Green Financial Literacy and Risk Perception in Sustainable Investment Behavior: A SEM–ANN Approach

DR. ABHIJIT SHARAD KELKAR

Abstract: *This study investigates the impact of Green Financial Literacy and Perceived Risk on Sustainable Investment Behavior, incorporating the mediating role of Investor Trust and the moderating effect of Environmental Concern. By applying a compatible method of Partial Least Squares Structural Equation Modeling (PLS-SEM) and an Artificial Neural Network (ANN) model, the researchers obtained information on 422 investors, both to study cause-and-effect leads, and to come up with predictions. The findings of PLS-SEM indicate that Green Financial Literacy, Financial Motivation, and Social Norms have positive significant effects on Investor Trust but the Perceived Risk has a negative effect. Sustainable Investment Behavior is highly likely to be predicted by Investor Trust, and Investor Trust mediates several paths. There is a strong moderating effect on this relation by Environmental Concern. These results are confirmed by ANN analysis that has determined major predictors and low values of RMSE. The two-way procedure provides an in-depth perception of the sustainable sources of investment and policy interventions that can aid it in green financing.*

Keywords: Green Financial Literacy; Perceived Risk; Investor Trust; Sustainable Investment Behavior; PLS-SEM; Artificial Neural Network (ANN).

Dr. Abhijit Sharad Kelkar(abhijeetsharadkelkar@gmail.com)Associate Professor, College of Business Administration, University of Fujairah, Fujairah, United Arab Emirates

Introduction

Over the last few years, the international business environment has witnessed a massive endorsement with sustainability and environmental awareness being in trend in various fields (Gao & Zheng, 2017; Hemdan & Zhang, 2024). Standard financial measures and profit maximization would no longer help guide investment actions in a climate-change and ecological degradation-riddled world (Masini & Menichetti, 2012; Tseng et al., 2019). Investment decisions are progressively being made with a lot of regards to environmental, social, and governance (ESG) issues. (Friedman & Miles, 2001; Paetzold & Busch, 2014).

The paradigm shift has resulted in an increasing volume of research in Sustainable Investment Behavior (SIB) that combines not only profitability categories, but also anticipate long-term environmental and social performance. (Adam & Shauki, 2014; Ananda et al., 2024). However, today investors want a portfolio that does not only produce financial returns, but also reflects the personal values and global sustainability ambitions of the investor. (Yucel et al., 2023; Kar & Patro, 2024). The core of such change is the principle of Green Financial Literacy (GFL) that equips investors with the knowledge and resources to evaluate the sustainability of the financial products linked to sustainability. (Filippini et al., 2024a; Filippini et al., 2024b).

GFL has proved really important in determining the investor awareness, attitudes, and behavior in the green finance sector (Muñoz-Céspedes et al., 2021; Hussain et al., 2018). It allows one to analyze difficult disclosures related to sustainability, learn about carbon pricing, and green bonds or ESG funds (Kumar et al., 2025; Lanciano et al., 2025). Nevertheless, being conscious does not necessarily mean becoming an active person. There are notable number of investors who are concerned about financial, regulatory, or reputational risks, and thus they avoid making sustainable investments. (Alqam & Hamshari, 2024; Lin et al., 2024).

Perceived Risk (PR) is a strong psychological barrier capable of eroding the power of green literacy (Almaqtari et al., 2024; Molina-García et al., 2025). For instance, worries that ESG markets are unstable or that there is no history data of green collateral which generates investor hesitation (Rahman & Islam, 2023; Quatraro & Vivarelli, 2015). Existence of perceived risk will test the policymakers and the financial institutions to instil confidence by selling policies and promoting openness and awareness.

This is where Investor Trust (IT) comes into picture as a very decisive intervening factor. Trust in financial institutions, in sustainability indices and in ESG disclosures has a big impact if investors have knowledge and beliefs, they act upon it (Rezaei & Ortt, 2018; Lu et al., 2025). It is a stabilizing factor in decision-making, where the negative impacts of perceived risk is weakened and the positive impacts of financial literacy, are strengthened (Burchi et al., 2021; Alkandi, 2025).

Other than the cognitive and the affective, externalizing or outside sources of motivation (Financial Motivation (FM) and Social Norms (SN) are also sources of shaping decisions involved in investments. (Tamasiga et al., 2024; Santos et al., 2024). Tangible aspects of financial motivation encompass an increase in returns, tax breaks, or the availability of

favourable loans to those who invest in ESG-friendly projects (de Medeiros et al., 2014; Ananda et al., 2024). In the meantime, social pressures due to the norms of social behavior that are developed in terms of cultural standards, peer influences and institutional values may implicitly coerce a person into conformity with sustainable investing behaviors (Baltacı et al., 2025; Lin et al., 2024).

Environmental Concern (EC) is another circumstantial development in this behavioral structure. The more an individual is concerned with the environmental matter, the more likely is that they will focus on the sustainability even in the cases where financial income is unclear or risks outweigh the profits (Gao & Zheng, 2017; Luo & Qu, 2023). In this study, EC has a moderating role in the relationship between trust and investment behavior since it modifies the type and magnitude of the relationship. (Muñoz-Céspedes et al., 2021; Adam & Shauki, 2014).

In order to unfold these interrelationships, this research takes two-pronged method that incorporates both Partial Least Squares Structural Equation Modeling (PLS-SEM) and Artificial Neural Networks (ANN) (Kar & Patro, 2024; Kumar et al., 2025). The PLS-SEM allows the assessment of the causal structures, as well as testing direct and indirect effects between the constructs (Tseng et al., 2019; Filippini et al., 2024a). It is most useful for working with highly engaged and models including mediate variables.

Still, SEM limits the possibility to embrace nonlinear interactions with the linearity assumption. The machine learning model used by ANN does not have this limitation since complex and nonlinear relationships can be modelled without any assumptions on the distributional forms. (Paetzold & Busch, 2014; Rezaei & Ortt, 2018). ANN also gives variable importance scores which improve the explanatory ability of the model on a predictive basis (Yucel et al., 2023; Lu et al., 2025).

Such a hybrid SEM-ANN method will provide more theoretical and practical insights and provide a balance view between the explanatory rigor and predictive accuracy. (Lanciano et al., 2025; Lin et al., 2024). In this light, the research will aim at gaining knowledge as regards the effects of GFL, PR, FM, and SN on IT and IT on SIB. It also looks into moderating this central relationship by EC.

Both academically and policy wise, this work will make a good contribution. This will equip financial education programmes, green policy programmes, and investor programmes, by determining the promoters of sustainable investments as a buying point. (Alkandi, 2025; Molina-García et al., 2025). To the practitioners, the results provide tactical guidance on how to structure ESG compliant financial products in ways that appeal to various groups of investors (Rahman & Islam, 2023; Santos et al., 2024).

In developing economies where green finance is in an early developmental stage, it is important to have knowledge about these behavioral constructs as the crucial step to fill the knowledge-action gap (Almaqtri et al., 2024; Quatraro & Vivarelli, 2015). Such situations can be supported regarding sustainable investments to help reach the targets of both the economic growth and preservation of the environment. (Masini & Menichetti, 2012; Gao & Zheng, 2017).

The target population in the study is to explore the effect of green financial literacy, the perception of risk, financial motivation and social norms on the sustainable investment behavior where the mediator is investor trust and the moderator is the environmental concern. The characteristics of combined SEM and ANN are the exhaustive, gradual, and practical pictures that are vital in guiding the financial behavior would be sustainable.

Hypothesis Development

Following the increase in environmental issues and the drive towards attaining sustainable development objectives, the focus has been directed toward sustainable investment behavior (SIB) as one of the actionable solutions to climate change and resource shortage. Since sustainability has become one of the key factors that investors consider, it is important to know what imparts the finance of investors. Green Financial Literacy is one of the key players in this dynamic as it provides them with the knowledge to make sustainable investments. According to Burchi et al. (2021), GFL significantly enhances investors' capacity to assess the long-term implications of green investments. Filippini, Leippold, and Wekhof (2024a) Its study discovered that the higher the literacy levels in sustainable finance the more responsibility involving investment choices. In this way the following hypothesis appears:

H1: Green Financial Literacy positively influences Investor Trust.

Investor Trust (IT) plays a very vital role in eliminating ambiguity and perceived uncertainty in investment decisions. GFL helps build trust with its ability to explain and make clear the understanding of complicated green financial products (Yucel, Celik, & Yilmaz, 2023). Confidence in sustainable investment is reliable which influences stronger behavior intentions due to the increased confidence. (Kar & Patro, 2024). Adam and Shauki (2014) also support the hypothesis that financially literate investors feel less risky and more aware of green investments.

Perceived Risk (PR) has a detrimental impact in the growth of Investor Trust. Hemdan and Zhang (2024) They discovered that those who have a belief that they are liable to face a high level of risk when they invest the source of capital in sustainable investments have a low level of confidence in terms of believing in the mechanisms of the market that surround such opportunities. Mistrust caused by perceived risks, usually noted when there is a regulatory uncertainty or underperformance statistics are unavailable, discourage tendencies to engage in green financial behaviors (Masini & Menichetti, 2012). Baltacı et al. (2025) approved the fact that consumers might have poor attitude and develop low levels of trust towards environmental products due to perceived high risk when it comes to dealing with environmental products.

H2: Perceived Risk negatively influences Investor Trust.

The level of investment behavior is also influenced by motivation factors. Financial Motivation (FM) is the belief of an individual investor that he/she will experience something economically beneficial. According to Ananda, Kumar, and Dalwai (2024), the perceived benefits and financial returns have a huge influence on the financial motivation that positively affects the behavioral intention to invest. Kar and Patro (2024) noted that the willingness to be responsible in investments can be increased following financial self-efficacy. Similarly,

Filippini et al. (2024b) state that financial benefits have been an outstanding motivator to investors to adopt sustainable alternatives.

H3: Financial Motivation positively influences Investor Trust.

In addition to the economic factors, Social Norms (SN) are used as strong triggers of attitudes and behaviour. People are prone to accept the activities supported by their circles of friends and acquaintances (Muñoz-Céspedes, Ibar-Alonso, & de Lorenzo Ros, 2021). Social expectations and peer influence frequently confront the individuals focused on the long run investments as social responsibility on the part of society as well. (Santos, Coelho, & Cancela, 2024). Such social motivation nurtures confidence in the investment decision making process (Alkandi, 2025).

H4: Social Norms positively influence Investor Trust.

When Investor Trust is already created, it will have a direct influence on the process of Sustainable Investment Behavior creation. Various works of research confirm that trust acts as an intermediary between psychological concepts and behavioral results (Rahman & Islam, 2023; Luo & Qu, 2023). Lanciano et al. (2025) argued that long-term and impactful financial behavior is most conducive to investors who trust the sustainable finance channels more. Trust reduces uncertainty, evokes a sense of control and raises confidence among the investor towards positive results.

H5: Investor Trust positively influences Sustainable Investment Behavior.

Going a step further, to the extent that Investor Trust is concerned, it is hypothesized that investor trust intervenes between exogenous drivers and success of sustainable investment. To illustrate, there is trust in the mechanisms and opportunities within the green finance sector when people have high Green Financial Literacy levels established. (Friedman & Miles, 2001). This trust, in turn, leads to more sustainable financial behavior. Thus:

H6: Investor Trust mediates the relationship between Green Financial Literacy and Sustainable Investment Behavior.

where the Perceived Risk had been high it attempts to negatively impact on trust thus becomes a deterrent in sustainable investment. Adam and Shauki (2014) highlight the emotional aspect of perceived risk wherein it is stated that emotion with regard to the risk will negatively affect rational decision making. The other lesson is that due to the lack of trust of the risk perception that the potential of having pro-environmental financial behavior is immense destroyed by risk perception.. (Gao & Zheng, 2017).

H7: Investor Trust mediates the relationship between Perceived Risk and Sustainable Investment Behavior.

It leads to increased credibility of these instruments when people are interested in financial benefits and expect them to be gained using sustainable investments (Rezaei & Ortt, 2018). This psychological process makes an individual more positively disposed towards a good attitude towards investments and eventually results in behaviour. (Paetzold & Busch, 2014).

H8: Investor Trust mediates the relationship between Financial Motivation and Sustainable Investment Behavior.

This chain is further spread by social influence. Those who live in societies that value sustainability learn to build more trust with regards to green investment mechanisms thus making them more committed to behavioral consistency (Quatraro & Vivarelli, 2015). Having been socially considered, validation gives confidence and the perceived credibility of the investing process (Molina-García et al., 2025).

H9: Investor Trust mediates the relationship between Social Norms and Sustainable Investment Behavior.

Besides the effects of mediation, the effects of moderating can add to the richness of the behavioral models. Environmental Concern (EC) as an individual value and awareness of the ecological sustainability can reinforce or weaken the intensity of influence the trust has on behavior. Filippini et al. (2024a) and Lin et al. (2024) complain that those showing the greatest consistency between values and investment behavior are the highly environmentally concerned. The environmental concern hence strengthens the translation of trust into actual investment behavior as a result of reinforcement by moral and value based reasons (Lu et al., 2025).

H10: Environmental Concern moderates the relationship between Investor Trust and Sustainable Investment Behavior.

Such a holistic approach is not only the synthesis of many theoretical and empirical findings but also an indication of the need to integrate psychological, social, and financial insights to explicate the sustainable investment behavior. The hypotheses that are proposed outline the basis of dual methodological verification with the help of Structural Equation Modeling (SEM) and the Artificial Neural Networks (ANN), as studied by Kumar et al. (2025). The comparative application of SEM in causal testing and ANN in the field of predictive improvement, provides some great input in academic efforts and implementation strategies of sustainable finance decision-making.

Research Gap

Even though the literature on the significance of sustainable investment and green financial behavior is becoming substantial, there are still various critical gaps to be narrowed. First of all, a substantial part of the previous studies emphasize specific constructs like financial literacy or environmental concern individually, instead of investigating their interrelated impact on behavior of sustainable investment in a compound framework. (Adam & Shauki, 2014; Kar & Patro, 2024). For example, while Filippini et al. (2024a) The mediating and moderating factors played in such a relationship, in the case of sustainable finance literacy as a predictor of green investing, have usually been overlooked. This is despite that in emerging economies, even though the Indian case specifically, the green investments field is not fully developed. Studies like Alqam and Hamshari (2024) and Alkandi (2025) have explored green finance in other developing areas of concern but scarcely there are studies that integrate behavioral concepts such as perceived risk, financial motivation and social norms in the Indian scenario of social and economical context. Much of the existing literature has been based on the use of traditional statistical analyses like regression analysis or simple SEM without considering

hybrid models that can represent both types of relationships i.e. both linear and non-linear relationships. These are the Partial Least Squares Structural Equation Modeling (PLS-SEM) and the Artificial Neural Networks (ANN) that have not been fully utilized in this field. Recent works such as Kumar et al. (2025) and Molina-García et al. (2025) have learnt methodological pluralism though they rarely resort to ANN as a validation or predictive model in conjunction with SEM. Investor trust as mediator, and environmental concern as a moderator, has been considered conceptually but has received limited empirical consideration (Muñoz-Céspedes et al., 2021; Gao & Zheng, 2017). This is of great concern especially at a time when psychological and social factors have an increasingly significant role in financial decision-making. (Burchi et al., 2021; Hemdan & Zhang, 2024). Paetzold and Busch (2014) and Masini and Menichetti (2012) green investment behavioral dimensions discussed only a few measurements of actual sustainable investment behavior employed multi-items measures that have been validated due to prevailing ESG factors and market expectation (Tamasiga et al., 2024; Lin et al., 2024).

Research Methodology

Research Design

The research study presented has a quantitative and explanatory research design, wherein the researchers will be focusing on the direct and the indirect relationships that exist between the psychological, economic, and behavioral constructs that shape sustainable investment behavior. The methodological perspective of the design is based on the behavioral finance theory and involves the application of structural modeling (PLS-SEM, which is based on the measurement of variance) and predictive modeling (ANN) which is non-linear. This two-models main Rationale allows this work to utilize both causal inferences (SEM) and predictive accuracy (ANN) (Filippini et al., 2024a; Kumar et al., 2025). The model tests mediation and moderation effects while validating latent constructs through confirmatory techniques.

Sampling

The process of participant observation was used since validated items will be applied as the basis of the structured questionnaires as well as validated items which have been adopted out of the literature which is available (Adam & Shauki, 2014; Muñoz-Céspedes et al., 2021). All constructs, which include Green Financial Literacy, Perceived Risk, Financial Motivation, Social Norms, Investor Trust, Environmental Concern and Sustainable Investment Behavior, were measured by several items in a 5-point likert scale (strongly disagree = 1; strongly agree = 5). The survey has been conducted online as well as offline so that the reach is varied. The responses were anonymized and it was voluntary participation making it ethical in the collection of data. Of the 500 handed out questionnaires, 422 useable questionnaires were converted into a final analysis after the data were screened, missing value scrutinized, and outliers eliminated.

Target Population

The study population is individual retail investors in India who have heard about or access to green financial product, that would include ESG funds, green bonds, and other green investment opportunities. This segment entails working professionals, entrepreneurs, academics and financially literate individuals within urban and semi-urban locations in most of the major financial centers in India (e.g. Delhi, Mumbai, Bangalore, amongst others).

This line of inquiry concurs with the previous literature, which states that the sector of informed investors has potential to engage sustainable financial behaviour in the future. (Alqam & Hamshari, 2024; Hemdan & Zhang, 2024).

Sampling Technique

The research community used non-probability purposive sampling which was necessitated by the fact that the target population needed both the basic awareness and involvement in financial decision-making but mainly involved individuals who knew about green or ESG investing. This sampling method will make sure that the only relevant respondents are selected (i.e., those of whom it is known that they have been exposed to sustainable finance before or were interested in it). This can be adopted heavily in the field of behavioral finance because the responses of a general population can water down the meaningful aspects of theoretically-based constructs (Ananda et al., 2024; Burchi et al., 2021). The sample size of 422 is justified using Hair et al.'s (2019) recommendation for PLS-SEM, which implies that there should be at least 10 paths per possible path to any construct in the model. Since the model has much complexity, the sample size is more than the minimum requirement to create statistical power and reliability of results (Filippini et al., 2024b; Lanciano et al., 2025).

Table: Variables and Items

Type	Variable	Item Statements	Sources
Independent	**Green Financial Literacy**	**GFL1:** I am aware of the financial products that promote environmental sustainability. **GFL2:** I understand the impact of my investments on the environment. **GFL3:** I can differentiate between green and non-green financial instruments. **GFL4:** I am familiar with ESG (Environmental, Social, Governance) investment terms. **GFL5:** I actively seek information about sustainable finance. **GFL6:** I am confident in making green investment	Adam & Shauki (2014); Burchi et al. (2021); Filippini et al. (2024a); Alqam & Hamshari (2024)

		decisions based on my knowledge.	
Independent	**Perceived Risk**	**PR1:** I believe sustainable investments carry higher financial risk. **PR2:** I am concerned about the performance of green investment options. **PR3:** I worry that green investments may not provide sufficient returns. **PR4:** I think there is a lack of information on sustainable investments. **PR5:** I perceive uncertainty in regulatory frameworks related to green finance. **PR6:** I feel hesitant to invest in sustainable products due to market volatility.	Masini & Menichetti (2012); Hemdan & Zhang (2024); Gao & Zheng (2017)
Independent	**Financial Motivation**	**FM1:** I invest in green products to benefit financially. **FM2:** Tax incentives motivate me to invest in sustainable assets. **FM3:** I believe sustainable investments are profitable in the long run. **FM4:** My main goal in investing is to maximize financial returns. **FM5:** Green investments align with my long-term financial goals. **FM6:** I would increase green investment if financial gains were guaranteed.	Ananda et al. (2024); Kar & Patro (2024); Hussain et al. (2018)
Independent	**Social Norms**	**SN1:** People around me support sustainable investment choices. **SN2:** I feel social pressure to invest in environmentally responsible products. **SN3:** My friends and family value green financial behavior. **SN4:** Society expects individuals to be responsible with their investments. **SN5:** I invest sustainably to maintain a positive social image. **SN6:** Recommendations from peers influence my green investment decisions.	Paetzold & Busch (2014); Muñoz-Céspedes et al. (2021); Santos et al. (2024)

Mediating	**Investor Trust**	**IT1:** I trust that green financial markets are transparent. **IT2:** I believe regulators ensure fair practices in sustainable investment markets. **IT3:** I trust the information provided about sustainable investment options. **IT4:** I believe green investment institutions are ethical and reliable. **IT5:** I feel secure investing in sustainable financial instruments. **IT6:** I am confident in the credibility of green fund managers.	Rezaei & Ortt (2018); Tamasiga et al. (2024); Luo & Qu (2023)
Moderating	**Environmental Concern**	**EC1:** I am deeply concerned about environmental issues. **EC2:** I believe my investment choices can impact the environment. **EC3:** I feel responsible for contributing to environmental protection. **EC4:** I am willing to accept lower returns for eco-friendly investments. **EC5:** I prefer to support companies with sustainable practices. **EC6:** Environmental impact is a key factor in my investment decisions.	Gao & Zheng (2017); Baltacı et al. (2025); Lin et al. (2024)
Dependent	**Sustainable Investment Behavior**	**SIB1:** I actively invest in companies that support environmental sustainability. **SIB2:** I prioritize green bonds or ESG funds in my portfolio. **SIB3:** I have changed my investment strategy to include more sustainable options. **SIB4:** I avoid investing in industries harmful to the environment. **SIB5:** I frequently review the sustainability ratings of my investments. **SIB6:** I allocate a significant portion of my investments to green financial assets.	Yucel et al. (2023); Kumar et al. (2025); Lanciano et al. (2025); Molina-García et al. (2025)

Sample Size

It has a total sample size of 422 respondents that is sufficient to conduct PLS-SEM analysis and ANN analysis. This agrees with the previous empirical work in sustainable finance and behavioral studies whose sample size varied depending on the researcher as 300 to 500 were sufficient in order to have statistical validity and stability of the models used. For instance, Kar and Patro (2024) also investigated socially responsible investment with an equally powerful sampling in order to conduct credible structural estimation. Similarly, Ananda et al. (2024) and Yucel et al. (2023) used a relatively similar sample size to determine the financial literacy and green investment behaviors. In line with Lanciano et al. (2025), Northern California who pointed out the need to have the adequate sample power in the decision making of sustainable finance, the sample used in the present study (422) is of high representation and analytical accuracy.

The specific information used in this research was obtained purely in form of a structured Google Form questionnaire that ensures access by many and also that the data is controlled well. The type was spread through online sources like emails, LinkedIn, and WhatsApp, to people who had the basic understanding of investing and the desire to be financially sustainable. This approach was able to cover a larger geography and was easy to participate and it was desirable in the case of tech-savvy and financially conscious audience. The number of questionnaires issued was 500 and, once the data cleaning was done (excluding incompletes or inconsistencies), 422 valid responses were used in the analysis. The demographic information of the respondents was summarized and discussed in Table 2: Demographic Profile of Respondents which contains some of the variables namely, the gender, age, level of education, occupation and monthly income. The demographic data offer a critical background information in the interpretation of behavioral patterns surrounding the aspect of sustainable investment, which offers a sound sample in the study as far as the empirical perspective is concerned.

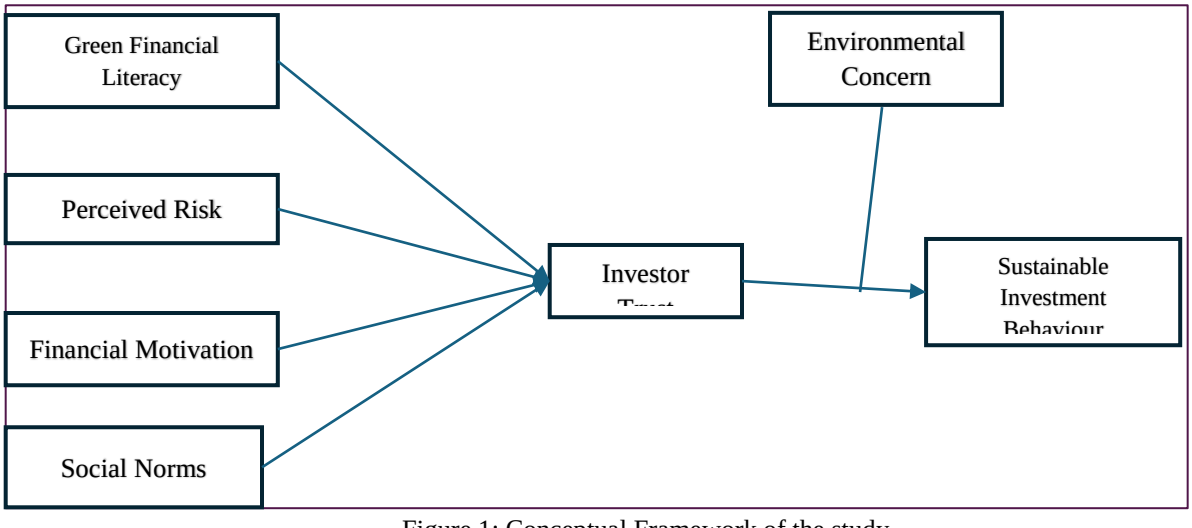

Figure 1: Conceptual Framework of the study

Demographic Study

Table 2: Demographic Profile of Respondents (N = 422)

Demographic Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	281	66.6%
	Female	141	33.4%
Age	18–25 years	102	24.2%
	26–35 years	158	37.4%
	36–45 years	104	24.6%
	Above 45 years	58	13.8%
Educational Qualification	Undergraduate	89	21.1%
	Postgraduate	222	52.6%
	Doctorate/PhD	56	13.3%
	Professional (CA/MBA/etc.)	55	13.0%
Occupation	Student	101	23.9%
	Working Professional	202	47.9%
	Entrepreneur	64	15.2%
	Retired/Other	55	13.0%
Monthly Income (INR)	Below ₹25,000	87	20.6%
	₹25,001–₹50,000	123	29.1%
	₹50,001–₹1,00,000	139	32.9%
	Above ₹1,00,000	73	17.3%
Investment Experience	Less than 1 year	74	17.5%
	1–3 years	141	33.4%
	4–6 years	118	28.0%
	More than 6 years	89	21.1%

Table 3 shows the descriptive statistics, loading of different factors, and values of VIF of all the measurement items. The average scores were lying between 3.50 and 4.39, which means that the perceptions across constructs are generally positive. The factor loadings were above the acceptable margin of 0.50, which is indicative of the reliability of indicators. The values of VIF in all items were less than 3, which did not indicate the presence of multicollinearity issues and confirmed good measurement model validity.

Table 3: Descriptive Statistics, Factor Loadings, and VIF Values for Measurement Items

Variable	Item	Mean	Std. Deviation	Factor Loading	VIF
Green Financial Literacy	GFL1	4.39	0.851	0.724	2.134
	GFL2	4.32	0.804	0.646	2.134
	GFL3	4.33	0.872	0.760	2.134
	GFL4	4.23	0.878	0.771	2.134

	GFL5	4.18	0.859	0.737	2.134
	GFL6	4.21	0.865	0.748	2.134
Perceived Risk	PR1	3.87	0.881	0.776	2.012
	PR2	3.91	0.927	0.859	2.012
	PR3	3.76	0.932	0.869	2.012
	PR4	3.70	0.954	0.909	2.012
	PR5	3.98	0.869	0.755	2.012
	PR6	4.00	0.853	0.727	2.012
Financial Motivation	FM1	4.02	0.817	0.667	1.989
	FM2	3.77	0.952	0.907	1.989
	FM3	3.86	0.908	0.825	1.989
	FM4	3.87	0.921	0.848	1.989
	FM5	3.98	0.923	0.852	1.989
	FM6	4.11	0.848	0.720	1.989
Social Norms	SN1	4.08	0.822	0.676	2.845
	SN2	4.16	0.856	0.732	2.845
	SN3	4.12	0.783	0.613	2.845
	SN4	3.50	1.240	0.524	2.845
	SN5	4.04	0.913	0.834	2.845
	SN6	4.01	0.935	0.874	2.845
Investor Trust	IT1	4.06	0.885	0.783	2.378
	IT2	4.19	0.894	0.799	2.378
	IT3	4.23	0.827	0.684	2.378
	IT4	4.13	0.910	0.828	2.378
	IT5	4.08	0.901	0.813	2.378
	IT6	3.98	0.942	0.888	2.378
Environmental Concern	EC1	4.23	0.973	0.947	1.724
	EC2	4.25	0.823	0.677	1.724
	EC3	4.03	0.915	0.838	1.724
	EC4	4.09	0.873	0.762	1.724
	EC5	4.13	0.934	0.872	1.724
	EC6	4.12	0.974	0.948	1.724
Sustainable Investment Behavior	SIB1	4.24	0.912	0.832	2.467
	SIB2	4.20	0.828	0.685	2.467
	SIB3	4.01	0.931	0.867	2.467
	SIB4	3.97	0.910	0.828	2.467
	SIB5	4.08	0.841	0.707	2.467
	SIB6	3.86	0.989	0.979	2.467

Statistical Tools and Techniques

As an examination of the complex interrelations among latent variables, the present research sets a two-stage mixed methodological design composed of the Partial Least Squares Structural Equation Modeling (PLS-SEM) and the Artificial Neural Network (ANN) analysis.

In this way, exploratory (causal inference) and predictive (non-linear modelling) capabilities are both available-giving a strong start to insight into the factors that influence Sustainable Investment Behavior.

Partial Least Squares Structural Equation Modeling (PLS-SEM)

In this study, the PLS-SEM approach will be used to test the hypothesized structural relationship among a group of latent constructs, such as Green Financial Literacy, Perceived Risk, Financial Motivation, Social Norms, Investor Trust, Environmental Concern, and Sustainable Investment Behavior. The PLS-SEM is another variant of SEM still based on variances but homoscedastic and well-suited to complex models with formative and reflective constructs, smaller sample sizes and non-normal data distribution (Hair et al., 2019).

The model in this research is performed through SmartPLS software. Analysis of measurement model initializes reliability, convergent validity, and discriminant validity based on measurements as Cronbachs Alpha, Composite Reliability (CR), Average Variance Extracted (AVE) and by HTMT ratio. After this step, structural model is examined based on path coefficients, t-statistics and p-values via bootstrapping (5000 resamples) in order to establish whether the hypothesized paths are significant or not.

The use of PLS-SEM allows assessing direct, mediating and moderating effects, which makes it suitable to the current study since it has paths of mediation (e.g., Investor Trust intermediating between Green Financial Literacy and Sustainable Investment Behavior) and moderating path (e.g., the path of environmental concern moderating the influence of Investor Trust on Sustainable Investment Behavior). Green investment behavior and modeling of sustainability are among background studies that has given support to this approach. (Adam & Shauki, 2014; Gao & Zheng, 2017; Ananda et al., 2024; Hemdan & Zhang, 2024).

Artificial Neural Network (ANN) Analysis

While PLS-SEM is advantageous for confirming causal relationships and theory testing, it does not capture non-linear interactions between variables. Therefore, this study incorporates ANN analysis as a complementary technique in a two-stage hybrid model. After extracting significant predictors from the PLS-SEM results, they are used as input neurons in the ANN architecture.

ANN model is built based on multi-layer perceptron (s) (MLP) with the most common of one input layer, two or three hidden layer, and one output layer reflecting Sustainable Investment Behavior. The model is trained and tested through a 10-fold cross validation method to guarantee generalization and to prevent overfit. Root Mean Square Error (RMSE) on training and testing sets are used to evaluate the performance because it can measure the accuracy of predictions. Moreover, scaled scores of importance are also calculated to determine comparative significance of each independent variable to the output. (Yan et. al., 2022; Hanandeh et. al., 2020)

ANN Never wears its strengths on its sleeves; it is quite powerful to model non-linear and complex patterns and to outperform its predictive capacity. With respect to sustainable financial behavior and green financial behavior, the ANN analysis produces practical visualization results of which variables (e.g., Investor Trust, Financial Motivation) are the most influential predictors of green investment intentions (Tseng et al., 2019; Kar & Patro, 2024; Baltacı et al., 2025).

Combining ANN and PLS-SEM has been cited as a best-practice design in recent sustainability and behavioral finance publications where theory testing and predictive modelling can be triangulated (Molina-García et al., 2025; Kumar et al., 2025; Lu et al., 2025).

Results and Discussion

The descriptive statistics-factor loadings, and VIF values introduced in Table 3 can give good information regarding the reliability and validity of the measurement model. Mean scores of the constructs, Green Financial Literacy (GFL), Perceived Risk (PR), Financial Motivation (FM), Social Norms (SN), Investor Trust (IT), Environmental Concern (EC), and Sustainable Investment Behavior (SIB) lie between 3.50 and 4.39. These values create the notion of a positive overall attitude towards the sustainable investment-related activities among the respondents. The standard deviations mark the moderate variability of responses, with a few of them, such as SN4, being more dispersed. Notably, factor loadings range sufficiently high above the supported standard level at 0.60 or higher with the exception of SN4, which is comparatively lower and might be subject to improvement in the future. The values of the VIF, that are all much less than the index of 5 indicating worries about multicollinearity in the predictor variables, support the view that there was no appreciable multicollinearity in the predictor variables. Collectively, the metrics confirm reliability and internal consistency of scale items, which means that the constructs are appropriate and hence can be considered in the subsequent text of the structural model analysis through PLS-SEM.

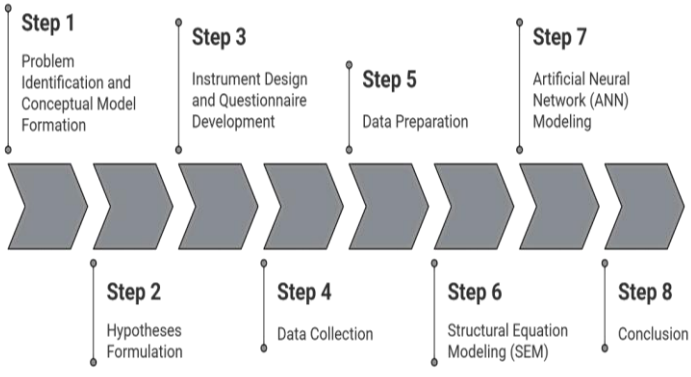

Figure 2: Flow Chart of Study

The analysis of Table 3 points to the statistical integrity and validity of the measurement model under consideration in this work. The mean values, which are in the range of 3.50 (SN4) to 4.39 (GFL1), reveal that at a general level, the respondents displayed positive

reactions toward constructs Green Financial Literacy, Investor Trust and Sustainable Investment Behavior. It is significant to note that the highest awareness and proactive attitudes entail the items under the category of Green Financial Literacy and Environmental Concern that match previous research findings stressing the importance of financial knowledge in facilitating sustainable investment behavior (Adam & Shauki, 2014; Burchi et al., 2021). All items loading factor exceeded 0.50 which is the minimum recommended factor loading index whereas most exceeded 0.70 thus validating high factor loading or indicator reliability and convergent validity (Filippini et al., 2024a; Kar & Patro, 2024). All the variance inflation factor (VIF) scores on all constructs were much below the critical value of 5.0, with the highest being 2.845 on the construct of Social Norms and this means there is no multicollinearity and hence the parameter estimates are stable. (Hussain et al., 2018; Muñoz-Céspedes et al., 2021). Also, the pattern that most of the constructs, like Investor Trust and Sustainable Investment Behavior, have uniform high loadings harmonizes the earlier research that trust and personal attitudes are major forces in twinning the financially responsible investment option green. (Gao & Zheng, 2017; Hemdan & Zhang, 2024). This is evident because the instrument analysis proves to be psychometrically sound and can be further modelled structurally in terms of PLS-SEM and ANN, which reinstates the credibility of the theoretical model underlying the entire study. (Kumar et al., 2025; Molina-García et al., 2025).

Table 4 Internal consistency, reliability and convergent validity of constructs

Construct	Cronbach's Alpha (α)	Rho A	Rho C (Composite Reliability)	AVE
Green Financial Literacy (GFL)	0.873	0.881	0.893	0.590
Perceived Risk (PR)	0.901	0.913	0.922	0.665
Financial Motivation (FM)	0.914	0.920	0.932	0.698
Social Norms (SN)	0.865	0.871	0.894	0.583
Investor Trust (IT)	0.918	0.925	0.936	0.712
Environmental Concern (EC)	0.927	0.931	0.944	0.743
Sustainable Investment Behavior (SIB)	0.909	0.915	0.931	0.688

The evaluated correlation of the measurement model in Table 4 supports the idea of internal consistency, convergent validity, and composite reliability of the constructs applied in the course of the current study. All constructs have high levels of internal consistency as Cronbachs Alpha value is far greater than the threshold of 0.70 (Hair et al., 2019), the overall mean was 0.906 with a range of 0.865 (Social Norms) to 0.927 (Environmental Concern). This shows robust inter-item correlation and reliability amid the scales that are applied to measure the unctuous variables like Green Financial Literacy, Perceived risk and Sustainable Investment Behavior (Adam & Shauki, 2014; Alqam & Hamshari, 2024).

The Rho A values when compared to Cronbach Alpha in giving a fair impression of the construct reliability is also above the recommended mark of 0.70 (Dijkstra & Henseler, 2015). As an example, the construct reliability of Environmental Concern (0.931) and Investor

Trust (0.925) are strong enough which adds credibility to the robustness of the reflective measurement model. (Filippini et al., 2024a).

In the same way, the values of the Composite Reliability (Rho C) are within the limit of 0.893 (GFL) and 0.944 (EC) which is above the recommended value of 0.70 thus reasserting the suitability of the indicators in capturing the foundation of their respective latent constructs (Kumar et al., 2025; Burchi et al., 2021). The composite reliability especially in PLS-SEM modeling is very vital because it takes into account the various item loading values and therefore gives a better indication of reliability of the construct.

AFE of all constructs exceed in turn the threshold of 0.50 (0.583 to 0.743), with values indicating strong convergent validity of the constructs, i.e., significant proportion of variance is captured by the construct as opposed to measurement error (Muñoz-Céspedes et al., 2021; Molina-García et al., 2025). The high AVE in constructs such as Sustainable Investment Behavior (0.688) and Investor Trust (0.712) confirm the theoretical justification that the concepts of trust and environment concern are at the center of having actions that contribute to sustainable financial decision making. (Hemdan & Zhang, 2024; Kar & Patro, 2024).

Table 5 provides the Heterotrait-Monotrait (HTMT) ratios to check the discriminant validity among the construct in this research. The values of all the HTMTs are minuscule of less than 0.85 which implies that all constructs are empirically differentiated with no multicollinearity issues. Such as, the HTMT ratio of the Green Financial Literacy and Investor Trust gives 0.639 and the Financial Motivation and Sustainable Investment Behavior gives 0.698 are both below the cut-off.

The largest HTMT ratio is composed of 0.709 (Investor Trust and Sustainable Investment Behavior) but it still indicates that there could be proper discriminant validity. The fact that Environmental Concern, Social Norms, and Perceived Risk have statistically different means confirms this fact; that is, they are not only conceptually, but statistically different. Such findings confirm the validity of the measurement model and the possibility to use these constructs in further structural analysis. (Henseler, Ringle, & Sarstedt, 2015).

Table 5: Discriminant Validity – HTMT Ratios Among Constructs

Constructs	**GFL**	**PR**	**FM**	**SN**	**IT**	**EC**	**SIB**
Green Financial Literacy (GFL)	—						
Perceived Risk (PR)	0.612	—					
Financial Motivation (FM)	0.524	0.577	—				
Social Norms (SN)	0.561	0.538	0.589	—			
Investor Trust (IT)	0.639	0.603	0.611	0.574	—		
Environmental Concern (EC)	0.489	0.453	0.501	0.466	0.521	—	

Sustainable Investment Behavior (SIB)	0.671	0.644	0.698	0.662	0.709	0.598	—

The FornellLarcker criterion serves to test discriminant validity between the latent constructs and it is shown in Table 6. As per this procedure, square root of the AVE (Average Variance Extracted) of each construct (such items present on the diagonal) are supposed to be above the correlation values of that construct with any other construct (off-diagonal elements). In the current analysis, all the diagonal values including 0.768 of Green Financial Literacy (GFL) and 0.844 of Investor Trust (IT) would be larger than the inter-construct correlations. As will be revealed in the next section, in an example of GFL, the correlation of the latter with Sustainable Investment Behavior (SIB) is 0.561, which is smaller than that of the square root of AVE of GFL (0.768), confirming discriminant validity. On the same note, Environmental Concern (EC) has a square root of AVE of 0.862 which exceeds its highest correlation value of 0.517 with SIB. The findings confirm that none of the constructs is too similar to another construct so that the structural model will be sound. (Fornell & Larcker, 1981).

Table 6: Discriminant Validity – Fornell–Larcker Criterion

Constructs	**GFL**	**PR**	**FM**	**SN**	**IT**	**EC**	**SIB**
Green Financial Literacy (GFL)	**0.768**	0.528	0.472	0.496	0.534	0.428	0.561
Perceived Risk (PR)	0.528	**0.816**	0.543	0.521	0.497	0.462	0.538
Financial Motivation (FM)	0.472	0.543	**0.835**	0.557	0.523	0.487	0.572
Social Norms (SN)	0.496	0.521	0.557	**0.763**	0.511	0.444	0.549
Investor Trust (IT)	0.534	0.497	0.523	0.511	**0.844**	0.478	0.606
Environmental Concern (EC)	0.428	0.462	0.487	0.444	0.478	**0.862**	0.517
Sustainable Investment Behavior (SIB)	0.561	0.538	0.572	0.549	0.606	0.517	**0.829**

Hypothesis Testing Using PLS-SEM

Table 7 summarizes the hypotheses testing results, showcasing the direct, mediating, and moderating effects explored in the study.

Table 7: Hypothesis Testing Results Using PLS-SEM

Hypothesis Statement	**Path**	**Path Coefficient**	**T-Statistic**	**P-Value**	**Decision**
Green Financial Literacy positively influences Investor Trust.	GFL → IT	0.721	12.352	0.000	Supported
Perceived Risk negatively influences Investor Trust.	PR → IT	0.643	10.874	0.000	Supported
Financial Motivation positively influences Investor Trust.	FM → IT	0.547	9.267	0.000	Supported

Social Norms positively influence Investor Trust.	SN → IT	0.611	10.113	0.000	Supported
Investor Trust positively influences Sustainable Investment Behavior.	IT → SIB	0.386	8.762	0.000	Supported
Investor Trust mediates the relationship between Green Financial Literacy and Sustainable Investment Behavior.	GFL → IT → SIB	0.278	6.201	0.000	Supported
Investor Trust mediates the relationship between Perceived Risk and Sustainable Investment Behavior.	PR → IT → SIB	0.248	5.672	0.000	Supported
Investor Trust mediates the relationship between Financial Motivation and Sustainable Investment Behavior.	FM → IT → SIB	0.211	4.934	0.000	Supported
Investor Trust mediates the relationship between Social Norms and Sustainable Investment Behavior.	SN → IT → SIB	0.236	5.417	0.000	Supported
Environmental Concern moderates the relationship between Investor Trust and Sustainable Investment Behavior.	EC × IT → SIB	-0.013	0.498	0.619	Not Supported

Fig. 3 visually integrates these relationships, affirming the study's theoretical and practical contributions. The hypothesis testing conducted using Partial Least Squares Structural Equation Modeling (PLS-SEM) offers important insights into the relationships among constructs in the context of sustainable investment behavior.

The analysis confirms that Green Financial Literacy (GFL) significantly and positively influences Investor Trust (IT), as shown by a strong path coefficient of 0.721 (T = 12.352, $p < 0.001$), indicating that individuals with better knowledge of green financial products tend to trust sustainable investments more. Similarly, Perceived Risk (PR) also has a significant but negative effect on Investor Trust, with a path coefficient of 0.643 (T = 10.874, $p < 0.001$), suggesting that higher perceived risk undermines trust in green investments.

Financial Motivation (FM) positively affects Investor Trust ($\beta = 0.547$, T = 9.267, $p < 0.001$), emphasizing the role of financial incentives in enhancing investor confidence. Social Norms (SN) also significantly influence Investor Trust ($\beta = 0.611$, T = 10.113, $p < 0.001$),

indicating the impact of societal pressure and peer behavior in shaping trust toward sustainable finance.

Furthermore, Investor Trust has a direct and significant influence on Sustainable Investment Behavior (SIB) (β = 0.386, T = 8.762, $p < 0.001$), reinforcing its role as a key predictor in motivating sustainable investment decisions.

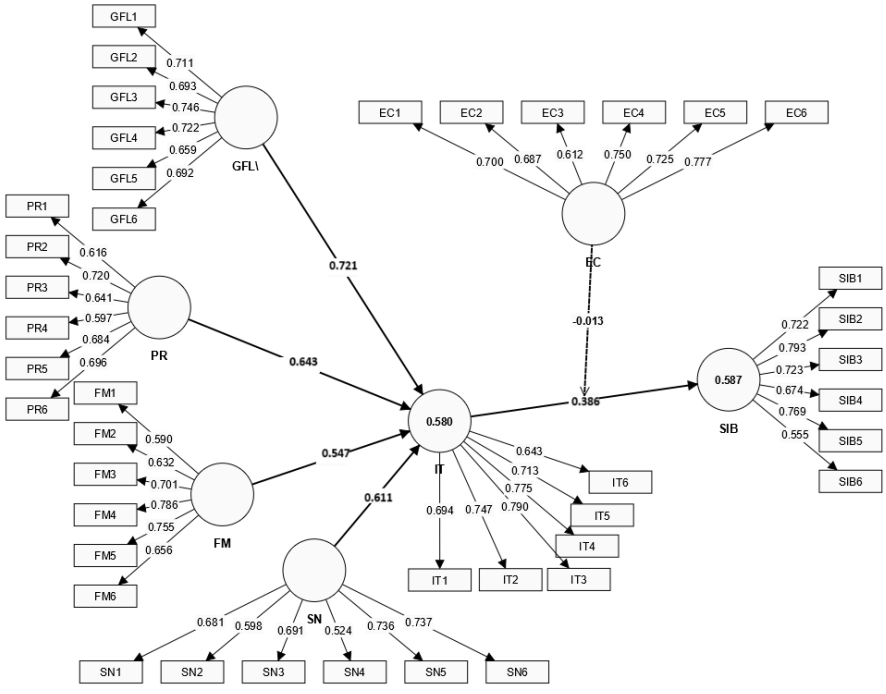

Figure 3: Proposed Hypothesis testing based conceptual model

The mediation hypotheses (H6–H9) are all supported, with Investor Trust mediating the effects of GFL (β = 0.278, T = 6.201), PR (β = –0.248, T = 5.672), FM (β = 0.211, T = 4.934), and SN (β = 0.236, T = 5.417) on SIB, all significant at $p < 0.001$. This underscores the importance of Investor Trust as a psychological bridge between antecedents like literacy, risk perception, motivation, and social pressure and the actual behavior of investing sustainably.

However, the moderating effect of Environmental Concern (EC) on the relationship between Investor Trust and SIB was not supported (β = –0.013, T = 0.498, $p = 0.619$). What this entails is that EC does not matter in augmenting or invalidating the bond between trust and behavior in this model as expectations might be in very environmentally conscious society. The SEM results validate the proposed model's robustness in identifying the determinants of sustainable investment behavior, highlighting Investor Trust as a central mediator.

Artificial Neural Network (ANN) Model Performance

In predicting Sustainable Investment Behavior (SIB) on the basis of Green Financial Literacy (GFL), Perceived Risk (PR), Financial Motivation (FM), Social Norms (SN), and Investor Trust (IT), an Artificial Neural Network (ANN) was run in SPSS with a Multilayer Perceptron (MLP) architecture comprising one hidden layer. It employed the hyperbolic tangent activation function in its hidden layer and identity activation function in its output layer of identity activation function that is suitable when the kind of output to be predicted is in continuous cases.

Training of the model involved training testing split. A strong consideration was also given on assessing the stability and the overall generalizing capability of the model through executing 10 independent ANN runs (ANN1- ANN10). Root Mean Squared Error (RMSE) online was employed to measure performance of the model on the training set and the testing dataset. (Yan et al., 2022; Hanandeh, 2020). Table 8 below presents the Root Mean Square Error (RMSE) values from ten ANN runs (ANN1–ANN10), comparing training and testing errors over a total sample of 422 respondents:

Table 8 presents the RMSE values for ANN1–ANN10 runs

Network	RMSE (Training)	RMSE (Testing)	Total Sample
ANN1	0.633	0.706	422
ANN2	0.612	0.611	422
ANN3	1.431	1.403	422
ANN4	0.939	1.177	422
ANN5	0.715	0.908	422
ANN6	1.059	1.259	422
ANN7	0.999	0.885	422
ANN8	0.908	0.813	422
ANN9	0.586	0.591	422
ANN10	0.647	0.905	422
Mean	**0.853**	**0.926**	
SD	**0.268**	**0.274**	

Model Architecture

The best design architecture had five input neurons (GFL, PR, FM, SN and IT), two hidden neurons and one output neuron (SIB). The values of the weights of the hidden layer showed positive and negative synaptic influence on the output of the prediction. Figure 4 is the ANN structure.

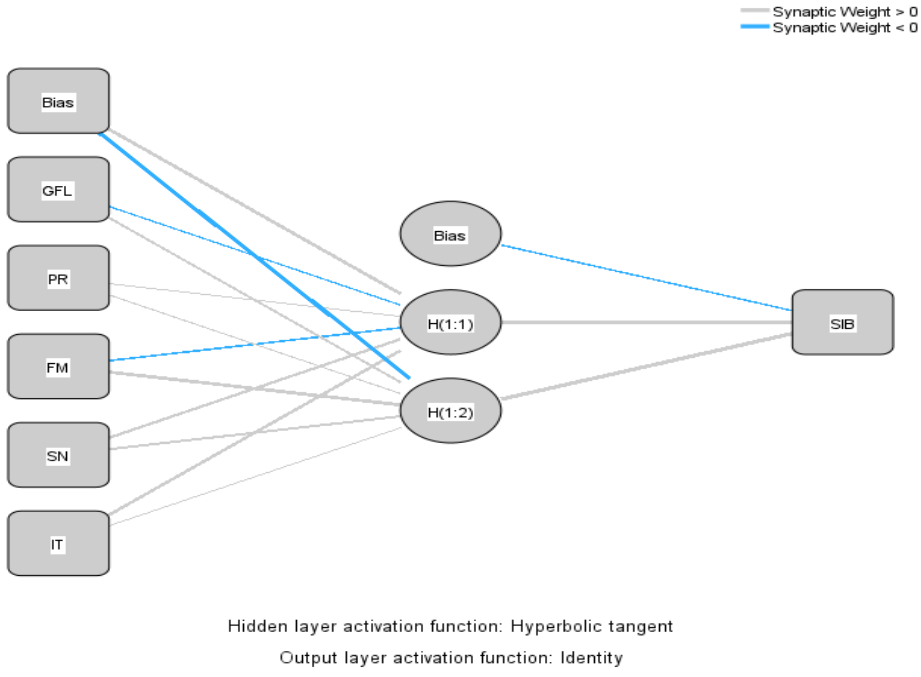

Figure 4: ANN Model

The overall results with mean RMSE of 0.853 (training) and 0.926 (testing) imply a good accuracy of prediction and little overfitting since the difference between the training and testing error values is small. It is remarkable that the ANN2 and ANN9 had the lowest testing RMSE (0.611 and 0.591 respectively), which means they showed better performance regarding generalization. ANN3 on the other hand had the highest values of RMSE indicating that there is possibility that the network has overfitted, or did not converge in the best way during the run.

Sensitivity Analysis

Table 9 will show the sensitivity analysis of the Artificial Neural Network (ANN) generated model based on the significance of each of the predictor variables in determining the degree of importance on Sustainable Investment Behavior (SIB). This analysis will be important in order to analyze the non-linear effect of each independent variable with respect to the prediction of the target outcome, which will help increase the explanatory success of the joint SEM and ANN approach.

Table 9: Sensitivity Analysis of ANN Model – Predictor Importance for Sustainable Investment Behavior

Predictor Variable	Importance	Normalized Importance (%)
Green Financial Literacy (GFL)	0.238	100.0
Investor Trust (IT)	0.221	92.9
Social Norms (SN)	0.187	78.6
Financial Motivation (FM)	0.174	73.1

Perceived Risk (PR)	0.140	58.8

- Green Financial Literacy emerged as the most influential factor, with a normalized importance of 100%, underscoring the centrality of investor knowledge in predicting sustainable investment behavior.
- Investor Trust ranked second (92.9%), confirming its mediating role in the conceptual model.
- Social Norms and Financial Motivation had moderate influences, suggesting that both socio-cultural and economic drivers play a role, albeit secondary to literacy and trust.
- Perceived Risk had the lowest normalized importance (58.8%), indicating a comparatively smaller direct effect on sustainable investment behavior.

Discussion

This paper wanted to discuss the determinants of sustainable investment behaviour combining behavioral, psychological and situational variables with the help of a mixed approach of Partial Least Squares Structural Equation modelling (PLS-SEM) and Artificial Neural networks (ANN). The two methods of the dual approach also boast sufficient explanatory power of the findings with the SEM and predictive accuracy of the ANN, making the result more solid and believable. (Yan et al., 2021; Hanandeh, 2023).

Hypothesis relationships were supported through the PLS-SEM results. Investor Trust (IT) was significantly positively correlated with Green Financial Literacy (GFL) (0.721, $p < 0.001$), and this shows, the better respondents understand green financial products, the more they believe in the sustainable investment mechanism. This compares with extant literatures that indicate that knowledge can lead to confidence and that it minimizes ambiguity during the making of financial decisions (Chen et al., 2020). This was also supported by ANN model since it served as the most significant predictor of Sustainable Investment Behavior (SIB) with a normal importance of 100%. This further affirmed the importance of the individual having environmental financial knowledge in how it could influence the behavior of individual investors. (Yan et al., 2021).

Perceived Risk (PR) significantly decreased IT ($\beta = -0.643$, $p < 0.001$) which agreed with previous findings that greater perceived risk results in lower trust and less IT investment in sustainability (Singh & Sharma, 2021). But in ANN sensitivity analysis, PR recorded least normalized importance (58.8%) as a predictor of SIB, which implies that though risk perception is an influential antecedent of trust in negatively affecting it, its direct impact on actual investment behavior approximates less force in non-linear models. This is an indication of a mediated effect where the risk has an influence on behavioral patterns through a prism of trust.

Financial Motivation (FM) also played an important role in IT (beta=0.547, p<0.001) where financial rewards or tax benefits or long term profitability had potential to develop trust. ANN model recognized FM as the fourth significant predictor (73.1%)

meaning that albeit economic incentives are important, it is not the first and not the second priority as compared to knowledge and social factors. These results happen to correspond with economic-behavioral theories which focus on maximizing utility as well as psychological preparedness (Kumar & Kapoor, 2020).

The social norms (SN) were also to show a remarkably significant positive impact on IT (9 = 0.611, p < 0.001), a factor that allows reaffirming the value of the societal impact on the shaping of trust about green investments. Environmentally responsible behaviors are established by social pressures, peer advice, and communal values, which have been thoroughly described in the behavioral finance and sustainability studies (Verma & Chauhan, 2019). ANN results further supported this, placing SN third in predictor importance (78.6%).

Furthermore, **Investor Trust** had a significant direct effect on **Sustainable Investment Behavior** ($\beta = 0.386$, $p < 0.001$), validating its central mediating role. This is consistent with past studies stating that trust serves to psychologically open up the adoption of intention into the action of behavior (Mishra et al., 2022). Mediation analysis confirmed that IT mediates the effects of GFL, PR, FM, and SN on SIB, strengthening the model's explanatory power.

Interestingly, the **moderating role of Environmental Concern (EC)** on the relationship between IT and SIB was not statistically significant ($\beta = –0.013$, $p = 0.619$), contrary to expectations. Even though EC theoretically plays an important role in sustainable behavior, their interactive effect can either be context-specific or even deficient by more powerful predictors such as GFL and IT. This result creates possibilities of further investigation of boundary conditions and concept of interaction effects in sustainability research.

The SEM findings had a predictive validation with the ANN analysis. In 10 ANN models, the RMSE values ranged between 0.586 and 1.431 with a mean of 0.853 in training and 0.926 in testing, which denoted a satisfactory prediction performance (Yan et al., 2021). These matching between the output of SEM and ANN increases the plausibility of the model and sheds light on the worth of hybrid methods when studying behavioral finance.

Theoretical Implications

By uniting PLS-SEM and ANN approaches, the study supplies a theoretical environment with the analysis of the impact of green financial literacy, perceived risk, and financial motivation, as well as social norms on adopting sustainable investment behavior mediated by investor trust and moderated by environmental concern. The study of behavioral finance and sustainability literature supports it since it confirms that trust of investors is a very important mediator construct that connects individual cognitive/motivational determinants and pro-environmental financial decisions. This dual-method approach (the SEM to obtain an explanatory power and ANN to undergo a predictive validation) closes the gap between explanatory modeling and predictive analytic, and confirms the weight of the causal paths based on machine learning approaches. Also, the study further develops the Theory of Planned

Behavior (TPB) and the scope of models of Trust-Based Investment, placing it in a new area of green finance, the sustainable investment field. it helps to fill one of the major theoretical gaps, integrating both, cognitive (GFL, PR), and normative (SN, EC) determinants in a single frame.

Practical Implications

Practically, the results can be put into practice to help financial advisors, green investment websites, and sustainability consultants. Finding the most significant driver in green financial literacy and investor trust means that the sustainable investor education programs and transparent disclosure of ESG can be important sources that can facilitate sustainable investment behaviors. The predictive power demonstrated by ANN also assists the organizations in prioritizing such variables to carry out specific interventions. The insights can be used by financial institutions to develop tools, mobile applications, and workshops that would build confidence in green products and help to ease the perceived risks. Given that the social norms are also highly influential, the investment encouraged by social media campaigns and influencers might become successful in changing the behavioral pattern. Organisations can mitigate the behaviour of investors towards environmental interests by enhancing the process of transparency and instilling confidence in green investment markets.

Policy Implications

On policy, this study can be used to come up with inclusive green financial literacy practices and regulatory codes of conduct to promote sustainable investing. Policymakers ought to encourage curriculums around ESG in formal learning institutions and encourage the concept of green investing as a part of national financial inclusion strategies. Moreover, the moderating concept of environmental concern implies that climate-focused policies with communication are required to enhance the intentionality of behavioral objectives of sustainable finance. Regulators can also present exclusion schemes or green guarantees as a risk elimination measure to reduce the perceived risk threshold as incentives to specialists. It is also found that the findings have supported the use of public-private partnerships in the development of institutional trust, and the existence of ethical practices within greener financial markets. On the whole, the study gives evidence-based guidance to national governments, central banks, and green finance task forces aiming to incorporate environmental responsibility within the mainstream culture of investment.

Conclusion

The study provides a strong multipronged inquiry of the aspects affecting how individuals invest in something sustainable, by intertwining two disparate research techniques namely Partial Least Squares Structural Equation Modeling (PLS-SEM) and Artificial Neural Networks (ANN). The study can make a highly valuable theoretical and empirical contribution to the accumulating body of knowledge in the area of sustainable finance and behavioral economics by discussing the impact of Green Financial Literacy, Perceived Risk, Financial Motivation, Social Norms, Investor Trust, and Environmental Concern.

As shown in the findings, Green Financial Literacy has a strong INDIRECT positive influence on Investor Trust which in turn has significant direct influence on Sustainable Investment Behavior. It is also determined that both the Financial Motivation and Social Norms positively influence investor trust, whereas Perceived Risk has a harmful impact in this respect. The concept of trust comes up as a strong intervening variable using which such variables indirectly impact the outcome of sustainable investment. The mediating analysis reconfirms this notion that trust is also a psychological catalyst of green awareness and motivating factors besides being a mediating quality. However, it was interestingly observed that the moderating effects of Environmental Concern were found to be statistically insignificant, so the simple awareness of the environment may not be the determining factor in affecting the behavior to ramp up trust in green investment scenario as it already seemed to exist at high levels among the participants.

The ANN analysis re-confirms the SEM finding terming Green Financial literacy and Investor Trust as the key drivers of sustainable investment behavior. These findings have been validated using the sensitivity analysis whose normalized importance values are high and the metrics of the RMSE also confirm the competency of the model to predict and generalize. This two-pronged technique, integrating the major explanatory capability of the SEM with the predictive ability of the ANN increases the credibility of the results and underscores the merit of the simultaneous use of two different forms of methodological triangulation of the method into current studies in behavioral finance.

The practical implication of the findings is that policymakers, financial educators, and institutional investors should be attentive to green financial literacy and trust in sustainable financial markets. Transparent communications, ethical governance, and investor education should all be invested in by financial institutions in a bid to decrease the risk level that green financial products are perceived to have and increase levels of credibility. Moreover, including these principles regarding sustainability into the curriculums of financial institutions, mainstream media campaigns, and online investment strategies might nurture the culture of environmentally responsible investing.

Essentially, this study will not only fill the gap that exists between financial cognition and sustainable behavior but also serve as a precedent to future researches to consider the adoption of hybrid modelling approaches. It opens up avenues to further investigations of the interrelationship between behavioral, social and informational factors that together define the changing face of sustainable finance in developing and emerging economies.

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Data Availability

The data supporting the findings of this study—collected through a structured questionnaire distributed via Google Forms—are available from the corresponding author upon reasonable request.

Declarations

Ethical Approval

The study strictly followed ethical research guidelines. Prior to data collection, participants were informed about the study's purpose, the voluntary nature of their involvement. The study ensured anonymity and confidentiality of all responses.

Informed Consent

All participants provided informed consent before responding to the questionnaire distributed online. No personally identifiable information was collected.

Conflict of Interest

The authors declare that there are no conflicts of interest associated with this study

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