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Association of climate awareness with urban mobility and consumption behaviour in Accra: a path analysis

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Abstract
This study evaluated the direct and indirect association of Climate Change Awareness (CCA) with urban mobility options (i.e., walking, biking, and driving a carbon-dependent car) through Green Purchase Intention (GPI) and Eco-Socially Conscious Consumer Behaviour (ECCB). The study adopted a cross-sectional design with sensitivity analyses, robustness tests, and common methods bias evaluation. The participants were 865 adults in Accra, Ghana. The relationship was tested concurrently with a path analysis through structural equation modelling. CCA was positively associated with walking, biking, and driving. It had an indirect positive association with walking time through ECCB but an indirect negative association through GPI with walking time. CCA had an indirect positive association with biking and driving through GPI. ECCB can be an important determinant of walking for transportation among city dwellers with higher CCA. This study was the first to assess the nexus between environmental knowledge, pro-environmental consumption indicators, and active and non-active travel, unfolding implications for city design in a Sub-Saharan African context.

Keywords Walking · Biking · Driving · Climate change awareness · Green purchase intention · City residents

Introduction

Climate change is a worrying global challenge influenced by travel behaviour. It is partly caused by transportation-related greenhouse gas emissions (Saleem et al. 2018a, b; Saleem et al. 2018a, b). Much of the greenhouse gases (e.g., carbon dioxide, methane, and nitrous oxide) emitted are from transportation involving the combustion of fossil fuels (Asiamah et al. 2023; Saleem et al. 2018a, b), which makes active commuting (e.g., walking and bicycling) a better option for the planet and an important concept within the sustainability-health

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debate. Over the past decades, the debate on sustainability has evolved to a stage where the role of environment-friendly action in individual health is strongly recognised (Grant et al. 2017). At this stage, the "sustainability-health" concept was used to delineate and value the health benefits of pro-environmental behaviour.

A pro-environmental behaviour is any choice or action taken by individuals and manufacturers to minimise the adverse impacts of their activities on the environment (Amoah and Addoah 2021; Opuni et al. 2022). Driving an electric vehicle and choosing active commuting over driving a carbon-dependent car (i.e., a car that depends on fossil fuel or produces greenhouse gases during its use) are examples of individuals' pro-environmental behaviour. The use of solar-powered energy sources in a manufacturing firm is an example of corporate pro-environmental behaviour. There is a growing consensus in the literature that these and similar behaviours are among the topmost efforts against the climate crisis. It is, thus, understandable why researchers (Asiamah et al. 2023; Saleem et al. 2021; Xu et al. 2022) are advocating mainstream adoption of pro-environmental behaviours. A notable pro-environmental behaviour is Eco-Socially Conscious Consumption Behaviour (ECCB).

ECCB encompasses consumer actions that reflect an awareness and consideration of both the environmental and social impacts of purchasing decisions (Saleem et al. 2021). Its antecedents are environmental awareness, religiosity, patriotism, morality, and social consciousness (Saleem et al. 2021; Saleem et al. 2018a, b). It encapsulates elements of socially responsible consumption and ecologically conscious consumption behaviour, which are also motivated by people's morality, patriotism, and ethical orientation (Connell 2011; Saleem et al. 2018a, b). ECCB is an outstanding pro-environmental behaviour because it is informed by a sense of morality driven by both social and environmental considerations (Saleem et al. 2018a, b), which implies that people with a high level of ECCB are conscious of the adverse impacts of their consumption on the environment and people. It is, therefore, rich in altruism and love for nature, which makes it an ideal behaviour for sustainability.

Environmental awareness, often used interchangeably with environmental knowledge (Amoah and Addoah 2021; Asiamah et al. 2024), is a noteworthy determinant of ECCB. Environmental knowledge is an individual's understanding and awareness of environmental issues such as global warming and climate change (Asiamah et al. 2024; Ünal et al. 2018). It includes knowledge about appropriate actions to take and avoid in the interest of sustainability. An example of environmental knowledge is Climate Change Awareness (CCA), defined as an individual's understanding of environmental and climate issues as well as their willingness and commitment to act and collaborate with others to address these issues (Iturriza et al. 2020). This definition portrays CCA as a socialist approach to addressing climate issues. Others have defined CCA as the extent to which people are aware of climate change events (e.g., extreme weather) and how to act against them (Asiamah et al. 2024).

CCA is an important indicator of environmental knowledge because it fosters Green Purchase Intention (GPI). Although it does not always translate into actual pro-environmental behaviour, GPI is the foundation for environment-friendly purchase decisions and actions. It is the desire of people to use products and services of organizations that employ environmentally friendly manufacturing processes (Ahmad et al. 2023). A growing body of empirical research has shown that GPI is predicted by CCA or environmental knowledge (Hwang et al. 2024; Myung Ja Kim and Hall 2019; Wang et al. 2020), and other studies (Amoah & Addoah 2021; Halady and Rao 2010; Hopkins 2016; Venghaus et al. 2022) have reported a positive association between CCA and different aspects of pro-environmental behaviour

that serve as proxies of ECCB. In this study, we refer to ECCB and GPI as pro-environmental consumption indicators, since they represent environmentally friendly consumption intention or behaviour.

To recall, much of the greenhouse gas emissions are from transportation, so the sustainability-health debate advocates for interventions enabling individuals to choose active commuting over driving carbon-dependent cars. Active commuting refers to travelling to places with active types of transportation, such as walking and bicycling (Osmënaj et al. 2024). Bicycling (subsequently referred to as biking) and walking are well recognised in the literature as health-seeking pro-environmental behaviours (Asiamah et al. 2023; Hopkins 2016; Mathisen et al. 2015), with the latter considered the most environmentally friendly mobility method (Asiamah et al. 2023). While some studies (Asiamah et al. 2024; Hopkins 2016) have found a positive association of environmental knowledge on biking and walking, others (Fallah Zavareh et al. 2020; Teixeira et al. 2023) have reported pro-environmental consumption indicators as predictors of these active forms of commuting. Yet, no study has simultaneously examined the association among environmental knowledge, pro-environmental consumption indicators, as well as active and non-active modes of commuting.

This study, therefore, aimed to advance the sustainability-health debate by answering the following two research questions: (1) does CCA have a direct influence on GPI, ECCB, and the three types of transportation [i.e., walking, biking, and driving a carbon-dependent car], and (2) does CCA indirectly influence the three forms of transportation through GPI and ECCB? A path analysis that allowed for the concurrent assessment of the foregoing nexus was utilised.

Accra is the capital city of Ghana, where the urban population is rapidly growing (Doan and Oduro 2012). Its residents are experiencing ubiquitous climate change events such as flooding and heatwaves, leading to climate anxiety in the general population (Abunyewah et al. 2023). A population-based study (Asiamah et al. 2025) recently found that climate anxiety in Ghana is highest in Accra, Cape Coast, Tamale, and Wa. Extreme weather is, thus, expected to influence mobility choices and consumption behaviours in these cities over the coming decades. Most vehicles used in Accra and similar cities in Sub-Saharan Africa depend on fossil fuels (Ackaah et al. 2022; Farinloye et al. 2024), but there is increasing adoption of electric cars among residents. This situation, coupled with climate anxiety and the ubiquity of extreme weather events in Accra, warranted an assessment of the correlation of CCA with different mobility choices.

This study is the first to incorporate environmental knowledge, the pro-environmental consumption indicators, walking, biking, driving, and personal factors in a path model or analysis. Testing the foregoing association with a concurrent path model is more statistically robust as it enabled us to avoid estimating the effect sizes with multiple models and type I error (i.e., confirming an effect that does not exist) (Kim 2015; MacKinnon et al. 2002). This is the first study to test a model that extends the link between environmental knowledge and ECCB to active and non-active modes of commuting. As a superior pro-environmental behaviour comprising social and environmental considerations, ECCB in a path model with GPI can unfold policy implications. Our path model is unique in the context of city residents who, for reasons discussed later, may choose to drive a carbon-dependent car despite having a high CCA. Finally, the association can be biased by various threats to internal validity, such as non-linearity. Yet, previous studies undermined assumptions such as model linearity, suggesting that non-linear relationships were possibly tested with linear models.

To address these gaps and better elucidate implications for practice, we employ sensitivity analyses and robustness tests in the path analysis.

Theoretical framework

The Theory of Planned Behaviour by Icek Ajzen in 1985 (Ateş 2020; Dangelico et al. 2021) has been predominantly utilised by researchers to explain pro-environmental consumption indicators and their associated factors (Ateş 2020). It posits that behavioural intentions are influenced by three interrelated factors: attitude, subjective norms, and perceived behavioural control. "Attitude" is an individual's evaluation of a behaviour as positive or beneficial, whereas "subjective norm" is a belief in other people's endorsement of the behaviour. If individuals recognise using an electric vehicle as a positive choice that may protect the environment and believe others endorse and value this behaviour, their motivation or intention to choose an electric vehicle over a carbon-dependent car would be high. Individuals' intention to perform a pro-environmental behaviour (e.g., walking instead of driving a carbon-dependent car) is more likely to result in the behaviour if their subjective norm and attitude are high.

The Theory of Planned Behaviour is an extension of the Theory of Reasoned Action (Sok et al. 2021), which shares the foregoing postulates. Unlike the Theory of Reasoned Action, however, the Theory of Planned Behaviour recognises and delineates the role of "perceived behavioural control" in people's behaviour. Perceived behavioural control, which is analogous to self-efficacy (Giles et al. 2004), is a belief in one's ability to perform a behaviour based on an evaluation of personal circumstances (Hwang et al. 2024; Sok et al. 2021). Some individuals with high "behavioural intention" or motivation may not have the requisite circumstances for performing a behaviour. For example, older adults who have both the attitude, subjective norm, and intention to choose walking over driving a carbon-dependent car may avoid walking owing to their low perceived behavioural control caused by their physical limitations. Thus, perceived behavioural control complements the intention to perform a pro-environmental behaviour.

Perceived behavioural control comes from a self-assessment of personal circumstances such as resources owned (e.g., money for buying an electric vehicle), physical functional ability, and knowledge needed to perform a behaviour safely or sustainably. This perspective unfolds the role CCA may play in pro-environmental behaviours. A high CCA is a resource with which individuals can understand and appreciate the value of pro-environmental behaviours and other people's appreciation of these behaviours. Invariably, individuals would have a high subjective norm and, in effect, the attitude and intention to perform pro-environmental behaviours at a high CCA. This thought is corroborated by several studies (Amoah and Addoah 2021; Asiamah et al. 2024; Halady & Rao 2010; Hopkins 2016; Venghaus et al. 2022) that have found a positive association of environmental knowledge with pro-environmental behaviour. Noteworthy are studies (Amoah & Addoah 2021; Asiamah et al. 2024) confirming a positive association between CCA and pro-environmental behaviours in Ghana.

Two models that recognise the potential effect of environmental knowledge on pro-environmental behaviours are the Tripartite Integrated Model of Social Influence (TIMSI) and the Knowledge Deficit Framework. Propounded by Mica Estrada and associates (Estrada et

al. 2011, 2017), the TIMSI avers that climate change education is a catalyst for social and community integration. It adds that climate change education fosters individual interest in the consequences of climate change and encourages action to avert these consequences. Although the TIMSI was aimed at explaining pro-environmental behaviours in younger adults, its imports apply to the general population, given that older adults can be as concerned about environmental protection as younger generations (Asiamah et al. 2023) and would perform pro-environmental behaviours if their circumstances allow them to do so. The TIMSI suggests that climate change education enlightens people about climate crises and shared actions (i.e., universally accepted actions that protect the environment) against these crises. It can be inferred that CCA is a possible outcome of climate change education and an antecedent of pro-environmental behaviours such as ECCB.

The imports of the TIMSI are consistent with the argument of the Knowledge Deficit Framework, which acknowledges increased pro-environmental action as a product of environmental knowledge. Individuals with higher environmental knowledge are more likely to make daily consumption or purchase choices in favour of sustainability. Deductively, the positive association of environmental knowledge with pro-environmental behaviour is not only supported by the Theory of Planned Behaviour and a growing body of empirical studies (Amoah & Addoah 2021; Asiamah et al. 2024; Hopkins 2016) but is also corroborated by the TIMSI and Knowledge Deficit Model. The firm theoretical and empirical backing of this relationship bolsters climate change education as an instrumental quest in favour of the environment. Yet, research needs to improve stakeholders' understanding of whether outcomes of this type of education (e.g., CCA) predict active transportation since carbon-dependent transportation is one of the major facilitators of climate change (Asiamah et al. 2023; Saleem et al. 2018a, b).

Active transportation through walking and biking is viewed as an environment-friendly choice (Asiamah et al. 2023; Galich et al. 2021; Hopkins 2016), and walking is considered the most sustainable form of commuting (Asiamah et al. 2023; Kim et al., 2020). The above theoretical deductions, thus, support the positive association of CCA (a type of environmental knowledge) with biking and walking, implying that city residents with higher CCA would spend more time commuting through walking and biking. As mentioned earlier, pro-environmental behaviour and intention driven by environmental knowledge depend on personal circumstances. In a sprawling city such as Accra, many residents may live far away from common destinations such as workplaces, churches, and shops. This reasoning is supported by studies (Pucher et al. 2010; Tsunoda et al. 2021) suggesting that walking and biking are usually for short-distance travel.

Heatwaves, unexpected rainfalls, and floods may necessitate travelling by a carbon-dependent car despite one's high environmental knowledge. Cars, compared to bikes, are more protective during extreme weather, so it is rational for residents with high environmental knowledge to choose driving a carbon-dependent car over walking or biking in Ghana where electric vehicles would not be affordable. This being so, CCA may not be associated with lower time spent on driving a carbon-dependent car as the above theoretical analysis implies. Instead, residents with high CCA may spend more time driving a carbon-dependent car. Average temperatures in Accra have increased in the past decades and heatwaves are frequently experienced throughout the year (Klutse et al. 2020). This situation is coupled with unexpected flooding and rainfalls, which render roads and floors muddy (Asiamah 2022). These situations can discourage active commuting among city residents. Hence,

CCA can be positively associated with driving time among residents of Accra. As depicted in Fig. 1, the association of CCA with the three types of transportation are potentially positive and are denoted as p1.

ECCB is a type of pro-environmental behaviour confirmed in research as an outcome or a correlate of environmental knowledge (Saleem et al. 2021; Saleem et al. 2018a, b). Thus, the potential positive association of CCA with ECCB is supported by our theoretical synthesis and empirical research, which forms the basis of the second hypothetical path (i.e., p2) in Fig. 1. A type of "behavioural intention" is GPI, which our theoretical framework reorganises as an outcome of CCA. Worth mentioning is the fact that this relationship has been confirmed by several studies (Hwang et al. 2024; Myung Ja Kim & Hall 2019; Wang et al. 2020). The study of Hwang and colleagues in the United States (Hwang et al. 2024), for example, found that individuals with higher environmental knowledge were more likely to report the intention to reduce single-use plastics. Similar results were reported by Wang and associates (Wang et al. 2020) as well as researchers in Korea (Myung Ja Kim and Hall 2019). Thus, a positive association of CCA with GPI (p3), as depicted in Fig. 1, is probable.

The independent association of CCA with the three transportation types depends on three paths in Fig. 1 (i.e., p4, p5, and p6). According to the Theory of Planned Behaviour, "behavioural intention" (e.g., GPI) can be strongly associated with actual behaviour (e.g., ECCB, walking, biking, and driving) depending on perceived behavioural control (Saleem et al. 2021; Saleem et al. 2018a, b). This argument forms the basis of the remaining direct effect sizes (i.e., p4, p5, and p6) in Fig. 1 and implies a potential indirect association of CCA with walking, biking, and driving. Although this relationship is supported by our theoretical framework and anecdotal evidence (Saleem et al. 2021; Saleem et al. 2018a, b), they have not been empirically confirmed with a concurrent structural equation modelling. Our theoretical model implies a negative association of ECCB and GPI with driving, but this relationship can be positive since residents with high CCA, ECCB, and GPI may not neces-

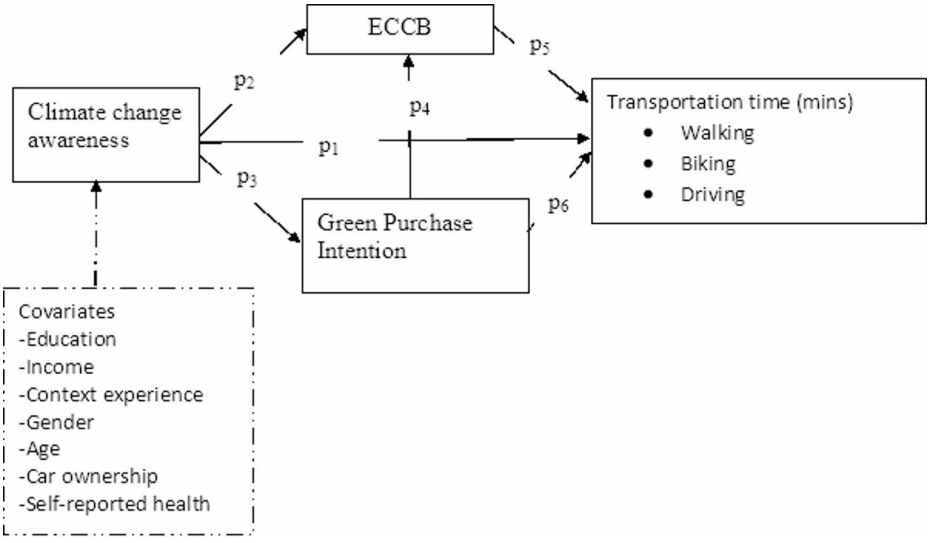

Fig. 1 The conceptual model. *Note*: ECCB–eco-socially conscious consumer behaviour; p1-p6 are the effects or paths linking climate change awareness to walking, biking, and driving time; broken arrow represents potential confounding effect

sarily avoid driving a carbon-dependent car. Regardless of whether this association is positive or negative, CCA would have an indirect association with the three transportation types through ECCB and GPI.

The direct and indirect association of CCA with the three transport behaviours can be confounded by personal variables. In a study undertaken in Egypt, men reported higher CCA (Mostafa 2007), which means gender may affect CCA and consequently confound the association. Environmental knowledge can depend on the level of formal educational attainment since individuals learn about climate change and environmental issues in school. If so, formal education can also confound the association of CCA in Fig. 1. Older and younger people have different experiences with the environment and its issues (Asiamah et al. 2023; Ayalon & Roy 2023), so age can likewise confound the model. To avoid or reduce confounding bias, we followed evidence in the literature to incorporate into the conceptual model relevant covariates. As discussed in the next section, a rigorous statistical procedure was employed to screen and adjust for such covariates.

Materials and methods

Design

This study adopted a cross-sectional design, which included sensitivity analyses and robustness tests performed with path analysis, curve estimation, and a Hierarchical Linear Regression (HLR) analysis.

Study setting, participants, and selection

The study setting was Accra, a sprawling city in Ghana, West Africa. The participants were permanent residents of Accra who met the following inclusion criteria: (1) being aged 18 years or older; (2) willingness to participate in the study voluntarily, (3) owned a bicycle and a private car, and (4) not having any disability that precluded community participation through walking, biking, and driving. Some rural and peri-urban suburbs of Accra (i.e., Dodowa, Dorimu, Shai Hills, and Prampram) were excluded from the study setting because their sociodemographic attributes differed from the rest of Accra. Moreover, it was difficult to find residents who met the third inclusion criterion in those suburbs.

The participants were selected with multistage sampling. Accra was divided into four cardinal blocks (i.e., north, south, east, and west), and the participants were selected randomly from neighbourhoods in each block. The balloting method was utilised to randomly select neighbourhoods from each block. The specific neighbourhoods selected are as follows:

Accra North – Roman Ridge, Dzorwulu, Kanda, Kaneshie, and Accra New Town

Accra South – Korle Gonno, Korlebu, Chorkor, Mamprobi, and New Mamprobi.

Accra West – Odorkor, Dansoman, Darkuman, and Abeka Lapaz.

Accra East – East Legon, Madina, Adenta, Dome, and Kwabenya

A checklist based on the above criteria was utilised by research assistants to select participants in each block and neighbourhood, and 930 individuals were selected from the four blocks. Eligible participants were selected at community centres, churches, and malls. Based on standard parameters for detecting weak effects ($\alpha = 0.05$, power = 0.8, effect size = 0.3, number of variables in the model = 8) used in a similar context (Asiamah et al. 2024), the minimum sample size was calculated with Daniel Sopper's sample size calculator for structural equation modelling. The minimum sample calculated was 161, but we included all eligible participants in the study to maximise the power of the tests.

Variables and their measurement

Walking time was measured by asking participants to report time (in minutes) spent on a typical day walking in (1) recreational or social activities, (2) economic activities such as work and trade, and (3) health-seeking and other activities. These three areas of activity are indicative of active and non-active travel patterns in Accra and were previously used in a study (Bempong & Asiamah 2022). Similarly, we asked participants to report biking and driving time spent on the above three activities on a typical day. Composite scores of walking, biking, and driving time were then generated by adding times reported for the three activities. Reference was made to activities performed over the past week in measuring the three modes of transportation. The measurement method adopted was consistent with the way physical activity has been measured with the World Health Organization's Global Physical Activity Questionnaire and the International Physical Activity Questionnaire (Alola et al. 2022; Cheng and Yu 2021; Craig et al. 2003). Yet, the approach was less vulnerable to recall bias for specifying three areas of activity indicative of the travel pattern in Accra.

ECCB was measured with a 9-item standard scale comprising five descriptive anchors (i.e., 1–strongly disagree, 2–disagree, 3–somewhat agree, 4–agree, and 5–strongly agree). This tool was adopted in whole from a previous study (Saleem et al. 2018a, b) and encompassed items suited for an African context. It produced a satisfactory Cronbach's $\alpha = 0.78$, which exceeds the baseline value of 0.7 (Ng 2013). GPI was measured with a 5-item standard sub-scale with five descriptive anchors (i.e., strongly disagree–1, disagree 2, somewhat agree–3, agree–4, and strongly agree - 5). This tool is a component of the Green Purchase Behaviour Scale (Kanchanapibul et al. 2014) that measures GPI. It yielded a satisfactory Cronbach's $\alpha = 0.81$ in the current study and was chosen over other scales for its suitability for an African context.

CCA was measured with a 17-item standard tool from previous research (Gönen et al. 2023). This tool accompanied the same descriptive anchors as ECCB and produced a satisfactory Cronbach's $\alpha = 0.77$. It was slightly adapted by rephrasing five items to reflect extreme weather conditions in Africa. Items rephrased are in bold cases in Appendix A. This adaptation was necessary since the original scale was developed in a Nordic context. To transform responses on the scales into continuous data, we summed all their items to create a composite (summative) score. Composite scores ranged from 9 to 45, 5 to 25, and 17 to 85 for ECCB, GPI, and CCA respectively. Higher scores represent higher levels of the variables. Responses were based on activities or situations experienced over the past week, and negative items were reverse-coded on all scales. Appendix A shows scales used to measure ECCB, GPI, and CCA.

Previous research (Bempong and Asiamah 2022; Sghaier et al. 2022) was followed to measure the potential confounding variables. Education was measured as a discrete variable by asking participants to report their years of schooling. Gender was measured as a categorical variable (men–1, and women–2). Income was also a discrete variable measured as the individual's gross monthly earnings in Ghana cedis. Age (in years) was a measure of one's chronological age. Self-reported health (poor–1, and good–2) and chronic disease status (none–1, and one or more–2) were measured as categorical variables. 'Years lived in the community' was measured as how long (in years) the individual had lived in their current neighbourhood in Accra. Categorical variables were coded into dummy-type variables and one level was set as a reference.

Survey instrument and common methods bias evaluation

A self-reported questionnaire comprising two sections or blocks was used to collect data. The first block presented measures of CCA, GPI, ECCB, and the three types of transportation. The second block encompassed questions measuring the potential confounders. Following previous research (Sghaier et al. 2022), we took two steps to avoid or minimise common methods bias. The first step involved clearly separating blocks, sections, and questions with specific survey completion instructions, ensuring that participants were guided to accurately answer questions in the right context. While administering the questionnaire, research assistants ensured every participant understood the survey completion instructions. The second procedure was Harman's one-factor statistical method (Jakobsen and Jensen 2015; Kock et al. 2021), which was used to verify the absence of common methods bias. Regarding this method, we performed an exploratory factor analysis with varimax rotation on each scale and evaluated the resulting factor structures. Each factor solution included two or more factors, each accounting for a variance of less than 40% as recommended in the literature (Jakobsen and Jensen 2015; Kock et al. 2021). These results evidenced the absence of common methods bias in our data.

Ethics and data collection

This study received ethical review and clearance from an institutional research ethics review board in Accra, Ghana (number 005–010-2023-ACE). The participants provided written informed consent and participated voluntarily. Five research assistants delivered questionnaires in stamped envelopes to participants between October and November 2023. Some participants responded instantly, but others returned completed questionnaires in two weeks through a private courier hired by the researchers. A total of 865 completed questionnaires were analysed. Fifty-two questionnaires were not returned, whereas 13 of those returned were partially filled. Participants who did not return their questionnaires had a change in personal circumstances or decided to withdraw from the study.

Statistical analyses techniques

Data were analysed with SPSS 28 (IBM Inc., New York, USA) and Amos 28. SPSS was used to summarise the data with descriptive statistics and perform robustness tests as well as sensitivity analyses. Amos was used for path analysis through structural equation model-

ling. Three stages of data analysis were completed. In the first stage, we summarised the data with descriptive statistics (i.e., counts and averages), enabling us to identify potential missing data. Only two personal variables (i.e., self-reported health and private car ownership) had up to 2% missing data. We proceeded to the next stage without removing the missing data because the missing observations constituted less than 10% of the data on each variable (Sghaier et al. 2022).

In the second stage, we carried out a sensitivity analysis to select covariates for our statistical model and investigated whether assumptions governing the use of structural equation modelling were met by our data. These assumptions are the linearity of the relationships, the multivariate normality of the data, and multicollinearity (Flora et al. 2012). Linearity was assessed with curve estimation under the linear regression option in SPSS. The R-square and its significance were computed and compared between linear and non-linear functions (i.e., quadratic, cubic, power, exponential, and power) for all paths in Fig. 2. The linear functions were significant at $p<0.001$ and yielded the largest R-squares, indicating that a linear model was the best estimator of the effect sizes.

Multivariate normality was assessed with a composite estimator in the adjusted model (i.e., Fig. 2). The result violated multivariate normality, but our data could still be analysed with structural equation modelling since our sample size was large enough (Flora et al. 2012; Garson 2012). Following previous research utilising HLR analysis (Sghaier et al. 2022), we screen for the ultimate covariates through a sensitivity analysis. Only age and chronic disease status qualified as the ultimate covariates in this analysis. The sensitivity analysis was necessary to remove potential confounders that did not influence the associations. Too many irrelevant covariates in structural equation modelling may result in higher multicollinearity since the likelihood of this problem occurring depends on the number of predictors in a model (Flora et al. 2012; Osborne & Waters 2003). The absence of multicollinearity was confirmed with "tolerance" values>0.5 for the two ultimate covariates,

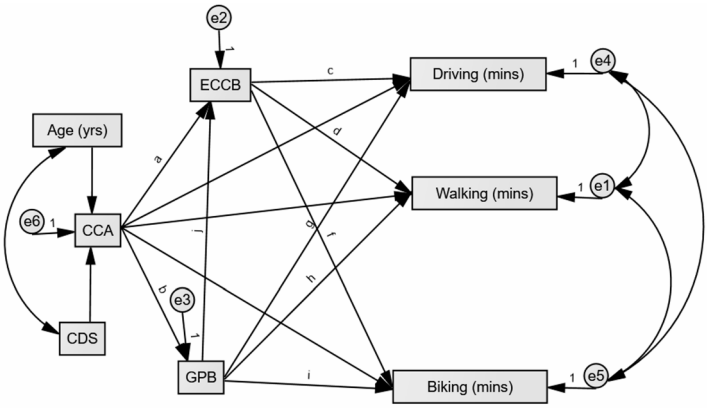

Fig. 2 The statistical (adjusted) model. *Note*: CCA–Climate Change Awareness; GPI–Green Purchase Intention; ECCB–Eco-socially Conscious Consumer Behaviour

CCA, GPI, and ECCB. Appendix B shows the steps taken in the sensitivity analysis and multi-collinearity assessment.

Finally, the effect sizes were estimated with two statistical models. The first (baseline) model was fitted to estimate crude coefficients, including the direct and indirect effect sizes. The second (adjusted) model (in Fig. 2) included age and chronic disease status as covariates from the sensitivity analyses. The conclusions of this study are based on this model. In another sensitivity analysis, we compared the two models' effect sizes and fit indices. In our comparative analysis, the relative fits of the models were assessed with the Akaike Information Criterion (Sghaier et al. 2022). We estimated the indirect effect sizes and their statistical significance with formulae shown in Appendix C through "user-defined estimands" in Amos. Our estimation was based on 2000 bias-corrected sampling iterations or bootstraps at a 95% confidence interval. We generated a Pearson's correlation matrix to guide model fitting, and the significance of all effect sizes was detected at a minimum of $p<0.05$.

Results

Table 1 shows descriptive statistics summarising the data. The average age of the participants was about 30 years (Mean = 29.64; SD = 6.33) whereas the average walking time was about 118 min (Mean = 118.42, SD = 94.90). About 64% (n = 550) of the participants were women whereas about 93% (n = 800) of them reported no chronic disease. Table 2 shows a correlation matrix of the variables. CCA was positively correlated with ECCB ($r=0.534$, $p<0.001$, two-tailed) and GPI ($r=0.351$, $p<0.001$, two-tailed), which suggests that individuals with higher CCA reported higher ECCB and GPI. GPI and ECCB were positively correlated ($r=0.241$, $p<0.001$, two-tailed), implying that participants who reported higher GPI reported higher ECCB.

Table 3 shows the direct effect sizes of the baseline and adjusted models. In the adjusted model, CCA had a positive association with ECCB ($\beta=0.481$, $p<0.001$, critical ratio = 16.100) and GPI ($\beta=0.351$, $p<0.001$, critical ratio = 11.017), confirming that higher CCA was associated with higher ECCB and GPI. CCA had a positive but weak association with walking ($\beta=0.081$, $p<0.05$, critical ratio = 1.996), biking ($\beta=0.12$, $p<0.05$, critical ratio = 2.907), and driving ($\beta=0.106$, $p<0.05$, critical ratio = 2.623). Thus, participants who reported higher CCA reported higher walking, biking, and driving time.

Table 4 shows the indirect effect sizes of the adjusted and baseline models. CCA had a positive indirect association through ECCB with walking only (unstandardised estimate = 0.621, $p<0.001$, CI = ± 0.736), implying that ECCB could transmit the influence of CCA only on walking time. The study further found an indirect positive association of CCA with driving time (unstandardised estimate = 0.383, $p<0.001$, CI = ± 0.377) and biking time (unstandardised estimate = 0.303, $p<0.001$, CI = ± 0.398) but an indirect negative association with walking time through GPI (unstandardised estimate = -0.504, $p<0.001$, CI = ± 0.767). CCA had an indirect positive association with only walking through ECCB and GPI (unstandardised estimate = 0.033, $p<0.05$, CI = ± 0.095) in the adjusted model.

Table 5 shows the fit indices of the adjusted and non-adjusted models. The adjusted model had a good fit in terms of the chi-square (at $p>0.05$), goodness-of-fit index, Tucker-Lewis index, and root mean square error of approximation (Sghaier et al. 2022). The adjusted

Table 1 Descriptive statistics on personal characteristics (n = 865)

Variable	*M*	*SD*	*Range*	*n (%)*
Climate change awareness	57.19	6.70	41–79	
Eco-socially conscious consumer behaviour	28.83	4.83	15–42	
Green purchase intention	17.21	3.42	1–25	
Walking (mins)	118.42	94.90	0–990	
Bicycling (mins)	25.34	54.83	0–390	
Driving (mins)	54.62	92.14	0–540	
Age (yrs)	29.64	6.33	19–48	
Education (yrs)	17.32	4.22	6–29	
Years lived in the community	5.67	2.99	1–15	
Sex				
Men				315(36%)
Women				550(64%)
Self-reported health				
Poor				40(5%)
Good				800(93%)
Missing				25(2%)
Chronic disease status				
None				715(83%)
One or more				150(17%)

M–mean; SD–standard deviation; n–frequency

Table 2 A correlation matrix of variables in the path model (n = 865)

Variable	1	2	3	4	5	6	7	8
Climate change awareness	1	.534**	.351**	.116**	.140**	.154**	-.070*	.092**
ECCB		1	.241**	.120**	.071*	.105**	-.110**	.224**
Green purchase intention			1	-0.054	.145**	.116**	-0.028	-0.022
Walking (mins)				1	.173**	.106**	-0.001	.230**
Bicycling (mins)					1	.106**	0.021	-.074*
Driving (mins)						1	.159**	.206**
CDS (none as a reference)							1	.191**
Age (yrs)								1

**p < 0.001; p < 0.05; ECCB–eco-socially conscious consumer behaviour; CDS–chronic disease status

model yielded a smaller value of Akaike Information Criterion and was, therefore, more strongly fitted (Sghaier et al. 2022).

Discussion

This study utilised a path analysis to simultaneously assess the (1) direct association of CCA with walking, biking, and driving, and (2) indirect association of CCA through GPI and ECCB with the three transport behaviours.

A positive association of CCA with GPI and ECCB was confirmed, suggesting that residents who reported higher CCA had higher GPI and ECCB. The Theory of Planned Behaviour supports the positive CCA-GPI relationship with its argument that a person's intention to perform a behaviour is an outcome of their environmental awareness. The con-

Table 3 Direct effects from the baseline (non-adjusted) and adjusted models (n = 865)

Dependent variable	Path	Independent variable	B	β	Standard error (B)	Critical ratio	95% CI (B)	p	Label
Baseline (non-adjusted) model									
Eco-socially conscious consumer behaviour	←	Climate change awareness	0.369	0.512	0.022	16.712	±0.094	***	a
Green purchase intention	←	Climate change awareness	0.179	0.351	0.016	11.017	±0.065	***	b
Eco-socially conscious consumer behaviour	←	Green purchase intention	0.086	0.061	0.043	1.982	±0.231	0.047	j
Walking (mins)	←	Climate change awareness	1.522	0.108	0.582	2.614	±1.691	0.009	
Biking (mins)	←	Climate change awareness	0.883	0.108	0.337	2.623	±1.075	0.009	
Driving (mins)	←	Climate change awareness	1.588	0.116	0.566	2.804	±1.595	0.005	
Driving (mins)	←	Eco-socially conscious consumer behaviour	0.521	0.027	0.758	0.687	±2.455	0.492	c
Walking (mins)	←	Eco-socially conscious consumer behaviour	1.771	0.090	0.780	2.271	±2.072	0.023	d
Biking (mins)	←	Eco-socially conscious consumer behaviour	-0.155	-0.014	0.451	-0.344	±1.788	0.731	f
Walking (mins)	←	Green purchase intention	-3.161	-0.114	0.995	-3.177	±4.403	0.001	h
Biking (mins)	←	Green purchase intention	1.777	0.111	0.575	3.089	±2.253	0.002	i
Driving (mins)	←	Green purchase intention	1.846	0.068	0.968	1.908	±2.161	0.056	g
Adjusted model									
Eco-socially conscious consumer behaviour	←	Climate change awareness	0.347	0.481	0.022	16.100	±0.093	***	a
Green purchase intention	←	Climate change awareness	0.179	0.351	0.016	11.017	±0.065	***	b
Eco-socially conscious consumer behaviour	←	Green purchase intention	0.103	0.073	0.042	2.455	±0.227	0.014	j
Walking (mins)	←	Climate change awareness	1.146	0.081	0.574	1.996	±1.635	0.046	
Biking (mins)	←	Climate change awareness	0.978	0.120	0.336	2.907	±1.068	0.004	
Driving (mins)	←	Climate change awareness	1.456	0.106	0.555	2.623	±1.654	0.009	

Table 3 (continued)

Dependent variable	Path	Independent variable	B	β	Standard error (B)	Critical ratio	95% CI (B)	p	Label
Driving (mins)	←	Eco-socially conscious consumer behaviour	0.528	0.028	0.758	0.697	±2.460	0.486	c
Walking (mins)	←	Eco-socially conscious consumer behaviour	1.790	0.091	0.781	2.293	±2.096	0.022	d
Biking (mins)	←	Eco-socially conscious consumer behaviour	-0.160	-0.014	0.451	-0.355	±1.788	0.723	f
Walking (mins)	←	Green purchase intention	-2.814	-0.101	0.977	-2.881	±4.323	0.004	h
Biking (mins)	←	Green purchase intention	1.690	0.105	0.574	2.946	±2.257	0.003	i
Driving (mins)	←	Green purchase intention	2.137	0.079	0.941	2.272	±2.002	0.023	g
Climate change awareness	←	Age	0.116	0.110	0.036	3.186	±0.144	0.001	
Climate change awareness	←	Chronic disease status	-1.286	-0.091	0.487	-2.641	±1.605	0.008	

***p < 0.001; CI–confidence interval; B–unstandardised coefficient; β–standardised coefficient

Table 4 Indirect effects (unstandardised estimates) from the baseline and adjusted models (n = 865)

Parameter	Baseline model		Adjusted model	
	Estimate (B)	95% CI	Estimate (B)	95% CI
CCA → ECCB → Driving	0.192	±0.898	0.183	±0.846
CCA → ECCB → Walking	0.654***	±0.789	0.621***	±0.736
CCA → ECCB → Bicycling	-0.057	±0.668	-0.055	±0.627
CCA → GPI → Driving	0.330***	±0.404	0.383***	±0.377
CCA → GPI → Walking	-0.566***	±0.797	-0.504**	±0.767
CCA → GPI → Bicycling	0.318***	±0.395	0.303***	±0.398
CCA → GPI → ECCB → Driving	0.008	±0.053	0.01	±0.064
CCA → GPI → ECCB → Walking	0.027	±0.087	0.033*	±0.095
CCA → GPI → ECCB → Bicycling	-0.002	±0.037	-0.003	±0.043

***p < 0.001; **p < 0.1; *p < 0.05; CCA–climate change awareness; ECCB–eco-socially conscious consumer behaviour; GPI–green purchase intention; CI–confidence interval

gruence between this result and the Theory of Planned Behaviour is complemented by studies (Hwang et al. 2024; Myung Ja Kim and Hall 2019; Wang et al. 2020) that have found a positive association between environmental knowledge and GPI. Notably, this study was the first to confirm this relationship in a sample of city residents in Africa. The positive association of CCA with ECCB is also consistent with the Theory of Planned Behaviour, which explains that environmental awareness can lead to behavioural intentions and behaviours, including pro-environmental behaviours. More so, the TIMSI and Knowledge Deficit

Table 5 Fit indices from the baseline and adjusted models (n = 865)

Index	Model	
	Baseline	Adjusted
Chi-square	5.548 ($p < 0.05$)	3.901 ($p > 0.05$)
Goodness-of-fit index	0.998	0.999
Tucker-Lewis index	0.866	1.000
Root mean square error of approximation	0.073	0.000
Akaike information criterion	67.901	45.548

Model recognise pro-environmental behaviour as an outcome of climate change education from which CCA or environmental knowledge stems. Supporting this result are studies (Amoah & Addoah 2021; Halady and Rao 2010; Hopkins 2016) that have confirmed a positive association between CCA and the social and environmental dimensions of ECCB. Yet, the current study was the first to confirm a link between CCA and ECCB.

This study further found a positive association between CCA and the three transport behaviours, although the relationship is weak. This result signifies that higher CCA was associated with higher walking, biking, and driving time. The positive association of CCA with walking and biking support the recognition of these transport behaviours in the literature as environmentally friendly actions (Asiamah et al. 2023; Bempong & Asiamah 2022). This outcome, nonetheless, does not necessarily mean CCA would be associated with less driving of a carbon-dependent car among city residents. As our result suggests, CCA may be associated with higher driving time among city residents. Since driving a carbon-dependent car is not a pro-environmental behaviour, this outcome is counterintuitive and may be explained by factors beyond the control of residents. In a sprawling city such as Accra, residents with a high CCA would choose driving over walking if their destinations cannot be reached by walking. Some residents would drive to protect themselves from extreme weather and psychosocial problems such as insecurity. The rates of crime, traffic accidents, and extreme weather events in Accra and other Ghanaian cities are increasing over time (Appiahene-Gyamfi 2022; Owusu-Ansah et al. 2024; Wemegah et al. 2025). Heatwaves and traffic accidents are increasingly prevalent in Ghanaian cities, including Accra (Owusu-Ansah et al. 2024; Wemegah et al. 2025). Hence, residents with high CCA may drive carbon-dependent cars for safety, prestige, or convenience. Since electric vehicles are not yet readily accessible in Ghana (Ayetor et al. 2022), residents with high CCA would be compelled to drive carbon-dependent cars instead of electric vehicles.

CCA indirectly influences only walking through ECCB, which means ECCB transmits a positive influence from CCA onto walking but not on driving and biking. Another unexpected result is the negative indirect association of CCA with walking through GPI. Even so, the indirect association of CCA with walking through GPI and ECCB is positive, which indicates that ECCB plays a role in whether CCA would be positively associated with walking through GPI. Given that walking is the most environmentally friendly travel behaviour (Asiamah et al. 2023), this result endorses ECCB as a superior pro-environmental behaviour, compared to GPI. The indirect association of CCA with faster modes of travel (i.e., driving and biking) through GPI is positive, implying that GPI would transmit a positive influence from CCA onto only faster commuting options. This evidence supports an argument in the literature about city residents with high CCA and pro-environmental intentions

choosing faster modes of travel over walking owing to long distances between homes and destinations (Asiamah et al. 2024).

To reiterate, ECCB as a pro-environmental behaviour is unique for being driven by a consideration of both the social and environmental consequences of everyday consumption. This special attribute could explain why the only indirect effect of CCA on walking was through ECCB. Similarly, GPI only relays a positive effect from CCA onto walking if ECCB intervenes. This outcome was expected since GPI or behavioural intentions do not always result in actual behaviour. Both the Theory of Planned Behaviour and TIMSI imply that intentions are plans to perform a behaviour that can be traded off or disregarded. Intentions are traded off and disregarded if they are not convenient or as valued and prioritized by the individual as other intentions. If an intention offers higher convenience and value than another, it does not result in a behaviour. ECCB, on the other hand, is the behavioural outcome of an intention and accompanies benefits for both the individual and the environment. GPI would not result in active travel if the individual is constrained by personal or environmental factors such as a disability or extreme weather event. Yet, future research including more pro-environmental behaviours (e.g., socially responsible consumption, and eco-conscious consumer behaviour) in our model is needed to substantiate our evidence and explanation. Judging by our evidence alone, pro-environmental behaviours based on a consideration of the social and environmental consequences of consumption may better encourage walking.

As our correlation matrix shows (see Table 2), the three types of transportation are correlated in our statistical model (i.e., Fig. 2). These correlations were modelled to maximise model fit and avoid biased effect sizes. It is worth considering these correlations in future research, especially in situations where the three types of transportation serve as predictors. In such instances, multi-collinearity is probable and could distort the estimated coefficients (Chan et al. 2022). It was further observed that coefficients between the baseline and adjusted models were different. This result attested to the significance of adjusting for the covariates, given that wrong effect sizes would have been reported without this adjustment. Controlling for confounders is recognised in the literature as a strategy to maximise internal validity (Busenbark et al. 2022; Min Ju Kim et al. 2014), but researchers should ensure that this procedure does not lead to issues such as model misfit and multi-collinearity, which were avoided in this study. The above results and thoughts have implications for policy and research.

Implications for policy and research

Sustainability campaigns emphasize a reduction in greenhouse gas emissions from transport-related travel, which accounts for a significant part of the global carbon footprint (Asiamah et al. 2023). The confirmed link between CCA and active commuting supports interventions intended to improve environmental knowledge. Researchers (Berkowitz et al. 2005; Bonney et al. 2009) are of the view that initiatives improving environmental knowledge should ultimately be driven by national or regional policies. This recommendation has been predominantly based on evidence linking environmental knowledge to pro-environmental behaviours and intention unrelated to active travel. Hence, this study consolidates empirical evidence in favour of the above recommendation. In some countries, there are policy-led educational programmes that provide environmental awareness (Agbedahin 2019). An

example is the rollout of climate change education to create awareness of environmental issues and pro-environmental actions. This study bolsters the importance of such policy-led programmes and unfolds a need for similar programmes targeted at everyone. Beyond formal educational programmes, governments can roll out campaigns to improve people's awareness of pro-environmental action.

The results of this study suggest that high environmental knowledge and pro-environmental behaviour are not necessarily associated with less driving of carbon-dependent vehicles in cities. An exploration of factors that explain this relationship was beyond the scope of this study, but it can be inferred from our result that improving environmental knowledge as suggested above without city design and human-developed programmes that enable residents to replace driving carbon-dependent vehicles with active travel is incomplete. Ensuring proximity to neighbourhood facilities and improvement in walkability (Otsuka et al. 2021) are among the steps recommended for encouraging active commuting, but more empirical evidence is needed to understand why people with high environmental knowledge and pro-environmental behaviour (i.e., ECCB) would drive carbon-dependent vehicles in cities.

Walking and biking are good for the planet and protective of health (Asiamah et al. 2023; Bempong and Asiamah 2022), which signifies their bi-dimensional impact on human society. As such, it is incumbent on researchers to adequately value active travel based on this impact, emphasizing to policymakers the sustainability-health reward of walking, and biking. Owing to their desired impacts on health and the environment, active commuting should be prioritised among pro-environment behaviours and encouraged through cross-sectorial and interdisciplinary campaigns. Advocacy for active travel by scholars may translate into improved stakeholder recognition of active commuting as a shared behaviour with which sustainability can be achieved. Policymakers would, in effect, improve their commitment to city design and human development programmes aimed at improving active travel as a mainstream sustainability behaviour. Similarly, governments may become more interested in policies encouraging and driving upstream pro-environmental actions. The above viewpoints ought to be evaluated and applied based on the limitations and strengths of this study.

As the results of this study suggest, residents with high CCA and environmental knowledge may need support from governments and city planners to avoid driving a carbon-dependent car. Extreme weather conditions, violence, high cost of electric vehicles, and traffic accidents involving cyclists and pedestrians can discourage active transportation among those with high CCA. It is, therefore, incumbent on governments to introduce policies aimed at enhancing traffic safety, reducing the cost of electric vehicles, and educating the public on how to navigate extreme weather events during their active travel. Planners should work closely with governments to reduce the carbon footprint of Accra and similar cities by empowering businesses to choose pro-environmental practices. Lowering the carbon footprint of cities would reduce the likelihood of extreme weather events (e.g., heatwaves, storms, and floods) that discourage active travel.

Limitations and strengths

This study utilised a self-reported survey instrument. Although individual measures of the variables have been reliably used in previous research, they are vulnerable to response bias. Our measurement of walking, biking, and driving time was susceptible to recall bias despite our effort to improve upon existing subjective measurement methods, such as the way walk-

ing has been measured with the International Physical Activity Questionnaire. Although our measurement was intended to overcome some issues with existing subjective methods, it did not capture potential differences in walking, biking, and driving times across days. Future researchers are encouraged to utilise objective measures (e.g., activity trackers) if possible. Other modes of transport (e.g., public transport, motorbiking, and paratransit) were not considered in this study, although they might have influenced active transport and driving. Future researchers are encouraged to consider these additional transport modes and assess their influences on the relationships explored in this study.

Our sampling method was not probabilistic, so this study's results have limited generalisability. The number of participants selected was not proportional to the population size of the neighbourhoods, and we may have missed potential participants by selecting individuals at malls, churches, and community centres. Future researchers may employ probabilistic and representative samples to enhance the external validity of this study. We did not have the requisite resources (e.g., funding and time) to adopt a longitudinal design, which is superior to the cross-sectional design employed in the current study. Thus, this study could not establish causation between the variables, so its regression coefficients should be viewed as correlations, and future researchers are encouraged to utilise a longitudinal design. The verification of the participants' bike ownership and permanent residency was based on self-report, an approach that could be biased. An objective method, such as checking receipts from bike purchases and permanent city residency documents, may be employed in future research.

This was the first study to link environmental knowledge and the pro-environmental consumption indicators to active and non-active travel in a path analysis. Estimating the direct and indirect effects with this analysis mitigated type I error, which is more probable when studies test a nexus (as shown in our conceptual model) in parts (Kim 2015). By capturing driving a carbon-dependent car and active transportation (i.e., walking and biking) in the same model, this study would provide unique evidence about how CCA, directly and indirectly, influences active and non-active commuting. This evidence would consolidate stakeholders' understanding of the roles of environmental knowledge and pro-environmental behaviours and intention in sustainable transportation among city residents. Our exploratory tests for ensuring the linearity of the relationships and the absence of multi-collinearity in the data add to the strength of this study. Our sensitivity analysis for screening covariates played a role in identifying variables most likely to confound the relationships examined. It also helped in minimising potential multi-collinearity among covariates in the model. These procedures and our test for multivariate normality are a model for maximising the robustness of future cross-sectional designs.

Conclusion

ECCB and GPI are associated with larger scores of CCA, and city residents with higher CCA are more likely to travel by walking, biking, and driving for transportation than those with lower CCA. GPI positively mediates CCA and driving as well as biking but negatively mediates CCA and walking. CCA was indirectly positively associated with only walking through both GPI and ECCB. City dwellers who walk and bike owing to high CCA may also travel by driving a carbon-dependent car. ECCB can be an important determinant of

walking for transportation among city dwellers with higher CCA. Our result reinforces the need for proximity between residential facilities (i.e., where residents live) and commercial infrastructure (e.g., workplaces, shops, and community centres) in Accra. The design of cities should be cognisant of the potential impact of extreme weather on travel behaviour. Future studies utilising a longitudinal design and objective measures of travel behaviour are needed.

Appendix A. Items and measures of climate change awareness, eco-socially conscious consumer behaviour, and green purchase intention

Appendix A1. Measures of climate change awareness scale

SN	Statement	1	2	3	4	5
1	Permanent changes in the habitats or environments of animals are some of the consequences of global warming					
2	I am aware that global warming is caused by human activities					
3	I am aware that the warm weather nowadays lasts longer each year					
4	I am amazed by people who are unaware of how dangerous climate change is					
5	I am aware that floods will occur if the temperature of the world increases					
6	**I am aware that most emissions of greenhouse gases (i.e., gases that cause global warming) are caused by people's use of fossil fuels such as petrol**					
7	I am aware that greenhouse gases such as nitrous oxide used in vehicles increase global warming					
8	It will make me happy to see the creation of new businesses that seek to produce environment-friendly energy options					
9	**I am aware that methane and carbon dioxide are natural greenhouse gases**					
10	I am worried about energy waste					
11	I would like to improve my knowledge on combating climate change					
12	**I am aware that less consumption of energy from fossil fuels slows down global warming**					
13	I am not worried about the number of hungry people in the world due to climate change (R)					
14	**I am not concerned about problems (e.g., flooding and extreme temperatures) faced by people due to climate change (R)**					
15	**I am not interested in the disappearance of animal species due to climate change (R)**					
16	I think that global climate change will not cause drought in my country (R)					
17	I don't think expected rises in the level of the sea is due to global warming (R)					

Descriptive anchors: 1; strongly disagree, 2; disagree, 3; somewhat agree, 4; agree, and 5; strongly agree; reworded items are in bold; items with an R in parentheses represent negative items.

Appendix A2. Measures and items of eco-socially conscious consumer behaviour

SN	Statement	1	2	3	4	5
1	I would select a car that produces least friction and saves energy					

SN	Statement	1	2	3	4	5
2	I would avoid using wide thread tires that cause road friction and consume more fuel					
3	I would consider using radial tires that help to preserve fuel resource knowing that excessive speed is inefficient and requires more energy to stop the car					
4	I would consider observing speed limits knowing that excessive speed is inefficient and requires more energy to stop the car					
5	I would move at a steady pace when driving					
6	I would use less fuel when using a car					
7	I would buy an electric vehicle even if its quality is lower than a conventional car					
8	I would buy an electric vehicle even if its performance is lower than a conventional car					
9	I would buy an electric vehicle even if it has a less appealing design					

Descriptive anchors: 1; strongly disagree, 2; disagree, 3; somewhat agree, 4; agree, and 5; strongly agree.

Appendix A3. Measures of green purchase intention

SN	Item	1	2	3	4	5
1	I avoid buying products which are potentially harmful to the environment					
2	I have changed my principal products for ecological reasons					
3	When I have to choose between two similar products, I choose the one that is less harmful to the environment					
4	I make a special effort to buy paper and plastic products that are made from recycled materials					
5	I will not consider environmental issues when making a purchase					

Descriptive anchors: 1; strongly disagree, 2; disagree, 3; somewhat agree, 4; agree, and 5; strongly agree.

Appendix B. Steps taken in the sensitivity analysis for confounders and multi-collinearity

Appendix B1. Steps taken in the sensitivity analysis

Stage	#	Action
1	1	Fit a simple linear regression model to assess the relationship between CCA and walking
	2	Note the standardised regression weight from step 1
	3	Fit a multiple linear regression model in which all measured covariates are treated as predictors of the primary independent variable, CCA
	4	Identify from step 3 potential confounders that have a p-value ≥ 0.25
	5	Predictors from step 4 that produced a $p \geq 0.25$ should be removed from the analysis and the others kept for the next stage of the analysis

Stage	#	Action
2	6	Adjust for each of the remaining confounding variables in the model fitted at step 1
	7	Compute the per cent (%) change between the standardised regression weight at step 1 and the new weight resulting from step 6
	8	All potential confounders that produce a change of 10% or more are the ultimate covariates and should be in the adjusted model
	9	Replace walking with biking and repeat steps 2 to 8 to note any ultimate covariate
	10	Replace biking with driving and repeat steps 2 to 8 to note any ultimate covariate

Following the above steps, age and chronic disease status were consistently noted as the ultimate covariates.

Appendix B2. Steps taken in assessing multi-collinearity with hierarchical linear regression

Block	Step	What to note	Result
1	Examine the effects of chronic disease status and age on CCA in multiple linear regression	Take note of the variance inflation factor or tolerance values	Tolerance for each predictor was greater than 0.5
2	Through multiple linear regression, assess the effects of CCA, GPI, and ECCB on walking	Take note of the variance inflation factor or tolerance values	Tolerance for each predictor was greater than 0.5
3	Perform step 2 again with walking replaced with biking	Take note of the variance inflation factor or tolerance values	Tolerance for each predictor was greater than 0.5
4	Perform step 2 again with walking replaced with driving	Take note of the variance inflation factor or tolerance values	Tolerance for each predictor was greater than 0.5

Appendix C. Equations used to estimate indirect effects through 2000 biased-corrected bootstraps and a 95% confidence interval

1. CCA → ECCB → Driving = a*c
2. CCA → ECCB → Walking = a*d
3. CCA → ECCB → Bicycling = a*f
4. CCA → GPI → Driving = b*g
5. CCA → GPI → Walking = b*h
6. CCA → GPI → Bicycling = b*i
7. CCA → GPI → ECCB → Driving = b*j*c
8. CCA → GPI → ECCB → Walking = b*j*d
9. CCA → GPI → ECCB → Bicycling = b*j*f

Note: Letters a, b, c, d, f, g, h, I, and j are paths or effects. Please see Fig. 2 in the main paper to know which paths these letters represent. Estimation was done through "user-defined estimands" in Amos.

KEY

CCA: Climate change awareness.

GPI: Green purchase intention.
ECCB: Eco-socially conscious consumer behaviour.

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Data availability The data used for this study will be made available by the corresponding upon request.

Declarations

Competing interests The authors declare no competing interests.

References

Abunyewah, M., Erdiaw-Kwasie, M.O., Acheampong, A.O., Arhin, P., Okyere, S.A., Zanders, K., Frimpong, L.K., Byrne, M.K., Lassa, J.: Understanding climate change adaptation in Ghana: the role of climate change anxiety, experience, and knowledge. Environ Sci Policy **150**, 103594 (2023)

Ackaah, W., Kanton, A.T., Osei, K.K.: Factors influencing consumers' intentions to purchase electric vehicles in Ghana. Transp. Lett. **14**(9), 1031–1042 (2022)

Agbedahin, A.V.: Sustainable development, education for Sustainable Development, and the 2030 agenda for Sustainable Development: emergence, efficacy, eminence, and future. Sustain. Dev. **27**(4), 669–680 (2019). https://doi.org/10.1002/sd.1931

Ahmad, W., Jafar, R.M.S., Waheed, A., Sun, H., Kazmi, S.S.A.S.: Determinants of CSR and green purchase intention: Mediating role of customer green psychology during COVID-19 pandemic. J. Clean. Prod. **389**, 1–13 (2023). https://doi.org/10.1016/j.jclepro.2023.135888

Alola, U.V., Bekun, F.V., Alola, A.A., Ahmed, Z.U.: Sustainable development amidst technological innovation and tourism activities in sub-Saharan Africa. Int. Soc. Sci. J. **72**(243), 111–127 (2022). https://doi.org/10.1111/issj.12316

Amoah, A., Addoah, T.: Does environmental knowledge drive pro-environmental behaviour in developing countries? Evidence from households in Ghana. Environ. Dev. Sustain. **23**(2), 2719–2738 (2021). https://doi.org/10.1007/s10668-020-00698-x

Appiahene-Gyamfi, J.: The trends and patterns of crime in Ghana: the case of robbery. Int. J. Crim. Just. Sci. **17**, 93–109 (2022)

Asiamah, N.: Walkable urban neighborhoods: The adverse effects of industrialization and climate change in developing countries. Sustain. Urban. Develop. Count. **20**, 247–262 (2022). https://doi.org/10.1201/9781003131922-16

Asiamah, N., Awuviry-Newton, K., Nesser, W., Alvarez, E.N.: Carbon footprints of active and non-active transport modes: hierarchy and intergenerational narrative analyses. Sustain. (Switzerland) **15**(17), 1–16 (2023a). https://doi.org/10.3390/su151712795

Asiamah, N., Frimpong Opuni, F., Aidoo, I., Benyi Ansah, N., Lomatey, T., Muhonja, F., Agormeda-Tetteh, K., Koranteng Kumi, P., Eku, E., Osumanu Doumbia, M., Kofi Anyanful, T.: Effects of climate change awareness on green purchase behaviour, biking, and walking time: moderated mediation by sustainability knowingness. Transp. Res. Interdiscip. Perspect. **25**, 1–11 (2024). https://doi.org/10.1016/j.trip.2024.101134

Asiamah, N., Mensah, K.M., Ansah, E.W.: Climate anxiety among older city dwellers: multi-city quantification and stratification by demographic, socioeconomic, and contextual factors. Environ. Sustain. Indic. Unpubl. Manuscr. **201**, 1–12 (2025)

Ateş, H.: Merging theory of planned behavior and value identity personal norm model to explain pro-environmental behaviors. Sustain. Prod. Consum. **24**, 169–180 (2020). https://doi.org/10.1016/j.spc.2020.07.006

Ayalon, L., Roy, S.: The role of ageism in climate change worries and willingness to act. J. Appl. Gerontol. **42**(6), 1305–1312 (2023)

Ayetor, G.K., Opoku, R., Sekyere, C.K.K., Agyei-Agyeman, A., Deyegbe, G.R.: The cost of a transition to electric vehicles in Africa: a case study of Ghana. Case Stud. Transp. Policy **10**(1), 388–395 (2022). https://doi.org/10.1016/j.cstp.2021.12.018

Bempong, A.E., Asiamah, N.: Neighbourhood walkability as a moderator of the associations between older Ghanaians' social activity, and the frequency of walking for transportation: A cross-sectional study with sensitivity analyses. Arch. Gerontol. Geriatr. **100**, 1–8 (2022). https://doi.org/10.1016/j.archger.2022.104660

Berkowitz, A. R., Ford, M. E., & Brewer, C. A. (2005). A framework for integrating ecological literacy, civics literacy, and environmental citizenship. In: *Environmental education …*. https://books.google.com/books?hl=en&lr=&id=ac2M9upsf54C&oi=fnd&pg=PA227&dq=environmental+literacy&ots=_lLylsRmIe&sig=7ABCxNN58KfXq8k2y778US5UlSA

Bonney, R., Cooper, C.B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K.V., Shirk, J.: Citizen science: a developing tool for expanding science knowledge and scientific literacy. Bioscience **59**(11), 977–984 (2009). https://doi.org/10.1525/bio.2009.59.11.9

Busenbark, J.R., Yoon, H., Gamache, D.L., Withers, M.C.: Omitted variable bias: examining management research with the impact threshold of a confounding variable (ITCV). J. Manage. **48**(1), 17–48 (2022). https://doi.org/10.1177/01492063211006458

Chan, J.Y., Mun, S., Leow, H., Bea, K.T., Cheng, W.K., Phoong, S.W., Hong, Z., Chen, Y.: Mitigating the multicollinearity problem and its machine learning approach: a review. Mathematics **10**(8), 1–17 (2022)

Cheng, J., Yu, H.: The relationship between neighborhood environment and physical activity in Chinese youth: a retrospective cross-sectional study. J. Public Health **30**, 2801–2808 (2021). https://doi.org/10.1007/s10389-021-01547-5

Connell, K.Y.H.: Exploring consumers' perceptions of eco-conscious apparel acquisition behaviors. Soc. Responsib. J. **7**(1), 61–73 (2011). https://doi.org/10.1108/17471111111114549

Craig, C.L., Marshall, A.L., Sjöström, M., Bauman, A.E., Booth, M.L., Ainsworth, B.E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J.F., Oja, P.: International physical activity questionnaire: 12-country reliability and validity. Med. Sci. Sports Exerc. **35**(8), 1381–1395 (2003). https://doi.org/10.1249/01.MSS.0000078924.61453.FB

Dangelico, R.M., Nonino, F., Pompei, A.: Which are the determinants of green purchase behaviour? A study of Italian consumers. Bus. Strat. Environ. **30**(5), 2600–2620 (2021). https://doi.org/10.1002/bse.2766

Doan, P., Oduro, C.Y.: Patterns of population growth in peri-urban Accra, Ghana. Int. J. Urban Reg. Res. **36**(6), 1306–1325 (2012)

Estrada, M., Woodcock, A., Hernandez, P.R., Schultz, P.W.: Toward a model of social influence that explains minority student integration into the scientific community. J. Educ. Psychol. **103**(1), 206–222 (2011). https://doi.org/10.1037/a0020743

Estrada, M., Schultz, P.W., Silva-Send, N., Boudrias, M.A.: The role of social influences on pro-environment behaviors in the San Diego region. J. Urban Health **94**(2), 170–179 (2017). https://doi.org/10.1007/s11524-017-0139-0

Fallah Zavareh, M., Mehdizadeh, M., Nordfjærn, T.: Active travel as a pro-environmental behaviour: an integrated framework. Transp. Res. Part D Transp. Environ. **84**, 1–11 (2020). https://doi.org/10.1016/j.trd.2020.102356

Farinloye, T., Oluwatobi, O., Ugboma, O., Dickson, O.F., Uzondu, C., Mogaji, E.: Driving the electric vehicle agenda in Nigeria: The challenges, prospects and opportunities. Transp. Res. Part d: Transp. Environ. **130**, 1–17 (2024)

Flora, D.B., LaBrish, C., Chalmers, R.P.: Old and new ideas for data screening and assumption testing for exploratory and confirmatory factor analysis. Front. Psychol. **3**, 1–21 (2012). https://doi.org/10.3389/fpsyg.2012.00055

Galich, A., Nieland, S., Lenz, B., Blechschmidt, J.: How would we cycle today if we had the weather of tomorrow? An analysis of the impact of climate change on bicycle traffic. Sustain. (Switzerland) **13**(18), 1–22 (2021). https://doi.org/10.3390/su131810254

Garson, G. D. (2012). Testing Statistical Assumptions. *Blue Book Series*, 1–52. http://www.statisticalassociates.com/assumptions.pdf

Giles, M., McClenahan, C., Cairns, E., Mallet, J.: An application of the theory of planned behaviour to blood donation: the importance of self-efficacy. Health Educ. Res. **19**(4), 380–391 (2004). https://doi.org/10.1093/her/cyg063

Gönen, Ç., Deveci, E.Ü., Aydede, M.N.: Development and validation of climate change awareness scale for high school students. Environ. Dev. Sustain. **25**(5), 4525–4537 (2023). https://doi.org/10.1007/s10668-022-02213-w

Grant, G., Machaczek, K., Pollard, N., Allmark, P.: Walking, sustainability and health: findings from a study of a walking for health group. Health Soc. Care Community **25**(3), 1218–1226 (2017). https://doi.org/10.1111/hsc.12424

Halady, I.R., Rao, P.H.: Does awareness to climate change lead to behavioral change? Int. J. Clim. Change Strateg. Manag. **2**(1), 6–22 (2010). https://doi.org/10.1108/17568691011020229

Hopkins, D.: Can environmental awareness explain declining preference for car-based mobility amongst generation Y? A qualitative examination of learn to drive behaviours. Transp. Res. Part A Policy Pract. **94**, 149–163 (2016). https://doi.org/10.1016/j.tra.2016.08.028

Hwang, S., Lee, J., Jang, D.: Climate change awareness and pro-environmental intentions in sports fans: applying the extended theory of planned behavior model for sustainable spectating. Sustainability (Switzerland) **16**(8), 1–17 (2024). https://doi.org/10.3390/su16083246

Iturriza, M., Hernantes, J., Abdelgawad, A.A., Labaka, L.: Are Cities aware enough? A framework for developing city awareness to climate change. Sustainability (Switzerland) **12**(6), 1–22 (2020). https://doi.org/10.3390/su12062168

Jakobsen, M., Jensen, R.: Common method bias in public management studies. Int. Public Manag. J. **18**(1), 3–30 (2015). https://doi.org/10.1080/10967494.2014.997906

Kanchanapibul, M., Lacka, E., Wang, X., Chan, H.K.: An empirical investigation of green purchase behaviour among the young generation. J. Clean. Prod. **66**, 528–536 (2014). https://doi.org/10.1016/j.jclepro.2013.10.062

Kim, H.-Y.: Statistical notes for clinical researchers: type I and type II errors in statistical decision. Restor. Dent. Endod. **40**(3), 249–252 (2015). https://doi.org/10.5395/rde.2015.40.3.249

Kim, M.J., Hall, C.M.: Can climate change awareness predict pro-environmental practices in restaurants? Comparing high and low dining expenditure. Sustainability (Switzerland) **11**(23), 1–20 (2019). https://doi.org/10.3390/su11236777

Kim, M.J., Cho, J., Ahn, Y., Yim, G., Park, H.Y.: Association between physical activity and menopausal symptoms in perimenopausal women. BMC Womens Health **14**(1), 1–8 (2014). https://doi.org/10.1186/1472-6874-14-122

Kim, E.J., Kim, J., Kim, H.: Neighborhood walkability and active transportation: a correlation study in leisure and shopping purposes. Int. J. Environ. Res. Public Health **17**(7), 6–10 (2020). https://doi.org/10.3390/ijerph17072178

Klutse, N.A.B., Owusu, K., Boafo, Y.A.: Projected temperature increases over northern Ghana. SN Appl. Sci. **2**(8), 1–14 (2020). https://doi.org/10.1007/s42452-020-3095-3

Kock, F., Berbekova, A., Assaf, A.G.: Understanding and managing the threat of common method bias: detection, prevention and control. Tour. Manag. **86**, 1–10 (2021). https://doi.org/10.1016/j.tourman.2021.104330

MacKinnon, D.P., Lockwood, C.M., Hoffman, J.M., West, S.G., Sheets, V.: A comparison of methods to test mediation and other intervening variable effects. Psychol. Methods **7**(1), 83–104 (2002). https://doi.org/10.1037/1082-989X.7.1.83

Mathisen, T.A., Annema, J.A., Kroesen, M.: The effects of weather and climate change on cycling in Northern Norway. Europ. J. Transp. Infrast. Res. **15**(2), 261–273 (2015). https://doi.org/10.18757/ejtir.2015.15.2.3072

Mostafa, M.M.: Gender differences in Egyptian consumers' green purchase behaviour: the effects of environmental knowledge, concern and attitude. Int. J. Consum. Stud. **31**(3), 220–229 (2007). https://doi.org/10.1111/j.1470-6431.2006.00523.x

Ng, S.M.: Validation of the 10-item chinese perceived stress scale in elderly service workers: one-factor versus two-factor structure. BMC Psychology **1**(1), 1–8 (2013). https://doi.org/10.1186/2050-7283-1-9

Opuni, F.F., Asiamah, N., Danquah, E., Ricky-Okine, C.K., Ocloo, E.C., Quansah, F.: The associations between pro-environment behaviours, sustainability knowingness, and neighbourhood walkability among residents of Accra Metro in Ghana: a cross-sectional analysis. J. Transp. Health **25**, 1–14 (2022). https://doi.org/10.1016/j.jth.2022.101375

Osborne, J.W., Waters, E.: Four assumptions of multiple regression that researchers should always test. Pract. Assess. Res. Eval. **8**(2), 2002–2003 (2003)
Osmënaj, T., Lam, T.M., Wagtendonk, A.J., den Braver, N.R.: Walking to work: the role of walkability around the workplace in a dutch adult commuting population. SSM Populat. Health **25**, 1–7 (2024). https://doi.org/10.1016/j.ssmph.2023.101578
Otsuka, N., Wittowsky, D., Damerau, M., Gerten, C.: Walkability assessment for urban areas around railway stations along the Rhine-Alpine corridor. J. Transp. Geogr. **93**, 1–10 (2021). https://doi.org/10.1016/j.jtrangeo.2021.103081
Owusu-Ansah, P., Abdul-Aziz, A., Obiri-Yeboah, A.A., Amoah, A.S., Woangbah, S.K., Adusei, E.: Modelling road fatalities from tricycle crashes in Ashanti Region, Ghana: an application of regression with ARIMA errors. Transp. Res. Interdiscip. Perspect. **26**, 1–8 (2024)
Pucher, J., Buehler, R., Bassett, D.R., Dannenberg, A.L.: Walking and cycling to health: a comparative analysis of city, state, and international data. Am. J. Public Health **100**(10), 1986–1992 (2010). https://doi.org/10.2105/AJPH.2009.189324
Saleem, M.A., Eagle, L., Low, D.: Climate change behaviors related to purchase and use of personal cars: development and validation of eco-socially conscious consumer behavior scale. Transp. Res. Part D Transp. Environ. **59**, 68–85 (2018a). https://doi.org/10.1016/j.trd.2017.12.023
Saleem, M.A., Eagle, L., Yaseen, A., Low, D.: The power of spirituality: exploring the effects of environmental values on eco-socially conscious consumer behaviour. Asia Pac. J. Mark. Logist. **30**(4), 867–888 (2018b). https://doi.org/10.1108/APJML-10-2017-0259
Saleem, M.A., Eagle, L., Low, D.: Determinants of eco-socially conscious consumer behavior toward alternative fuel vehicles. J. Consum. Mark. **38**(2), 211–228 (2021). https://doi.org/10.1108/JCM-05-2019-3208
Sghaier, S., Asiamah, N., Danquah, E., Opuni, F.F., Hatsu, S.: Information technology ability mediates the association between older adults' subjective age and social activity: a STROBE-compliant cross-sectional analysis. Arch. Gerontol. Geriatr. **103**, 1–9 (2022). https://doi.org/10.1016/j.archger.2022.104790
Sok, J., Borges, J.R., Schmidt, P., Ajzen, I.: Farmer behaviour as reasoned action: a critical review of research with the theory of planned behaviour. J. Agric. Econ. **72**(2), 388–412 (2021). https://doi.org/10.1111/1477-9552.12408
Teixeira, A., Gabriel, R., Martinho, J., Santos, M., Faria, A., Oliveira, I., Moreira, H.: Pro-environmental behaviors: relationship with nature visits, connectedness to nature and physical activity. Am. J. Health Promot. **37**(1), 12–29 (2023). https://doi.org/10.1177/08901171221119089
Tsunoda, K., Soma, Y., Kitano, N., Jindo, T., Fujii, K., Okura, T.: Acceptable walking and cycling distances and their correlates among older Japanese adults. J. Popul. Ageing **14**(2), 183–200 (2021). https://doi.org/10.1007/s12062-020-09272-9
Ünal, A.B., Steg, L., Gorsira, M.: Values versus environmental knowledge as triggers of a process of activation of personal norms for eco-driving. Environ. Behav. **50**(10), 1092–1118 (2018). https://doi.org/10.1177/0013916517728991
Venghaus, S., Henseleit, M., Belka, M.: The impact of climate change awareness on behavioral changes in Germany: changing minds or changing behavior? Energy. Sustain. Soc. **12**(1), 1–11 (2022). https://doi.org/10.1186/s13705-022-00334-8
Wang, L., Wong, P.P.W., Narayanan Alagas, E.: Antecedents of green purchase behaviour: an examination of altruism and environmental knowledge. Int. J. Cult. Tour. Hosp. Res. **14**(1), 63–82 (2020). https://doi.org/10.1108/IJCTHR-02-2019-0034
Wemegah, C.S., Yamba, E.I., Quansah, E., Nyantakyi, E.K., Amekudzi, L.K.: Evidence of heatwaves: characteristics and trends in selected ghanaian cities. Int. J. Climatol. **21**, 1–17 (2025)
Xu, L., Yang, H., Ling, M.: Interpersonal contextual influences on the relationship between values and pro-environmental behaviors. Sustain. Prod. Consum. **32**, 532–540 (2022). https://doi.org/10.1016/j.spc.2022.05.012

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