobotanical, local cultural knowledge	Y N
		38	Agronomic/horticultural activities	Y N
H	**Collection accessions/management policy**			1 2 3 4 5 6 7 8 9 10
		39	Focus on local/regional fora	Y N
		40	Focus on rare/endangered	Y N

		41	Collects data on province	Y N
		42	Invasive species assessment/deaccession programme	Y N
		43	Priority taxa clearly articulated	Y N
I	**Marketing and Public Outreach programme**			1 2 3 4 5 6 7 8 9 10
44		44	Use of Social media & regular website updates	Y N
45		45	Use of traditional media and advertisements	Y N
46		46	Local community patronage outreach	Y N
47		47	Domestic International collaborations i.e. schoolchildren through schools	Y N
48		48	ii. Adults through societies	Y N
49		49	Domestic/International collaborations association membership	Y N
50		50	Gift shops (physical or online)	Y N
J	**Funding**			1 2 3 4 5 6 7 8 9 10
51			Government	Y N
52			Private	Y N
53			Patrons contribution – Charitable act	Y N
54			Self-funding Education/Membership/Entrance	Y N
	Total Scores (out of 100)		TS = A + B + C +D + E + F + G + H + I + J	
	%Percentage Scores			
	(Assaf, et al., 2012; UEN, 2020)			

10.6 Appendix 6

TIMELINE FOR BOTANICAL GARDENS

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Timeframe	Mid-1500s to Late 1600s	Late 1600 to Late 1700s	Late-1700s to mid-1800s	Mid-1800s to the Present	Mid-1800s to the Present	1980 to present	Present into the Future
Classification	European Medicinal gardens	Classic European botanic gardens	Colonial Tropical botanical gardens	Botanical gardens largely - Aesthetic, horticulture, economy	Special kinds	Botanical Gardens - Special Kinds Aesthetic, horticulture, Economy	BOTANICAL GARDENS: CONSERVATION and ECOLOGY
Source	Heywood 1987; Wengel 1987; Mielcarek 2000; Prest 1981	(Hill, 1915) Heywood 1987; Mielcarek 2000	Heywood 1987; Mielcarek 2000	Heywood 1987; Mielcarek 2000	Heywood 1987; Mielcarek 2000	BGCI, 2000; CBD 2000; IUCN 1987; Valdivielso 1987; Wright 1999; Portico Group 1997; Wyse Jackson and Sutherland 2000; Hoversten and Jones 2002; Klemmer and Skelly 2006; Mejia 1991; Evans 1999; Tankersley and Jones 1999; Forero 1985; Hamann 1987; Robertson 1989	BGCI 2020; CBD/GPSC 2020
Purpose	1. collect, grow, and display plants for use by medical students 2. classify plants & determine their usefulness to man 3. build comprehensive plant collections for	1. Continued to identify and taxonomically catalog new plants 2. seek economic and medicinal uses for plants, and 3. began to work at acclimatizing plants for	1. commercial undertakings intended to provide lumber, fruit, vegetables, and other products with economic potential 2. centres for agricultural and horticultural study, including the study of ornamental plants, with a focus on tropical botany	1. public education and horticulture than science or research 2. emphasized aesthetics over science and education 3. blurred the line between botanic & public gardens	Areas of specialization include agricultural plants, germplasm collections, medicinal plant research, native plants, or a single plant species	1. education a) plant conservation b) ecological system & sustainability c) interconnectedness of plants & organisms d) how humans interact with earth on local & global scales 2. conservation a) Cultivate native plants and make them the core of their collections b) organize their collections at the ecosystem level c) getting involved at the local level and supporting local conservation efforts d) allowing their staff to work on conservation projects	Presents suggestions for future botanical gardens. In the future, botanic al gardens should present nature interconnected with people

	scientific study, much like a living encyclopedia	growth in particular regions	3. acclimatization & propagation of economically valuable plants			e) choosing to protect plant habitats over growing plants in cultivation f) working to solve specific environmental issues, demonstrating good conservation practices in their infrastructure and facilities h) showing the value and beauty of the local region and developing place-specific horticultural knowledge i) working to conserve food and agricultural plants, as well as plants with other economic values 3. research a) Conduct & support scientific research b) Focusing on plants at risk of becoming extinct 4. public appeal.	
Origin	Response to a renewed interest in learning and the natural sciences	Travels Ship Journeys	Colonialism begins	Founded and sponsored by governments, called civic and municipal botanical gardens	Economic	Economic Deforestation, Plant Extinction Issue	Plant extinction issue – critical
Facts	The first 10 gardens recognised as a modern botanic gardens was founded in Pisa, Italy in 1543	Growth of learning and increase in observation of herbs (Hill, 1915)	1. began to change in purpose from past botanical gardens 2. Private botanical gardens (not connected to a university) began to be established	1. Founded as university botanical gardens began to decline 2. Did not have significant scientific or taxonomic programs	In an atmosphere of increasing generality, some botanical gardens have specialized in a specific area of scientific research	Shows not only an ongoing shift in botanical garden purpose, but also a melding of traditional purposes with those of more recent origin	Five types of plant collections are suggested as necessary for future botanical gardens: (1) Native Plants (2) Ecological & bio-geographic, (3)Taxonomic, (4)Adaptive lifestyle and

							experiential and (5) Reclamation & genetic Conservation (Robertson 1997).

10.7 Appendix 7

Participating MRSM Students Backgrounds

2021 VIRTUAL WOC 23rd TAICHUNG

Alwinchel Lovinner Douglas

Country Malaysia
Organization Organization MARA JUNIOR SCIENCE COLLEGE Kuching
Position Student

I was born in Miri, Sarawak. I am an enthusiastic, creative, and determined person. I am very interested in artistic activities such as pottery, dancing, exploring the nature, and cooking. I am able to speak multiple languages, namely, Malay, English, Mandarin, and my mother tongue, Bidayuh. During my school time, I was once a prefect, handled quite a lot of programme, and great at leaderships. I play rugby, joined the cultural club, and a part of the scouts team. I've also joined the 13th Asia Pacific Orchid Conference on 2019.
I enjoy meeting new faces, easily socialize with others, and work together. Regardless the work assigned to me, I will always put my very best to complete it. I know how to segregate my assignments, assure to complete them from the nearest to the latest due and end my days with benefits.

Humaira binti Hossain

Country Malaysia
Organization MARA JUNIOR SCIENCE COLLEGE (MRSM)
Position Student

Humaira is currently one of the four students from MRSM KUCHING that are the pioneers of this orchid micropropagation project. She has had a long interest in orchids and it has only been blooming more ever since she has taken on this project. She has participated and has experience in other orchid conferences such as the 13th Asian Pacific Orchid Conference (APOC). She is also an active student in her school and is well versed in many science or research related topics and is enthusiastic to learn more.

Nur Husnina Binti Mohamad Iskandar

Country Malaysia
Organization MARA Junior Science College Kuching
Position Student

Nur Husnina is an aspiring student who wishes to become a lecturer. She is one of the star students in MJSC Kuching. She has participated in competitions and is experienced in socializing with new people. She enjoys learning about orchids as she grew up with them and she wants to share her knowledge of these magnificent species to everyone.

Natalia Jurcy Anak Jurit

Country Malaysia
Organization MARA Junior Science College
Position Student

Natalia is an outstanding and one of the most prestigious students in MRSM Kuching. With excellent academic results, optimistic thinking and easy-going attitude, she is loved by almost everyone. She has represented MRSM Kuching in the 2019 MRSM Se-Malaysia National Young Scientists & Rocket Competition held in MRSM Tun Abdul Razak, Pahang and also participated in the 13th Asia Pacific Orchid Conference held in Kuching,Sarawak. Natalia has never been very interested in orchids before, but ever since she found out that some of the plants around MRSM Kuching are species of orchids, she has taken interest to them. She does not know a lot about orchids, but hopes that by doing this research, she could learn and gain more knowledge about orchids. Then, she would surely share this knowledge to the society and continue to help conserving the orchids to prevent the extinction of this plant all around the world.

10.8 Appendix 8

History and Timeline of the Trial

This study was initiated when the author visited The Kuching North City Hall Orchid Park (Kuching North City Hall, 2019) in December 2017. Despite Sarawak having 2500 species of Sarawak Orchids recorded in the Sarawak Herbarium, there were less than 5 species of Sarawak Orchids (Phalaenopsis bellina and borneonsis were two OS seen) found in the Orchid greenhouse and the rest were hybrid Phalaenopsis (without label) and hybrid Masd.weberbaueri x tonduzil which originated from South America, Mexico and the Andes (The American Orchid Society, 2019). The Author as a visitor of the orchid park asked the Manager for the reason of the absence of Sarawak OS. His reply was that it was too expensive to obtain for a reasonable price.

From then onwards, the author visited all the three licensed species orchid nurseries that have monopolised the industry in Sarawak and discovered that the prices were ridiculously expensive and that it was no wonder the illegal trade was booming. It was not observed that any flask orchids were sold in the nurseries however all plants were from the wild. The Author then asked if any flask orchids were sold but was told that no flask orchids were available – all plants were mature plants from the wild.

The Author next visited the Borneo Research Centre, Sarawak Biodiversity Centre and University Malaysia Sarawak, who have pioneered orchid research and responsible for development of the State's biological resources. All three organisations had laboratories for in vitro propagation and have experimented on propagating orchids - however, they could not teach those interested to learn and their experiment had not been successful due to the orchids failing to survive once being removed from the flask. SARORSO members requested for them to conduct a class on in vitro orchid propagation but none of the three organisations were able to offer such courses.

On the 18th European Orchid Council Conference in Paris, 22-25 March 2018, the author met Dr Simon Pugh Jones of Mendip Orchid Project (Pugh-Jones, 2003) and his team who have developed internationally recognised expertise in orchid propagation, science, conservation and orchid education over the past thirty years. The Author then visited his greenhouse and in vitro laboratory during their school's open day. The Author observed that Dr Simon Pugh Jones and has team had shared their knowledge and skill with Rwanda school children in Africa and the Author enquired as to whether he would do the same with students in Kuching. Dr Simon kindly offered to share his knowledge with the SARORSO members in Kuching, Sarawak but the SARORSO members had a better idea which was to share the knowledge with students at a selected school in Kuching, Sarawak. The pilot project started in July 2019 with the aim to develop OC and education in Sarawak by linking local schools in Sarawak with WSOP in the UK. The project also links the schools to the local community and is supported through the SARORSO.

In July 2019, the first team of students from the UK travelled to Sarawak and were fully sponsored by the Sarawak Government to set up and commission an orchid propagation laboratory at MRSM School, Kuching. The laboratory was renovated by Sarawak orchid Society and all furniture, fixtures and equipment were purchased by the Sarawak Orchid Society. Dr Simon Pugh-Jones kindly donated orchid seeds for practice purposes and together with his students, they shared their knowledge and expertise in basic laboratory techniques including media making, seed sowing and re-plating seedlings with the Sarawak Orchid Society and the MRSM school students.

The team of MRSM students comprising of four Year 7 students and the SARORSO members then exhibited their learning at the Asia Pacific Orchid Congress (APOC) in Kuching to show propagation techniques and highlight efforts for OC in Sarawak (Choo, 2019; Cowan, 2019; Cowan, 2019). Both Sarawak Orchid Society representing the public and the MRSM school students representing the YG presented their work with the objective to conserve the OS of Sarawak by aiming to produce as many seedlings as possible of endangered and valuable orchids through in vitro propagation using fresh green seed pods, providing long-term, sustainable and reliable supply for the intended orchid Botanical garden.

In October 2019 a second batch of group of 12 students from WSOP as a follow up to the first trip under the sponsorship of SARORSO(for Transportation within Kuching, meals other than breakfast) and the British Council (airline tickets and accommodation) – the Year 7-11 students each delivered a workshop on orchids, botany, field techniques, threats to biodiversity, propagation techniques, de-flasking and many more to the now larger student group at MRSM school. Real progress had been made in the MRSM laboratory, in the new MRSM shade house, and in developing a growing community interest in Sarawak Orchids and their conservation which would lead to a successful orchid Botanical Park. Educational field trips as visiting Bako Parks, Santubong Climbing, Herbariums and Oil Palm Estates with orchid translocation programmes were organised. Visiting the places were eye-openers to the world of Tropical Orchids especially on how orchid strives and adapt in the wild and the length of time for new plants to regenerate. The visit also taught the participants how important in vitro micropropagation technology helps in the conservation effort. The field trips brought awareness and adoption of alternative, multi-faceted approaches to learning (Atalar, 2019).

MRSM, WSOP,SARORSO Educational Orchid Field Trip Oct-Nov, 2019. Source: Tengku Auvaroza T.Abraham 2019

10.9 Appendix 9

Experiment Procedure- Detailed

1. Using a container twice the size of the desired final volume, measure out approximately 90% of the final required volume of sterile water. Example: 900 mL for a final volume of 1000 ml.

2. While stirring, add the powdered medium.

3. Add desired supplements: e.g. gelling agent, auxin, cytokinin.

4. While stirring, adjust the medium to the desired pH (e.g. 5.6 ± 0.1) using KOH.

5. Add additional tissue culture-grade water to bring the medium to the final volume.

6. If a gelling agent is used, heat the solution to approx. 100°C while stirring.

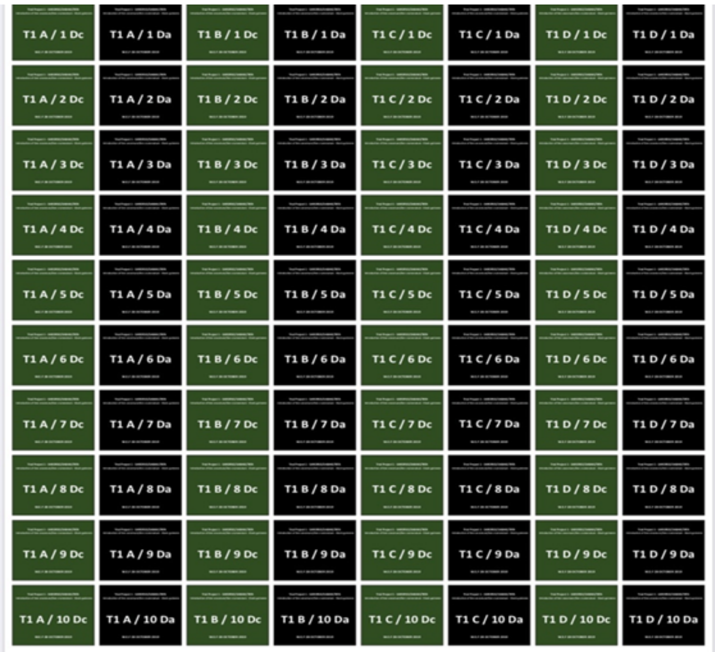
7. Dispense the medium into culture vessels before or after autoclaving according to your application. Add heat labile constituents after autoclaving.

8. Sterilize the medium in a validated autoclave at Kg/cm^2 (15 psi).

9. The medium should attain a temperature of 121°C for at least 15 min. Refer to the Sigma Plant Cell Culture Catalogue for recommended autoclave times for different volumes.

10. Storage: All media preparations should be stored at 0-5°C. Store dry powder in a desiccator. Deterioration of powdered medium may be recognized by1) granulation, clumping, or particulate matter throughout the powder, 2) pH change and 3) inability to promote growth when properly used.

10.10 Appendix 10



lay out Plan Of Trial 1 Introduction of Da and Dc. Source TATA, 2019

Row A June 2018 to June 2019

Reference labels	**Orchid Species on the left-hand side of the host-tree**	**Reference /label**	**Orchid Species on the right-hand side of the host-tree**
A1/Dc	Dendrobium crumenatum	A1/Da	Dendrobium anosmum
A2/Dc	Dendrobium crumenatum	A2/Da	Dendrobium anosmum
A3/Dc	Dendrobium crumenatum	A3/Da	Dendrobium anosmum
A4/Dc	Dendrobium crumenatum	A4/Da	Dendrobium anosmum
A5/Dc	Dendrobium crumenatum	A5/Da	Dendrobium anosmum
A6/Dc	Dendrobium crumenatum	A6/Da	Dendrobium anosmum
A7/Dc	Dendrobium crumenatum	A7/Da	Dendrobium anosmum
A8/Dc	Dendrobium crumenatum	A8/Da	Dendrobium anosmum
A9/Dc	Dendrobium crumenatum	A9/Da	Dendrobium anosmum
A10/Dc	Dendrobium crumenatum	A10/Da	Dendrobium anosmum

Table 1. Each label represents the location of Den crumenatum and Den anosmum being introduced one each oil palm tree in Row A. Two species of Dendrobium share an Oil Palm Tree.

Row B June 2018 to June 2019

Reference labels	Orchid Species on the left-hand side of the host-tree	Reference /lables	Orchid Species on the right-hand side of the host-tree
B1/Dc	Dendrobium crumenatum	B1/Da	Dendrobium anosmum
B2/Dc	Dendrobium crumenatum	B2/Da	Dendrobium anosmum
B3/Dc	Dendrobium crumenatum	B3/Da	Dendrobium anosmum
B4/Dc	Dendrobium crumenatum	B4/Da	Dendrobium anosmum
B5/Dc	Dendrobium crumenatum	B5/Da	Dendrobium anosmum
B6/Dc	Dendrobium crumenatum	B6/Da	Dendrobium anosmum
B7/Dc	Dendrobium crumenatum	B7/Da	Dendrobium anosmum
B8/Dc	Dendrobium crumenatum	B8/Da	Dendrobium anosmum
B9/Dc	Dendrobium crumenatum	B9/Da	Dendrobium anosmum
B10/Dc	Dendrobium crumenatum	B10/Da	Dendrobium anosmum

Each label represents the location of Den crumenatum and Den anosmum being introduced one each oil palm tree in Row B. Two species of Dendrobium share an Oil Palm Tree.

Row C June 2018 to June 2019

Reference labels	Orchid Species on the left-hand side of the host-tree	Reference /label	Orchid Species on the right-hand side of the host-tree
C1/Dc	Dendrobium crumenatum	C1/Da	Dendrobium anosmum
C2/Dc	Dendrobium crumenatum	C2/Da	Dendrobium anosmum
C3/Dc	Dendrobium crumenatum	C3/Da	Dendrobium anosmum
C4/Dc	Dendrobium crumenatum	C4/Da	Dendrobium anosmum
C5/Dc	Dendrobium crumenatum	C5/Da	Dendrobium anosmum
C6/Dc	Dendrobium crumenatum	C6/Da	Dendrobium anosmum
C7/Dc	Dendrobium crumenatum	C7/Da	Dendrobium anosmum
C8/Dc	Dendrobium crumenatum	C8/Da	Dendrobium anosmum
C9/Dc	Dendrobium crumenatum	C9/Da	Dendrobium anosmum
C10/Dc	Dendrobium crumenatum	C10/Da	Dendrobium anosmum

Each label represents the location of Den crumenatum and Den anosmum being introduced one each oil palm tree in Row C. Two species of Dendrobium share an Oil Palm Tree.

Row D June 2018 to June 2019

Reference labels	**Orchid Species on the left-hand side of the host-tree**	**Reference /label**	**Orchid Species on the right-hand side of the host-tree**
D1/Dc	Dendrobium crumenatum	D1/Da	Dendrobium anosmum
D2/Dc	Dendrobium crumenatum	D2/Da	Dendrobium anosmum
D3/Dc	Dendrobium crumenatum	D3/Da	Dendrobium anosmum
D4/Dc	Dendrobium crumenatum	D4/Da	Dendrobium anosmum
D5/Dc	Dendrobium crumenatum	D5/Da	Dendrobium anosmum
D6/Dc	Dendrobium crumenatum	D6/Da	Dendrobium anosmum
D7/Dc	Dendrobium crumenatum	D7/Da	Dendrobium anosmum
D8/Dc	Dendrobium crumenatum	D8/Da	Dendrobium anosmum
D9/Dc	Dendrobium crumenatum	D9/Da	Dendrobium anosmum
D10/Dc	Dendrobium crumenatum	D10/Da	Dendrobium anosmum

Table 4. Each label represents the location of Den crumenatum and Den anosmum being introduced one each oil palm tree in Row D. Two species of Dendrobium shares an Oil Palm Tree**. Source authou's own**

10.11 Appendix 11

Reference	Observation Period 1	Observation Period 2	Observation Period 3	Observation Period 4	Observation Period 5	Observation Period 6	Observation Period 7
A1/Dc		Flowering	Flowering				
A2/Dc							
A3/Dc	Flowering				Flowering		
A4/Dc	Flowering						
A5/Dc			Flowering				
A6/Dc							
A7/Dc							
A8/Dc	Flowering						
A9/Dc		Flowering	Flowering				
A10/Dc							
A1/Da					Flowering		Flowering
A2/Da						Flowering	
A3/Da				Flowering			
A4/Da							
A5/Da	Flowering			Flowering			
A6/Da	Flowering						
A7/Da							
A8/Da				Flowering			
A9/Da	Flowering				Flowering		Flowering
A10/Da							

Row B

Reference	Observation Period 1	Observation Period 2	Observation Period 3	Observation Period 4	Observation Period 5	Observation Period 6	Observation Period 7
B1/Dc		Flowering	Flowering	Flowering			
B2/Dc	Flowering						
B3/Dc							
B4/Dc	Flowering	Flowering					
B5/Dc	Flowering						
B6/Dc							
B7/Dc	Flowering						
B8/Dc		Flowering					
B9/Dc							
B10/Dc							
B1/Da							
B2/Da							
B3/Da		Flowering				Flowering	
B4/Da			Flowering				
B5/Da							
B6/Da							
B7/Da	Flowering		Flowering				
B8/Da				Flowering			
B9/Da							
B10/Da	Flowering and Seed Pods						

Row C

Reference	Observation Period 1	Observation Period 2	Observation Period 3	Observation Period 4	Observation Period 5	Observation Period 6	Observation Period 7
C1/Dc							
C2/Dc		Flowering	Flowering				
C3/Dc							
C4/Dc	Flowering		Flowering				
C5/Dc			Flowering				
C6/Dc							
C7/Dc	Flowering						
C8/Dc							
C9/Dc			Flowering				
C10/Dc							
C1/Da							
C2/Da				Flowering			
C3/Da							
C4/Da	Flowering			Flowering	Flowering		
C5/Da						Flowering	
C6/Da							
C7/Da							
C8/Da							
C9/Da							
C10/Da							

Row D

Reference	Observation Period 1	Observation Period 2	Observation Period 3	Observation Period 4	Observation Period 5	Observation Period 6	Observation Period 7
D1/Dc							
D2/Dc							
D3/Dc							
D4/Dc							
D5/Dc	Flowering		Flowering				
D6/Dc							
D7/Dc	Flowering						
D8/Dc		Flowering	Flowering				
D9/Dc							
D10/Dc							
D1/Da	Flowering						
D2/Da				Flowering			
D3/Da						Flowering	
D4/Da							
D5/Da							
D6/Da							
D7/Da							
D8/Da	Flowering			Flowering			
D9/Da							
D10/Da							

10.12 Appendix 12

Proposed Interactive, Informative and functional Sarawak Urban Botanic Garden, Illustrated by Hakim, WA, 2022. Source: Tengku Auvaroza, 2022

10.13 Appendix 13

Sketch of Proposed Sarawak Urban Orchid Botanic Garden. Illustrated by Hakim W.A. Designed by Tengku Auvaroza, 2021

10.14 Appendix 14

List of Orchidaceace found In Murum Dam during rescue work 2013-2014

(Ling & Sang, 2018)

155	*Eria nutans* Lindl.	CMHEP-2175, CMHEP-6562
156	*Eria robusta* (Blume) Lindl.	CMHEP-0523, BMHEP-1719, CMHEP-2779, AMHEP-2829, CMHEP-1384, BMHEP-3861, BMHEP-4118, BMHEP-04518, CMHEP-05108, CMHEP-5921, BMHEP-2389
157	*Eria spp.*	CMHEP-2457, CMHEP-0538, AMHEP-1283, CMHEP-0981, CMHEP-0247, CMHEP-0253, CMHEP-0255, CMHEP-0256, CMHEP-0261, BMHEP-0297, BMHEP-1617, BMHEP-1618, BMHEP-1648, CMHEP-2671, CMHEP-2675, CMHEP-2676, CMHEP-2806, CMHEP-2807, CMHEP-2824, AMHEP-2835, CMHEP-2205, CMHEP-2211, BMHEP-2250, CMHEP-2254, CMHEP-2255, CMHEP-1326, CMHEP-1345, BMHEP-1365, BMHEP-4008, CMHEP-05010, CMHEP-05028, CMHEP-05071, CMHEP-05126, CMHEP-05185, CMHEP-05189, CMHEP-2181, CMHEP-3308, BMHEP-04496
158	*Geesinkorchis sp.*	CMHEP-0245, CMHEP-1496, CMHEP-1632, AMHEP-2838, CMHEP-2267, CMHEP-1315, BMHEP-4037, CMHEP-5930, AMHEP-815, BMHEP-6908
159	*Grammatophyllum speciosum* Blume	CMHEP-0524, CMHEP-0021, CMHEP-1349, CMHEP-3193, CMHEP-05075
160	*Hylophila cheangii* Holttum	CMHEP-5984, CMHEP-6051
161	*Lecanorchis multiflora* J.J.Sm.	CMHEP-5972
162	*Liparis barbata* Lindl.	AMHEP-1041, AMHEP-0436, CMHEP-2736, BMHEP-3028, BMHEP-3911, CMHEP-5964
163	*Liparis cespitosa* (Lam.) Lindl.	CMHEP-2458
164	*Liparis elegans* Lindl.	BMHEP-2881, BMHEP-3854
165	*Liparis grandiflora* Ridl.	AMHEP-1272, BMHEP-3806 (endemic to Borneo)
166	*Liparis lacerata* Ridl.	AMHEP-858, AMHEP-0419, CMHEP-0116, BMHEP-3994, CMHEP-05011
167	*Liparis latifolia* Lindl.	BMHEP-04941
168	*Liparis rheedei* Lindl.	BMHEP-1580, CMHEP-6541, BMHEP-04908
169	*Liparis spp.*	BMHEP-3027, BMHEP-0684, BMHEP-04502, BMHEP-04540, BMHEP-05730
170	*Luisia antennifera* Blume	CMHEP-1376, CMHEP-05079, CMHEP-5931
171	*Macodes petola* (Blume) Lindl.	BMHEP-2315
172	*Malleola sp.*	AMHEP-0598
173	*Mycaranthes citrina* (Ridl.) Rauschert	BMHEP-1616, CMHEP-2201, CMHEP-1330, CMHEP-1344
174	*Mycaranthes latifolia* Blume	CMHEP-1327, CMHEP-1380
175	*Mycaranthes magnicallosa* (Ames & C.Schweinf.) J.J.Wood	CMHEP-1342, CMHEP-0230 (endemic to Borneo)

176	*Mycaranthes obliqua* Lindl.	CMHEP-1478, CMHEP-1334, CMHEP-0650, BMHEP-4054, AMHEP-889, BMHEP-04794
177	*Mycaranthes oblitterata* Blume	CMHEP-0235, BMHEP-1682-1, BMHEP-1610, CMHEP-2723, BMHEP-3859, BMHEP-3922, BMHEP-04514, BMHEP-04942, CMHEP-05005, CMHEP-5906, BMHEP-05704
178	*Mycaranthes pannea* (Lindl.) S.C.Chen & J.J.Wood	CMHEP-1821, CMHEP-1353, CMHEP-05184
179	*Mycaranthes sp.*	CMHEP-2214, BMHEP-06395
180	*Nephelaphyllum pulchrum* Blume	BMHEP-04708
181	*Neuwiedia borneensis* de Vogel	CMHEP-06339 (endemic to Borneo)
182	*Neuwiedia veratrifolia* Blume	CMHEP-6012
183	*Oberonia* cf. *rubra* Ridl.	AMHEP-0596
184	*Oberonia ciliolata* Hook f.	BMHEP-4017
185	*Oberonia insectifera* Hook. f.	AMHEP-1140
186	*Oberonia padangensis* Schltr.	BMHEP-2229, BMHEP-2253, CMHEP-2257, CMHEP-1377, AMHEP-884, CMHEP-05182
187	*Oberonia spp.*	BMHEP-4058, CMHEP-05176, CMHEP-6029
188	*Ornithochilus difformis* (Wall. ex Lindl.) Schltr.	BMHEP-4057
189	*Oxystophyllum sinuatum* (Lindl.) M.A.Clem.	AMHEP-1112
190	*Oxystophyllum spp.*	CMHEP-4296, CMHEP-5981
191	*Pennilabium struthio* Carr	AMHEP-597
192	*Peristylus gracilis* Blume	AMHEP-0437
193	*Peristylus hallieri* J.J.Sm.	CMHEP-0515, BMHEP-1688, CMHEP-2786, BMHEP-4004 (endemic to Borneo)
194	*Phaius sp.*	BMHEP-2858, BMHEP-2875, CMHEP-1399
195	*Phalaenopsis cornu-cervi* (Breda) Blume & Rchb.f.	AMHEP-1199, CMHEP-0663, CMHEP-6525
196	*Phalaenopsis maculata* Rchb.f.	CMHEP-2788, CMHEP-6104
197	*Pholidota carnea* (Blume) Lindl.	BMHEP-2323, BMHEP-2432
198	*Pholidota gibbosa* (Blume) Lindl. ex de Vriese	AMHEP-1152-1, CMHEP-0043, CMHEP-1346, BMHEP-04512, BMHEP-04727, BMHEP-04901, CMHEP-6507, CMHEP-6540, CMHEP-05149
199	*Pholidota imbricata* Lindl.	CMHEP-6549
200	*Pholidota sulcata* J.J.Sm.	AMHEP-878, CMHEP-5917
201	*Pholidota sp.*	BMHEP-4122

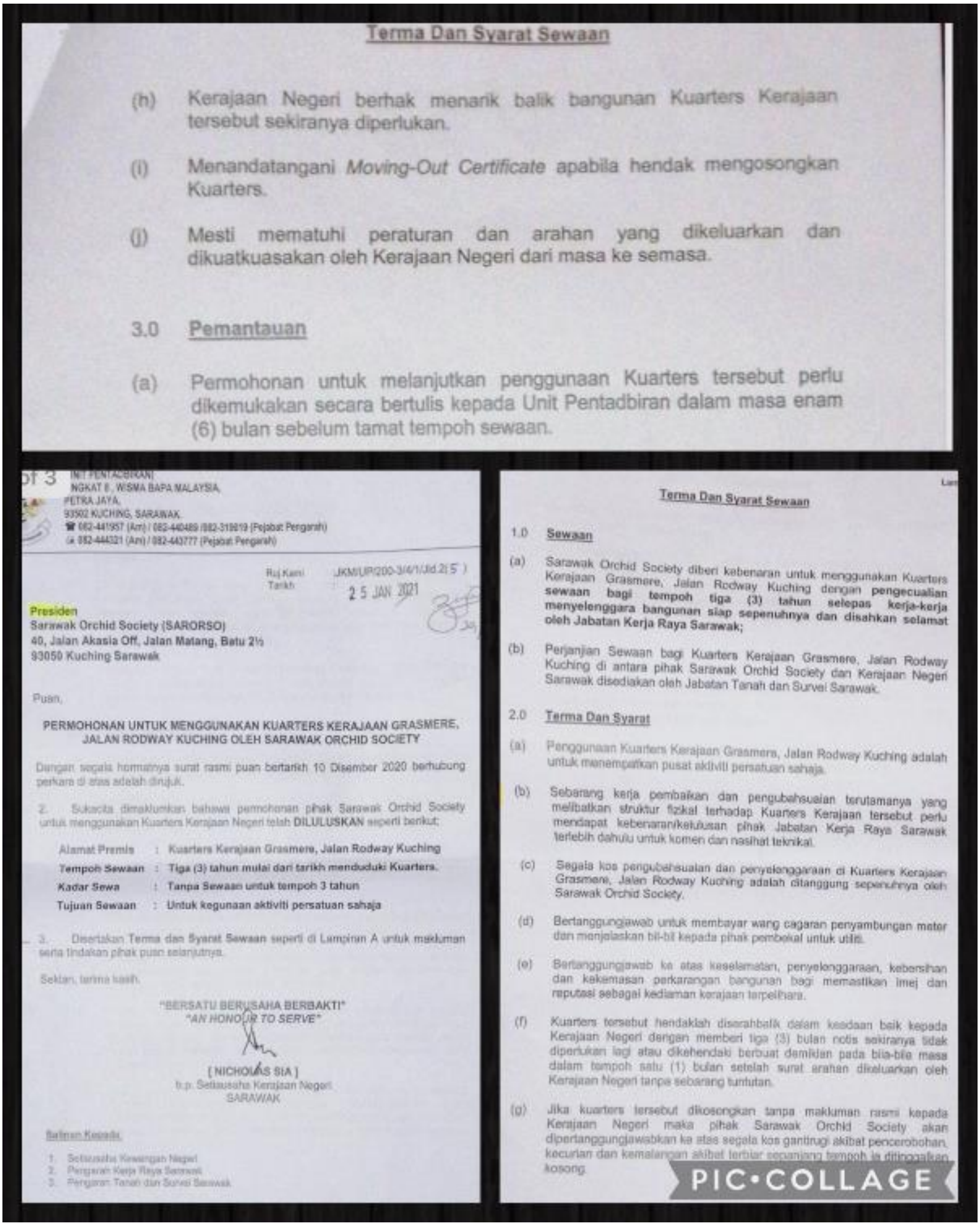
202	*Phreatia densiflora* (Blume) Lindl.	CMHEP-0627
203	*Pinalia* aff. *saccifera* (Hook.f.) Kuntze	CMHEP-05165, CMHEP-6041
204	*Pinalia cepifolia* (Ridl.) J.J.Wood	CMHEP-2478 (live plant planted in garden at dam site)
205	*Pinalia floribunda* (Lindl.) Kuntze	AMHEP-1228-1, BMHEP-04904, BMHEP-04790-1
206	*Pinalia latibracteata* (Ridl.) J.J.Wood	CMHEP-1338
207	*Pinalia tenuiflora* (Ridl.) J.J.Wood	CMHEP-2183, CMHEP-6513, CMHEP-05153
208	*Pinalia xanthocheila* (Ridl.) W.Suarez & Cootes	CMHEP-4233
209	*Plocoglottis hirta* Ridl.	CMHEP-6013 (endemic to Borneo; live plant planted in garden at dam site)
210	*Plocoglottis plicata* (Roxb.) Ormerod	CMHEP-6526, CMHEP-6550, CMHEP-6568
211	*Plocoglottis sp.*	BMHEP-1703, CMHEP-2905, BMHEP-2859, BMHEP-4000, BMHEP-04543
212	*Poaephyllum sp.*	BMHEP-5712 (live plant planted in garden at dam site)
213	*Podochilus microphyllus* Lindl.	CMHEP-0258
214	*Podochilus* cf. *schistanthera* Schltr.	BMHEP-3877
215	*Podochilus sp.1*	BMHEP-1550
216	*Pteroceras fragrans* (Ridl.) Garay	CMHEP-5951 (endemic to Borneo)
217	*Pteroceras teres* (Blume) Holttum	CMHEP-2940
218	*Renanthera breviflora* (Rchb.f.) R.Rice & J.J.Wood	BMHEP-3802 (new record)
219	*Renanthera elongata* (Blume) Lindl.	CMHEP-1329
220	*Robiquetia transversisaccata* (Ames & C.Schweinf.) J.J.Wood	CMHEP-5901 (endemic to Borneo)
221	*Robiquetia sp.*	CMHEP-2263
222	*Saccolabiopsis viridiflora* Aver.	BMHEP-3889, BMHEP-4035 (new record)
223	*Spathoglottis aurea* Lindl.	CMHEP-2163, CMHEP-1388
224	*Spathoglottis plicata* Blume	BMHEP-2436, AMHEP-0466, BMHEP-3897, CMHEP-6022
225	*Stichorkis* cf. *gibbosa* (Finet) J.J.Wood	AMHEP-1064, AMHEP-0443
226	*Taeniophyllum sp.*	AMHEP-1247
227	*Tainia obpandurata* H.Turner	AMHEP-2358 (new record)

228	*Tainia paucifolia* (Breda) J.J.Sm.	CMHEP-2740, BMHEP-3828, BMHEP-03668, BMHEP-05749
229	*Tainia scapigera* (Hook.f.) J.J.Sm.	CMHEP-6050 (endemic to Borneo)
230	*Tainia speciosa* Blume	CMHEP-0030
231	*Tainia sp.*	BMHEP-2857
232	*Thecopus secunda* (Ridl.) Seidenf.	BMHEP-04530
233	*Thelasis macrobulbon* Ridl.	AMHEP-1180, CMHEP-0510, CMHEP-1319
234	*Thelasis micrantha* (Brongn.) J.J.Sm.	BMHEP-3890
235	*Thelasis pygmaea* (Griff.) Lindl.	CMHEP-1438
236	*Thrixspermum centipeda* Lour.	AMHEP-833, CMHEP-2177, CMHEP-5907, BMHEP-3351
237	*Thrixspermum lingiae* P.O'Byrne & Gokusing	AMHEP-1944 (endemic to Borneo)
238	*Thrixspermum pulchrum* Carr	BMHEP-3892 (new record)
239	*Thrixspermum raciborskii* J.J.Sm.	CMHEP-1491, CMHEP-2266, BMHEP-3882, CMHEP-6001
240	*Thrixspermum ridleyanum* Schltr.	AMHEP-1098, CMHEP-2910, AMHEP-3195, CMHEP-5952
241	*Thrixspermum scopa* (Rchb.f. ex Hook.f.) Holttum	CMHEP-1324
242	*Thrixspermum tenuicalcar* Carr	BMHEP-3835 (new record)
243	*Thrixspermum spp.*	CMHEP-2751, CMHEP-2818, BMHEP-2251, BMHEP-3019, CMHEP-1352, CMHEP-05186, CMHEP-05183
244	*Trichoglottis persicina* P.O'Byrne	AMHEP-2840, CMHEP-2256, CMHEP-5994 (endemic to Borneo; new record)
245	*Trichoglottis* aff. *scaphigera* Ridl.	BMHEP-0299, CMHEP-2941, AMHEP-2841, CMHEP-2258, BMHEP-3996
246	*Trichoglottis smithii* Carr	BMHEP-6909
247	*Trichoglottis sp.*	CMHEP-1336
248	*Trichotosia ferox* Blume	CMHEP-6074
249	*Trichotosia gracilis* (Hook.f.) Kraenzl.	CMHEP-0498, CMHEP-0254, CMHEP-2680, CMHEP-2174, CMHEP-2204, CMHEP-2221, BMHEP-3985, CMHEP-6005, CMHEP-3327
250	*Trichotosia microphylla* Blume	AMHEP-2830, BMHEP-1373
251	*Trichotosia teysmannii* (Hook.f.) Kraenzl.	AMHEP-1176
252	*Trichotosia vestita* (Wall. ex Lindl.) Kraenzl.	BMHEP-1546, CMHEP-2916, BMHEP-2155, AMHEP-2834, CMHEP-2213, CMHEP-03639, CMHEP-05103, CMHEP-06202
253	*Trichotosia spp.*	AMHEP-1170, CMHEP-0240, BMHEP-2600, CMHEP-2203

254	*Vanilla* aff. *borneensis* Rolfe	BMHEP-3119
255	*Vanilla sumatrana* J.J.Sm.	CMHEP-5950 (new record)
256	*Vrydagzynea sp.1*	CMHEP-5986
257	*Zeuxine purpurascens* Blume	BMHEP-5759 (live plant planted in garden at dam site)
258	Unknown species (two species)	BMHEP-1605, CMHEP-2634, CMHEP-05049, BMHEP-05735, CMHEP-06608

10.15 Appendix 15

Letter of Offer to Use Land



Terma Dan Syarat Sewaan

(h) Kerajaan Negeri berhak menarik balik bangunan Kuarters Kerajaan tersebut sekiranya diperlukan.

(i) Menandatangani *Moving-Out Certificate* apabila hendak mengosongkan Kuarters.

(j) Mesti mematuhi peraturan dan arahan yang dikeluarkan dan dikuatkuasakan oleh Kerajaan Negeri dari masa ke semasa.

3.0 **Pemantauan**

(a) Permohonan untuk melanjutkan penggunaan Kuarters tersebut perlu dikemukakan secara bertulis kepada Unit Pentadbiran dalam masa enam (6) bulan sebelum tamat tempoh sewaan.

---

of 3

NIT PENTADBIRAN

NGKAT 8, WISMA BAPA MALAYSIA,
PETRA JAYA,
93502 KUCHING, SARAWAK.
082-441957 (Am) / 082-440489 /082-319819 (Pejabat Pengarah)
082-444321 (Am) / 082-443777 (Pejabat Pengarah)

Ruj Kami : JKM/UP/200-3/4/1/Jld.2(5)
Tarikh : 25 JAN 2021

Presiden
Sarawak Orchid Society (SARORSO)
40, Jalan Akasia Off, Jalan Matang, Batu 2½
93050 Kuching Sarawak

Puan,

PERMOHONAN UNTUK MENGGUNAKAN KUARTERS KERAJAAN GRASMERE, JALAN RODWAY KUCHING OLEH SARAWAK ORCHID SOCIETY

Dengan segala hormatnya surat rasmi puan bertarikh 10 Disember 2020 berhubung perkara di atas adalah dirujuk.

2. Sukacita dimaklumkan bahawa permohonan pihak Sarawak Orchid Society untuk menggunakan Kuarters Kerajaan Negeri telah **DILULUSKAN** seperti berikut:

Alamat Premis	:	Kuarters Kerajaan Grasmere, Jalan Rodway Kuching
Tempoh Sewaan	:	Tiga (3) tahun mulai dari tarikh menduduki Kuarters.
Kadar Sewa	:	Tanpa Sewaan untuk tempoh 3 tahun
Tujuan Sewaan	:	Untuk kegunaan aktiviti persatuan sahaja

3. Disertakan Terma dan Syarat Sewaan seperti di Lampiran A untuk makluman serta tindakan pihak puan selanjutnya.

Sekian, terima kasih.

"BERSATU BERUSAHA BERBAKTI"
"AN HONOUR TO SERVE"

[NICHOLAS SIA]
b.p. Setiausaha Kerajaan Negeri
SARAWAK

Salinan Kepada:

1. Setiausaha Kewangan Negeri
2. Pengarah Kerja Raya Sarawak
3. Pengarah Tanah dan Survei Sarawak

Terma Dan Syarat Sewaan

1.0 **Sewaan**

(a) Sarawak Orchid Society diberi kebenaran untuk menggunakan Kuarters Kerajaan Grasmere, Jalan Rodway Kuching dengan **pengecualian sewaan bagi tempoh tiga (3) tahun selepas kerja-kerja menyelenggara bangunan siap sepenuhnya dan disahkan selamat oleh Jabatan Kerja Raya Sarawak;**

(b) Perjanjian Sewaan bagi Kuarters Kerajaan Grasmere, Jalan Rodway Kuching di antara pihak Sarawak Orchid Society dan Kerajaan Negeri Sarawak disediakan oleh Jabatan Tanah dan Survei Sarawak.

2.0 **Terma Dan Syarat**

(a) Penggunaan Kuarters Kerajaan Grasmere, Jalan Rodway Kuching adalah untuk menempatkan pusat aktiviti persatuan sahaja.

(b) Sebarang kerja pembaikan dan pengubahsuaian terutamanya yang melibatkan struktur fizikal terhadap Kuarters Kerajaan tersebut perlu mendapat kebenaran/kelulusan pihak Jabatan Kerja Raya Sarawak terlebih dahulu untuk komen dan nasihat teknikal.

(c) Segala kos pengubahsuaian dan penyelenggaraan di Kuarters Kerajaan Grasmere, Jalan Rodway Kuching adalah ditanggung sepenuhnya oleh Sarawak Orchid Society.

(d) Bertanggungjawab untuk membayar wang cagaran penyambungan meter dan menjelaskan bil-bil kepada pihak pembekal untuk utiliti.

(e) Bertanggungjawab ke atas keselamatan, penyelenggaraan, kebersihan dan kekemasan perkarangan bangunan bagi memastikan imej dan reputasi sebagai kediaman kerajaan terpelihara.

(f) Kuarters tersebut hendaklah diserahbalik dalam keadaan baik kepada Kerajaan Negeri dengan memberi tiga (3) bulan notis sekiranya tidak diperlukan lagi atau dikehendaki berbuat demikian pada bila-bila masa dalam tempoh satu (1) bulan setelah surat arahan dikeluarkan oleh Kerajaan Negeri tanpa sebarang tuntutan.

(g) Jika kuarters tersebut dikosongkan tanpa makluman rasmi kepada Kerajaan Negeri maka pihak Sarawak Orchid Society akan dipertanggungjawabkan ke atas segala kos gantirugi akibat pencerobohan, kecurian dan kemalangan akibat terbiar sepanjang tempoh ia ditinggalkan kosong.

10.16 Appendix 16

ORCHID HISTORICAL WALK for Sarawak Orchid Botanic Garden and Museum

Orchid Collectors

	List of Early Foreign Orchid Collectors of Sarawak Orchids SOURCE (Beaman, et al., 2001, pp. 23-28)				
	tanist/ Collectors	**OCCUPATION**	**Date Ist In Swk**	**Location/Source**	**Remarks – Orchids/Books/others**
a	Sir Hugh Low 1824-1905 Made friends With Rajah Brooke Ist orchid collector 1st introduced Hevea Rubber	1.Colonial Secretary Of Labuan1848-1876 2.Resident of Perak 1877-188	1845	Labuan	Dimorphorchis lowii (Arachnis) Paphiopedilum lowii (Cyprepedium) B: Sarawak-Inhabitants & Production 1847(Reeve 1988) B: Life in the Forest of Far East Sarawak 1862-Spenser St John Numerous paintings of orchids and other subjects are kept at Kew. (Beaman, et al., 2001)
b	Thomas Lobb 1820-1894 2nd Collector	Prof Orchid Collector Worked for a firm of nurserymen Messrs. Veitch & Sons (The Gardener's Chronicle 1872)	1857	Lawas	Bulbophyllum lobii Orchids published by Lindley 1859 Merill-1915b,pp.184-185; 1921, p11 Erroneous as to locality cited (Beaman, et al., 2001)
c	Odoardo Beccari	Talian Naturalist /Botanist who	1865-1868	Kuching, Matang,	Bulbophyllum becarri

	1843-1920	found Titan Arum in Sumatera 1878		Mount Santubong Bintulu	B: Wondering in the Great Forest of Borneo – 1902/4 Built lodging and laboratory called Vallombrosa near Mount Matang 4000 collections Florence herbariu, (Beaman, et al., 2001)
d	Frederick W. Burbridge 1847-1905	Gardener of RHS Kew Botanical artist British Explorer Collect rare plants for Veich Nursery Curator of Botanic Gardens of Trinity College, Dublin from 1879 to death	1877-1878	Lawas, Meropok River	Phalaenopsis marie burb Vanda sanderiana (4 sarawak orchids) B: The Garden of the sun or a Naturakists Journal on the Mountains and in the Forest and swamps of Borneo and Sulu Archipelago 1880 (Beaman, et al., 2001)
e	Ignatz F. Förstermann	Tree Flora of Sabah and Sarawak Vol.1	1886	Sarawak	Employed by English horticulture firm Sander & Sons (SFDM,FRIM,SWFDM, 1994)
f	Charles Hose	Orchids of Sarawak	1891-1894	Mount Dulit, Mount Lambia	26 orchid taxa collected (Beaman, et al., 2001)
g	George D. Haviland	Orchids of Sarawak	1892	Kuching, Mount Barang, Mount Penrissen,	Sarawak medical officer and Curator of the Sarawak Museum (Beaman, et al., 2001)

				Limbang, Ulu Tawaran, Rajang, Mount Lambia	
h	Henry N. Ridley	Orchids of Sarawak	1894, 1897, 1903, 1905, 1915	Bau, Matang, Lundu	Made about 50,000 collections in his lifetime (Beaman, et al., 2001)
i	Johannes Waterstradt	Tree Flora of Sabah and Sarawak Vol.1	1891	Padas River	Danish zoological collector. Much of his orchid collections went to the firm of Hugh Low in London (SFDM,FRIM,SWFDM, 1994)
		Tree Flora of Sabah and Sarawak Vol.1	1892-1893	Lawas River & Kinabalu	
		Tree Flora of Sabah and Sarawak Vol.1	1894	Kudat, Banggi, Balambbangan, Labuan, Kinabalu, Lawas River, Limbang River	
		Tree Flora of Sabah and Sarawak Vol.1	1895	Kinabalu	
		Tree Flora of Sabah and Sarawak Vol.1	1902	Brunei	
		Tree Flora of Sabah and Sarawak Vol.1	1903, 1908, 1912	Kinabalu	

j	Friedrich R. R. Schlechter	Tree Flora of Sabah and Sarawak Vol.1	1901	Labuan, Kudat, Sandakan, Banjarmasin, Balikpapan, Samarinda, Kutei	German orchid specialist (SFDM,FRIM,SWFDM, 1994)
		Tree Flora of Sabah and Sarawak Vol.1	1906-1907	Kuching	
k	John Hewitt	Orchids of Sarawak	1905	Kuching, Limbang	Curator of Sarawak Museum in 1905-1908 (Beaman, et al., 2001)
			1907	Baram	
			1908	Bungo Range, Mount Matang, Saribas, Mount Pueh	
l	Cecil J. Brooks	Orchids of Sarawak	1907-1910	Bungo Range, Mount Penrissen, Mount Santubong, Mount Pueh, Bau, Mount Senggi, Mount Kapor, Tringos	Collected 85 orchid taxa (Beaman, et al., 2001)
m	John C. Moulton	Orchids of Sarawak	1909	Lawas	Founded Sarawak Museum Journal in 1911. Curator of Sarawak Museum 1905-1915 and
			1910	Limbang River	

			1911	Batu Lawi	returned to Sarawak as Chief Secretary of the Government (Beaman, et al., 2001)
			1913	Mount Pueh, Mount BBeumput	
			1914	Mount Murud	
n	James W. Anderson	Orchids of Sarawak	1912	Bau, Mount Pueh, Mount Berumput, Mount Pensaung	39 orchid taxa collected (Beaman, et al., 2001)
o	Eric P. Mjöberg	Orchids of Sarawak	1922	Mount Murud, Mount Dulit, Bidi Caves, Mount Pueh, Mount Matang, Mount Penrissen, Lundu, Sadong, Santubong	95 orchid taxa collected (Beaman, et al., 2001)
			1925	Batu Tibang	
p	Mary Strong Clemens and Joseph Clemens	Orchids of Sarawak	1929	Kuching, Lundu, Mount Pueh, Mount Gading, Bidi Caves, Mount Matang	49 orchid taxa collected (Beaman, et al., 2001)
q	Richard Eric Holttum	Tree Flora of Sabah and Sarawak Vol.1	1931	Kinabalu	Director of Singapore Botanic Garden together with Joseph

					Clemens and wife Mary Strong Clemens (SFDM,FRIM,SWFDM, 1994)
r	Paul W. Richards	Orchids of Sarawak	1932	Marudi, Dulit, Bidi, Bau, Santubong	Botanist on Oxford University Expedition (Beaman, et al., 2001)
s	Patrick M. Synge	Tree Flora of Sabah and Sarawak Vol.1 and Orchids of Sarawak	1932-1933	Miri, Baram, Marudi, Bidi, Bau, Santubong	Assisted Paul Westmacott Richards of Oxford University Expedition (SFDM,FRIM,SWFDM, 1994)
t	Winifred M. A. Brooke	Orchids of Sarawak	1954-1956	Kuching	Collected approximately 3000 number which is in the herbaria of Leiden, Natural History Museum, London, Geneva and Sarawak (Beaman, et al., 2001)
u	John W. Purseglove	Orchids of Sarawak	1955-1956	Kuching, Batu Kitang, Setapok, Mile 6 Penrissen Road, Semanggoh Forest Reserve, Bau, Lundu, Mount Gading, Sematan, Mount Pueh, Bako, Tau River, Mayeng	Collected 64 orchid taxa and are in Singapore Botanic Gardens Herbarium with duplicates at Kew, Leiden, Sarawak and Arnold Arboretum (Beaman, et al., 2001)

				River, Bukit Mersing, Tatau	
v	Eduardo Quisumbing	Tree Flora of Sabah and Sarawak Vol.1	1963	Bako, Santubong, Semengoh, Bau, Brunei, Mt Kinabalu	Filipino orchidologist (SFDM,FRIM,SWFDM, 1994)
w	Jim B. Comber	Tree Flora of Sabah and Sarawak Vol.1	1967-1968	Tenom and Crocker Range, Sabah	Collections have been given to Kew (SFDM,FRIM,SWFDM, 1994)
X 23	Anthony Lamb	Tree Flora of Sabah and Sarawak Vol.1	1974, 1977-1981, 1990s	Sabah	Collections are sent to Kew or Leiden. Used Sandakan herbarium collecting numbers although did not always lodge there (SFDM,FRIM,SWFDM, 1994)

10.17 Appendix 17

The Subdivision of SUOBG is into 12 zones and each zona represent the 12 administrative divisions with different landscape representing the orchid habitat

No	**Division**	**Landscape/vegetation**
1	Kuching	Littoral Forest/Mangove Forest
2	Kota Samarahan	Peat Swamp Forest
3	Sri Aman	Mixed Dipetrocap
4	Betong	Terrace Kerangas (Tropical heath forest)
5	Sarikei	Sandstone Forest
6	Sibu	Mixed Dipterocarp
7	Mukah	Littoral Forest
8	Miri	Limestones Forest
9	Limbang	Mangrove Forest
10	Bintulu	Secondary Forest Mixed Dipterocarp
11	Kapit	Montane Lower Forest
12	Serian	Monoculture Forest

LATEST DEVELOPMENT of PhD CASE STUDIES Since 2018

1.MRSM Kuching, from JIVOM to their very own Orchid Botanical Garden in the School Compound. The JIVOM Project students mounted rescued orchids on 29 hosts (trees) and 5 artificial hosts (Concrete Poles

Plate 33Unlike the Orchid Translocation Project in Oil palm Estate, seed pods were produced after flowering. Source: SARORSO 2023

2. Inaugural Malaysian Conservation Conference, 2022

Plate 34 The JIVOM Project: Students were invited to exhibit their work at the Inaugural Malaysian Conservation Conference on March 29, 2022 where the Premier of Sarawak visited their exhibition booth and commended the students as well as delivered encouraging words. They received national Media Coverage which has encouraged younger generation to be involved in Orchid Conservation Project. There were many interested parties enquiring for opportunity to poarticipate. Source SARORSO, 2022.

3. Modules being taught as part of the JIVOM project has recently been recognized by University Malaysia Sarawak (UNIMAS)– A collaboration between SARORSO and UNIMAS that offers JIVOM- involved students a certificate signed by UNIMAS scientists and lecturers. This recognition encourages the community to participate actively.

Plate 35 Latest Achievement: SARORSO's basic JIVOM Module for In Vitro Orchid Micropropagation has been recognised by University Malaysia Sarawak (UNIMAS). Source: SARORSO, 2023

4. Visits by Ministers, Chief executive officers, Head of Department, Scientists to the Jumaani In Vitro Orchid Micropropagation (JIVOM) laboratory in MRSM Kuching

Plate 36 TKPP and MARA Board Members visit to the Juma'ani Laboratory in MRSM Kuching on 10th April 2021. Source: SARORSO, 2023

Plate 37 A visit by the Chief Executive Officer to JIVOM Laboratory and MRSM mini orchid botanical garden. At the same time a tree planting ceremony were held for the second time. First was done in November 2018

5.MRSM/SARORSO Educational Orchid Conservation Visit to the UK -25 June- 9th July 2023

Tentative Itinerary- First Week -London- Cambridge - Oxford

Day	Activity	Location
1 -Mon	Orchid Herbarium, Kew Garden Jodrel Laboratory, Kew Garden Marianne North Gallery , Kew Garden Kew Tour by Kew Train	Kew Garden Prof Michael F Fay Dr. Andre Schuitemann
2- Tues	Millennium Seed Bank, Sussex	Sussex
3- Wed	Hari Raya Aidil Adha Cambridge Orchid Conservation, Cambridge University Cambridge New Mosque	Cambridge Dr Tim Upson
4- Thur	Oxford Orchid Conservation, Oxford University Oxford Botanical Garden	Oxford Dr Amy Himsley
5 -Fri	Friday Prayers London Free and Easy Optional Museums. Queen Mary Rose Garden	London
6 - Sat	London Free and easy Optional Madame Tussauds	London
7- Sun	To Bath Accommodation 72 Great Pulteney Elegance BA2 4DL	Bath

2nd Week – Bath/ Radstock

Orchids - Laboratory Propagation, Conservation and Education- Short Course

Mendip Studio School, Radstock, UK

Day	Activity	Location/tutor
1	Introduction to the propagation laboratory and orchid biology • Aseptic technique and equipment • Making in-vitro growing media • Orchid Botany Workshop • Orchid pollination for seed production	Mendip Studio School propagation Laboratory Writhlington School's Glasshouses
2	Seed preparation, storage, testing and sowing • Seed collection and storage (seed banking) • TZ viability testing (day 1) • In-vitro seed sowing (dry seed method)	Mendip Studio School propagation Laboratory Writhlington School's Glasshouses
3	Maintenance of orchids in-vitro • Re-plating seedlings at various stages • TZ viability testing (day 2) • In-vitro seed sowing - green pod method • Deflasking seedlings and establishment ex-vitro • Visiting/online speaker - Mike Fay	Mendip Studio School propagation Laboratory Writhlington School's Glasshouses
4	Orchids and botanic Gardens • Visit to Bristol University Botanic Gardens • Botanic Garden practice - plant records, health and safety, permanent displays and interpretation • Practical design of a orchid display workshop and challenge • TZ viability testing (day 3)	Bristol University Botanic Gardens Mendip Studio School propagation Laboratory Writhlington School's Glasshouses
5	Orchid Conservation and the place of in-vitro propagation. • Threats and opportunities • Orchids and community projects • Illegal trade and wild collection • Visiting/online speaker Amy Hinsley • Orchids and education Assessment - Practical and theory	Mendip Studio School propagation Laboratory Writhlington School's Glasshouses
Course tutors	The Course will include contributions from internationally recognised experts in the fields of Orchid propagation, conservation, horticulture and scientific research.	This will include: Course Lead: Dr Simon Pugh-Jones MBE who has run the innovative 'Writhlington Schools'Orchid Project for more than 30 Years. Nicholas Wray - Curator of the Bristol University Botanic Gardens Professor Michael F. Fay FLS Senior Research Leader, Conservation Genetics Royal Botanic Gardens, Kew Dr Amy Hinsley Postdoctoral Research Associate at the University of Oxford

6.Reintroduced Rescued Orchids in Oil Palm estates bearing seedpods proving the presence of pollinators- recorded in 2022 (inserted in moodle)


PIC•COLLAGE

7.Latest Proposed Concept for the Urban Orchid Botanic garden (inserted in Moodle)

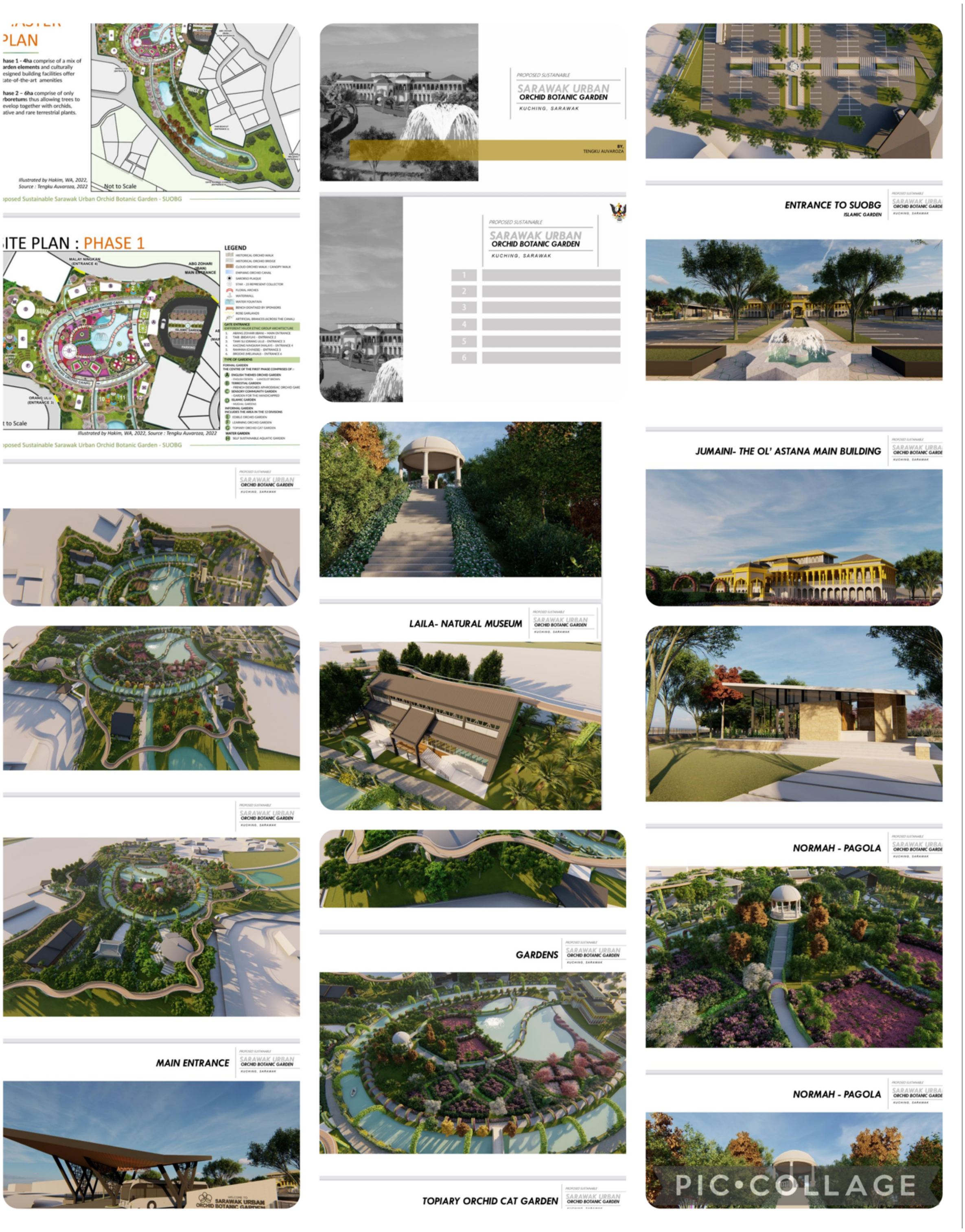


Plate 38 This is just a rough drawing based on the sketches and details guven by myself. Because of the limitation of software, many landscapes found in Sarawak as in proposed concept could not be included here. Source: Nollina 2023

7.Books for Publishing on Creating Awareness for the Public and Younger generation

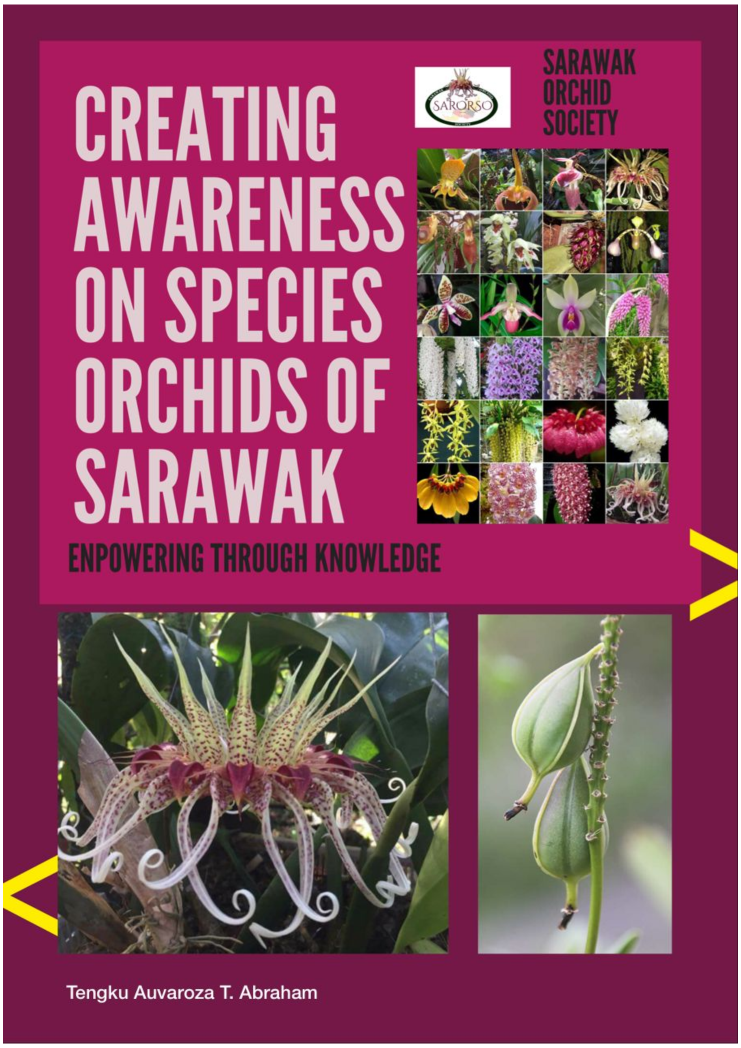


Plate 39 Targeting the younger generation. Source: Tengku Auvaroza, 2022