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Adaptive Capacity and Technology Adoption: Mediating Climate Change Sensitivity and Economic Well-being among Farmers in Kelantan River Basin, Malaysia

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Abstract

In recent decades, extreme climate events have increasingly affected the Kelantan River Basin (KRB), a major agricultural region in northeast Peninsular Malaysia. This study examines the effects of climate change sensitivity, defined in economic, political, cultural, and institutional dimensions, on farmers' adaptive capacity and technology adoption, and assesses their mediating roles in influencing economic well-being. Data were collected using questionnaires distributed to 400 farmers in the KRB through convenience sampling, and analysed using PLS-SEM. The results indicate that adaptive capacity, rather than technology adoption ($\beta = -.09$, $p > .10$), significantly improves farmers' economic well-being ($\beta = .67$, $p < .01$). Economic sensitivity ($\beta = .24$, $p < .01$) positively influences adaptive capacity, while cultural sensitivity ($\beta = -.25$, $p < .01$) has a negative effect. Political and institutional sensitivities show no significant direct influence. Furthermore, adaptive capacity plays a significant mediating role in the relationships between economic and cultural sensitivities and economic well-being. In addition, all dimensions of climate change sensitivity, including economic ($\beta = .23$, $p < .01$), political ($\beta = .13$, $p < .05$), cultural ($\beta = -.16$, $p < .01$), and institutional sensitivity ($\beta = .19$, $p < .01$), significantly influence technology adoption; however, these effects are not translated into improved economic well-being. From a policy perspective, the findings indicate that strengthening farmers' adaptive capacity is more critical than promoting technology adoption alone for improving economic well-being under climate change. Policies should therefore prioritise capacity-building interventions, including financial resilience, skills development, and access to adaptive support systems, alongside technology-oriented programmes.

Keywords: Economic well-being, Kelantan River Basin, Climate change sensitivity, Technology adoption, Adaptive capacity, Agricultural community

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1 Introduction

The Kelantan River Basin (KRB) is Kelantan's largest water resource, covering approximately 13,135 square kilometres, or 85% of the state's total area. This is a very important basin that provides water for a variety of purposes, including domestic, irrigation, industrial, and fish farming. KRB's socioeconomic development is primarily focused on agriculture, with crops such as paddy, vegetables, rubber and oil palm plantations, as well as fishing and livestock farming (Suhana et al., 2023). According to the Department of Statistics Malaysia (2023), there are approximately 1.90 million people living in the state of Kelantan. Nonetheless, the KRB is extremely vulnerable to climate stresses such as floods and droughts, which disrupt the agriculture and economy of the area's farmers. The KRB has a tropical climate with two distinct monsoon seasons: the Northeast Monsoon, which occurs from November to January and brings heavy rainfall, and the Southwest Monsoon, which occurs from May to August and brings relatively little rainfall (Faizalhakim et al., 2017).

Climate change has increased the frequency and severity of weather-related disasters in the KRB over the last several decades. For example, the maximum daily precipitation indices have been rising from 1985 to 2014, implying that rainfall intensity has increased. Such changes have resulted in frequent floods and droughts, which have caused significant problems for Kelantan's agricultural sector. Flooding is a common problem for the KRB, particularly during the Northeast Monsoon. The floods of 2014-2015, also known as the Great Yellow Flood, impacted the region, causing an estimated loss of over RM1 billion and displacing 202,000 residents (Berita Harian, 2015). Flood-affected areas were submerged in water up to two metres deeper than normal, affecting farms, houses, and other infrastructure. The fact remains that flooding in the KRB is caused by a variety of factors, including not only changes in rainfall but also poor drainage systems and changes in land use such as deforestation and agricultural expansion (Faizalhakim et al., 2017; Jaafar et al., 2016). The Kelantan River, the basin's main river, has always been known to flood many areas during heavy rainfall (Khan et al., 2014). The floods have had a significant impact on the economy, particularly the agricultural sector.

The KRB is prone to both floods and droughts, particularly during the Northeast Monsoon and El Nino. Droughts have a direct impact on the water supply for irrigation, which is critical for agriculture in this region. For example, the 2014 drought affected over 8,000 paddy farmers and caused crop damage totalling USD 22 million (Faizalhakim et al., 2017). Tew et al. (2022) discovered an increase in temperature and high variability of rainfall in Kelantan, which has resulted in severe drought. For example, severe droughts occurred in 1997, 1998, 2002, 2003, 2005, 2006, 2007, 2009, and 2010 (Hashim et al., 2016; Yusof et al., 2013). Suhana et al. (Suhana et al., 2023) and Tew et al. (Tew et al., 2022) reported that KRB experienced extremely dry years in 1986, 1987, 1989, 1990, 1992, 1997-1998, 2015-2016, and 2020, with the paddy field being the most affected due to a lack of irrigation water. Drought affects agriculture in a variety of ways, including crop production, livestock, and fishing. Drought causes lower water levels in rivers and reservoirs, reducing the availability of water for irrigation and livestock. As Hashim et al. (2016) point out, this forces farmers to reduce their output or abandon farming (Hashim et al., 2016).

Specific flood and drought events over time demonstrate the persistence and cumulative nature of climate extremes in the Kelantan River Basin. Climate change is perceived by farmers in this region as a series of shocks that influence livelihood decisions, risk perceptions, and adaptive behaviour. This historical context is critical for understanding climate change sensitivity and explains why adaptive capacity and technology adoption are being investigated as key responses.

Climate change has had a significant impact on the region's hydrology, increasing the frequency of both floods and droughts. Flooding and drought have been common occurrences in the KRB, and their impact on the social and economic lives of farmers and others in affected areas cannot be overlooked. Farming is an important source of income in Kelantan, and crop and farmland losses due to floods and droughts have resulted in income loss and increased poverty rates among residents (Hamdan et al., 2012). Climate disasters disproportionately affect smallholder farmers, who make up the majority of Kelantan's agricultural labour force. This is because they are typically unprepared to deal with disasters such as floods and droughts, resulting in longer recovery times during which crop yields are lower (M. Shaari et al., 2017). This also has an impact on other sectors of the economy by reducing agricultural income due to crop failure,

which results in higher-priced food and reduced purchasing of other goods and services (Sarkar et al., 2014).

The KRB is extremely vulnerable to climate stressors like floods and droughts, which disrupt agricultural production, income stability, and livelihood security for farmers in the region. Despite increased exposure to climatic risks, farmers face a number of challenges in adapting to climate change, including uncertainty about future climate conditions, agricultural livelihood instability, limited financial capacity, and difficulty making informed decisions about effective adaptation strategies. These challenges influence whether farmers prioritise improving their adaptive capacity or implementing new technologies. This study fills these gaps by investigating how various dimensions of climate change sensitivity influence farmers' adaptive capacity and technology adoption decisions, as well as how these responses affect their economic well-being.

The purpose of this study is to determine the effects of climate change sensitivity on the adaptive capacity, technology adoption, and economic well-being of farmers in the KRB. This research focusses on the roles of adaptive capacity and technology adoption in mitigating the effects of climate change on economic well-being. This study looked at economic, political, cultural, and institutional sensitivity to climate change as described by Fenton et al. (2007) and Marshall et al. (2010) to see how farmers' perceptions of these factors affect their adaptive capacity and technology adoption in order to improve their economic well-being. These dimensions capture how climate extremes influence livelihoods, governance responses, social norms, and institutional support structures within farming communities. To date, none of the previous empirical studies on climate change and agricultural adaptation have examined all four sensitivity dimensions together, despite the availability of this conceptual framework. This work is relevant because it seeks to establish the perceived economic and cultural impacts of climate extremes on farmers, as well as the capacity of political systems and institutions to address such issues from the farmers' perspective. Finally, these four dimensions of climate change sensitivity are likely to have an impact on farmers' economic well-being via adaptive capacity and technology adoption in response to changing climate. Figure 1 depicts the relationships between these variables, which are mediated by adaptive capacity and technology adoption. It is therefore useful in understanding the extent to which climate change sensitivities impact the economic well-being of farmers in the KRB.

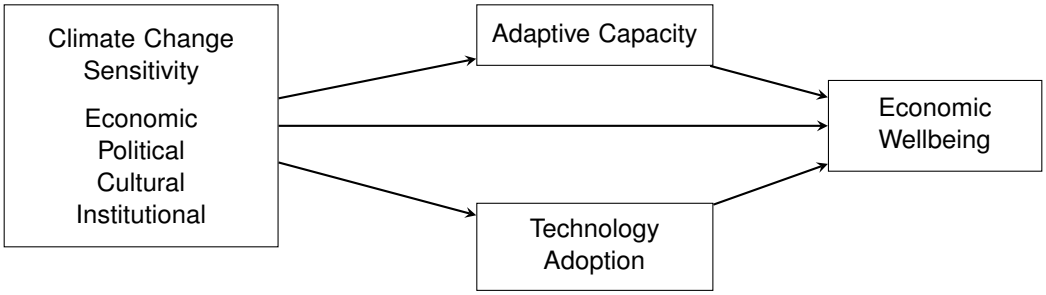

Figure 1: The hypothesized relationships between climate change sensitivity, adaptive capacity, technology adoption, and economic wellbeing. Source: Authors' illustration.

This study used Rational Choice Theory (RCT), which states that farmers, as rational individuals, should consider the knowledge and options that will allow them to maximise their farming productivity and sustainability. These outcomes could be realised through increased adaptive capacity and technology adoption. The current study contended that farmers do not automatically change themselves to improve their adaptive capacity and adopt technology in the face of climate variability because these require a significant amount of effort or expenditure, such as time and resources. As a result, it is important to note that farmers' climate change sensitivity may serve as a trigger or push factor in their willingness to cope with climate extremes. As noted by Fenton et al. (2007) and Marshall et al. (2010), these sensitivities include economic, political, cultural, and institutional aspects. In this study, perceived sensitivities are used to raise awareness, provide information, or gain knowledge about risk and uncertainty. These factors may compel farmers to take action, such as selecting strategies from the available options, improving their adaptability, or

using technology to address climate variability risks in order to increase the productivity of their agricultural or business investments, all of which are consistent with RCT.

The remaining sections of this work are organised as follows: Section 2 discusses rational choice theory and farmers' responses to climate change. Section 3 contains the specific concepts and definitions of the variables used in this research. The fourth section focusses on previous research that has established a link between climate change sensitivities, technology adoption, adaptive capacity, and economic well-being. The fifth section discusses the methodology, the sixth section presents the study's findings, and the final section discusses the conclusion.

2 Realising rational choice theory and farmers' action to climate change

According to Rational Choice Theory (RCT), people make decisions based on the potential returns and costs of various options in order to maximise their returns (Scott, 2000). RCT could be useful in understanding why farmers choose specific adaptation strategies. It could also aid in understanding the decision-making system that governs farmer behaviour in response to climate change, which is particularly useful given recent occurrences of climate change and variability.

Farmers, like everyone else, act purposefully to make the most of their lives, and do what they believe is the best way to improve their standard of living. Climate change has an impact on agriculture in a variety of ways, including crop yields, pest and disease management, and irrigation water availability. Farmers must decide which strategies to employ in order to adapt to the changing environment, such as selecting new crop varieties, planting at different times, and investing in irrigation. According to RCT, the farmer should select the strategy that he or she believes will result in the lowest costs and highest returns. For example, a farmer may decide that the benefits of planting a drought-tolerant crop, such as high yield during the dry season, outweigh the costs, such as the cost of acquiring the seeds and/or skills required to grow the new variety. According to Deressa et al. (2009), some of the factors influencing this decision making include the farmer's access to information, income status, and social relationships. All of these factors contribute to the farmer's assessment of the likely returns from the various adaptive options available to him/her.

In its most basic form, RCT assumes that people understand what is at stake when making a decision. However, there is much uncertainty about how climate change will affect farmers' actions and their adaptive strategies. The problem is that climate change scenarios are often unpredictable, and the effectiveness of adaptive solutions varies depending on the environment. However, this does not preclude the use of RCT, as farmers' behaviour is influenced by their perception of risks and uncertainties (Grothmann & Patt, 2005). As a result, farmers may choose to take slightly less risky measures such as crop rotation rather than completely changing their farming system. These decisions are a clear attempt to maximise the potential payoff in risky situations, which is a hallmark of RCT (Cinner et al., 2009). Farmers who have access to better climate information or who have been affected by previous climate events may be willing to embrace costly adaptation measures because they will yield high returns in the future.

In the context of this study, RCT provides a foundation for understanding how farmers respond to climate change sensitivity by weighing the perceived costs, benefits, risks, and constraints of various adaptation options. Economic sensitivity heightens awareness of potential income losses, reinforcing incentives to develop adaptive capacity. Cultural sensitivity influences the acceptability of change and may raise the perceived costs of adaptation, lowering adaptive responses. Political and institutional sensitivities shape farmers' expectations of external support and policy effectiveness, influencing their willingness to invest in adaptation or adopt new technologies. According to RCT, adaptive capacity and technology adoption are rational responses to climate risks when perceived benefits outweigh costs, explaining the relationships hypothesised in the study's conceptual model.

3 Definition of terms

This section defines several terms used in this study. Literature review is used to define concepts such as economic well-being, adaptive capacity, technology adoption, and climate change sensitivity.

3.1 Economic well-being

Economic well-being refers to an individual's or family's financial situation or economic health. It entails their economic resilience, contentment with their income, planning for future events, and achieving economic self-reliance. These include having enough financial means to address financial challenges, being satisfied with income levels, keeping an emergency fund, managing finances in the best way possible, and being prepared for the event of unemployment or retirement (Graham, 2011; Joo, 2008; OECD 2013, 2020; Osberg, 2024; Stiglitz et al., 2009; Wilmarth, 2021; Yassin et al., 2015).

3.2 Adaptive capacity

Adaptive capacity refers to the ability of individuals, households, and communities to prepare for, deal with, or benefit from the effects of climate change in order to improve or maintain their well-being to the greatest extent possible. It encompasses knowledge on climate change, the capacity to acquire new knowledge, knowledge on skills and strategies, financial and social assets, and support systems from within and outside the community, which all enhance the coping capacity to climate-related disasters (Adger, Arnell, et al., 2005; Adger, Brooks, et al., 2005; Brooks et al., 2005; Engle, 2011; IPCC 2014; Marshall et al., 2010; Nelson et al., 2007; Smit & Wandel, 2006; Yohe & Tol, 2002).

3.3 Technology adoption

Technology adoption refers to an individual's or organization's readiness and capacity to use agricultural technologies. Some of the criteria used include identifying the benefits, appropriateness, feasibility, and the possibility of using these technologies to improve agricultural productivity (F. D. Davis, 1989; Feder et al., 1985; Li et al., 2024; Rodríguez-Barillas et al., 2024; Rogers, 2003).

3.4 Sensitivity to climate change

Marshall et al. (2010) defined sensitivity in the IUCN climate change adaptation framework as 'the extent to which a system is influenced by or can be changed by climate change'. According to Fenton et al. (2007) and Marshall et al. (2010), the sensitivity of social systems is determined by economic, political, cultural, and institutional contexts. These factors can have a positive or negative impact on the social system. Climate change is likely to have an impact on social systems that rely on vulnerable natural resources (Marshall et al., 2007). As a result, a climate adaptation plan should assess the community's vulnerability to climate change as well as available resources.

According to leading scholars, the economic, political, cultural, and institutional aspects of the social system's sensitivity are as follows:

Economic sensitivity

Economic sensitivity to climate change refers to how people perceive the impact of climate change on their economy. These effects extend to income, financial standing, sources of income, standard of living, job security, businesses, and the economy as a whole. It includes issues concerning the costs of climate change impact and adaptation, potential economic consequences, and benefits of adaptation measures (IPCC 2014; O'Brien & Leichenko, 2000; Stern, 2007; Tol, 2009; World Bank, 2010).

Political sensitivity

> *Political sensitivity to climate change is defined as the level of trust that people have in the political system's ability to address climate change. It covers political leadership, the role of political systems in planning for mitigation and adaptation measures, impacts on political systems, and participation in decision-making and policy-making for change (Adger, Quinn, et al., 2013; Barnett & Adger, 2007; Gemenne et al., 2014; McCright & Dunlap, 2011).*

Cultural sensitivity

> *Cultural sensitivity refers to the extent to which climate change disrupts or challenges cultural practices, values, and traditions, thereby influencing communities' ability to adapt. It emphasises the importance of culture, indigenous knowledge systems, and community identities in the development of strategies and measures to help mitigate and adapt to the impacts of climate change (Adger, Barnett, et al., 2013; Berkes et al., 2000; Crate & Nuttall, 2016; Ford et al., 2006; Hulme, 2015).*

Institutional sensitivity

> *Institutional sensitivity to climate change measures people's perceptions of institutions' and organisations' ability to respond to climate change. This includes the capacity of the institutions to implement climate policies, promote efforts to mitigate the effects of climate change, and improve resource management (Biermann et al., 2009; Gupta et al., 2010; World Bank, 2010; Young et al., 2008).*

It should be noted that what is measured in this study are farmers' perceptions of institutional and political capacity, which may or may not fully align with the actual ability of institutions or political actors to address climate challenges. For instance, governments and agencies may in reality have policies, budgets, or technical expertise in place, but if farmers are unaware of these efforts or distrust political leaders, their perceptions will reflect low capacity. Conversely, farmers may believe political leaders are responsive and committed even when actual implementation is weak. This divergence between perceived and actual capacity, both institutional and political, represents an important limitation of the present study.

4 Literature review

Climate change is one of the most serious concerns in the modern world, and it affects farmers in the sense that they will need to adjust their livelihoods and crop-growing methods in order to make a living. This section gives an overview of the factors that can affect a farmer's ability to respond to climate extremes by adopting technology and improving their adaptive capacity.

4.1 Enhancing farmers' economic wellbeing through adaptive capacity and technology adoption

The use of technology in agriculture helps to increase yields and effectiveness by utilising improved methods such as precision farming, efficient irrigation and drainage systems, and genetically modified crops. GPS in tractors and remote sensing in agriculture reduce input costs, increase output, and protect the environment (Shofiyati et al., 2024; Sishodia et al., 2020). Genetic modifications for pest and disease resistance reduce crop damage and chemical use while increasing yield (ISAAA 2017). Technological innovations also reduce costs by mechanising and automating processes such as planting and harvesting, resulting in lower labour costs (Daum, 2023; Lowenberg-DeBoer et al., 2020). Technology has aided supply chain management by reducing post-harvest losses and transportation costs, thereby increasing profitability (Nath et al., 2024; Sonka et al., 2023).

Technology helps farmers gain market access and compete more effectively. E-commerce and digital marketing improve market coverage, eliminate middlemen, and increase profitability (Lemma D et al., 2018; Yiridomoh et al., 2022). Better market access has the potential to increase income and economic security for farmers. Technology adoption also helps with risk management in agriculture and improves resilience to climate change. Weather and climate prediction tools assist farmers in determining the timing of cultivation, as well as avoiding some of the worst effects of climate change (Challinor et al., 2018; Lobell et al., 2014). Crop insurance and risk management technologies help farmers manage the risk of crop failure and price fluctuations (Birthal et al., 2021; Velandia et al., 2009).

In agriculture, adaptive capacity can be defined as a farmer's ability to change and adapt to new conditions while also implementing new measures. It is about adaptability, creativity and learning, allowing farmers to experiment with new technologies and methods of working to improve efficiency and profitability, thereby fostering innovation (Smit & Wandel, 2006). Availability of resources and support systems also influences adaptive capacity. Certain factors, such as the availability of financial resources, technical support and extension services, help farmers adopt new technologies (Anderson & Feder, 2007). According to the World Bank (World Bank, 2012), financial assistance in the form of grants or low-interest loans allows for the removal of barriers to technology adoption. Extension services and training programs assist farmers in acquiring the knowledge required to use new technologies (K. Davis et al., 2012).

Social networks and collaboration help farmers increase their adaptive capacity by providing access to information and resources that allow them to adopt new practices (Pretty et al., 2012). Such measures as farmer co-oper increasing their resilience (Wigboldus et al., 2016). Adaptive capacity is thus heavily dependent on institutional and policy support. Farmers will benefit from policies that incentivise research, provide financial support, and encourage the use of technology. Government policies that promote climate-smart crops and secure land tenure contribute to long-term changes and technology adoption (Thornton et al., 2009).

The integration of technology and the strengthening of adaptive capacity are critical for increasing farmers' income and growth. Technology has the potential to raise income and provide a more stable economic outcome by improving productivity and lowering costs (Ma & Rahut, 2024). These technologies assist farmers in increasing crop productivity and thereby income while decreasing farming costs (Shofiyati et al., 2024). Adaptive capacity allows farmers to protect their income from risks and uncertainties due to extreme weather events, climate change, and market volatility (IPCC, 2014). Technology adoption is just as important as adaptive capacity in the future of sustainable farming. Conservation tillage and integrated pest management are two helpful practices that improve soil health and biodiversity to support agricultural production (Garnett et al., 2013). Sustainable practices reduce the likelihood of depleting natural resources and polluting the environment, both of which can have a negative impact on farm yields and income generation (Rosset & Altieri, 2017).

The impact of technology and adaptive capacity extends beyond equity and inclusion. The use of technology and resources can help to close the gap between smallholder and large-scale farmers (Atube et al., 2021). Yet, if technologies and adaptation measures are prohibitively expensive, they may instead accelerate farm consolidation, with only larger farms able to adopt them. This trend can discourage younger generations from farming while older farmers remain, making inclusive and affordable adaptation policies all the more important. When explicit inclusive policies are directed at vulnerable communities, adaptation and economic performance may improve, leading to effective rural development (Gupta & Vegelin, 2016). As a result, technology adoption and adaptive capacity are critical for improving farmers' economic conditions in the face of climate change impacts. They increase farmers' income and economic well-being by improving efficiency, lowering costs, and managing risks. Overcoming barriers and inclusive policies can help ensure that all farmers benefit from them. Climate change has had an impact on agriculture, and farmers' ability to earn a living in the future will be determined by technology adoption and adaptive capacity building.

4.2 Influence of climate change sensitivity on technology adoption

It is critical to understand how economic, political, cultural, and institutional sensitivities influence farmers' adoption of technology in the face of climate change. By addressing these sensitivities, authorities and stakeholders will be able to develop policies and programs that will encourage farmers to adopt the technologies needed to deal with climate change impacts.

Economic sensitivity to climate change on technology adoption

Economic sensitivity to climate change can be defined as the effect of climatic shocks on farmers' incomes and the economy. Droughts, floods, and heat waves all cause significant losses for farmers as they seek ways to alleviate the financial burdens they face. Positive and negative economic factors have a significant impact on their readiness to incorporate new technologies into their operations. First, the economic damage caused by climate extremes drives farmers to seek out improved technology that can reduce risk and increase production. According to studies, farmers who suffer significant losses as a result of adverse weather conditions are more likely to invest in technologies that promise to increase production output or help with risk management (Harvey et al., 2018; Wodaju et al., 2023). Climate change effects can be mitigated by implementing technologies such as drought-tolerant crops, efficient irrigation, and advanced weather prediction tools (Aishwarya & Kumar, 2024; Frimpong et al., 2023; Khatun et al., 2021). From a Rational Choice Theory perspective, heightened economic sensitivity increases farmers' awareness of potential income losses from climate extremes, making technologies that promise yield stability, cost reduction, or risk mitigation more attractive due to their higher expected benefits relative to inaction.

Additionally, economic sensitivity influences farmers' technology choices. In the face of economic stress, farmers may choose technologies that provide economic returns or reduce costs in the short term, even if they require an initial investment (Hassan et al., 2008). However, economic sensitivity does not always increase technology adoption, as financial stress, risk aversion, and liquidity constraints may discourage farmers from investing in new technologies despite their potential benefits. Government agencies, cooperatives, and non-governmental organisations also require support in the form of subsidies or grants to encourage technology adoption and improve farmers' readiness to adopt new technologies (Barbosa, 2024; Wu et al., 2022). Farmers who expect high returns from new technologies are more likely to invest in them, especially if they have recently experienced losses due to climate variability (Asante et al., 2024; Rizzo et al., 2024; Wang et al., 2019). As a result, the opportunities provided by new technologies encourage farmers to embrace them when perceived benefits outweigh financial and risk-related costs.

Political sensitivity to climate change on technology adoption

Political sensitivity refers to farmers' understanding of government policies and political responses to climate change phenomena. Such political factors have a significant impact on farmers' preparedness to adopt technology, as government policies can either promote or discourage such change. Subsidies for climate-friendly technologies and funding for agricultural research and development improve technology adoption readiness (Belmin et al., 2023; Hebsale Mallappa & Pathak, 2023). Political instability or unfavourable policy changes, on the other hand, can cause uncertainty and thus discourage investment in technologies (Abadie & Gardeazabal, 2003; Aisen & Veiga, 2013; Bertin et al., 2016).

Political sensitivity in this study is understood as farmers' trust in political actors and their perception of how government policies address climate change. This trust shapes whether farmers believe that leaders are committed to supporting adaptation and innovation. When farmers perceive strong political commitment, they are more likely to adopt new technologies, whereas perceptions of neglect reduce their willingness to do so (Crentsil et al., 2020; Han et al., 2022). Furthermore, political risk influences farmers' perceived risk and willingness to adopt new technologies. Farmers in areas where political leaders are more concerned about climate change and have expressed clear support will embrace technology as a means of dealing with its effects (Hebsale Mallappa & Pathak, 2023; Lamichhane et al., 2022; Ma & Rahut, 2024). Political instability, on the other hand, or the provision of ambiguous signals can slow technology adoption (Chavas & Nauges, 2020; Harik et al., 2023; Wu et al., 2023). From a Rational Choice Theory perspective, political

distrust and uncertainty regarding policy continuity reduce technology adoption by increasing perceived risks and lowering farmers' confidence in the long-term benefits of investing in new technologies.

Cultural sensitivity to climate change on technology adoption

Cultural sensitivity refers to how disasters affect social relationships, values and beliefs, which in turn influence farmers' adoption of technologies. A lack of motivation to adopt new technology can also be observed in agricultural cultures, where the traditional approach to farming is dominant and people may resist the introduction of innovations (Duong et al., 2019; Shen et al., 2023). For example, changes in farming practices may be difficult to implement if the technology is perceived as threatening to cultural beliefs or indigenous knowledge systems (Antonelli, 2023; Mohan et al., 2021). From a Rational Choice Theory perspective, cultural sensitivity shapes how farmers perceive the risks and benefits of innovation. In contexts where cultural values emphasise stability and tradition, innovation may be perceived as risky, reducing technology adoption. Conversely, when cultural norms support learning, experimentation and collective action, technology adoption becomes a rational response, as shared knowledge and social support lower perceived risks and increase expected benefits.

Cultural sensitivity, on the other hand, can aid in the adoption of those new technologies that are consistent with, or even support, cultural norms. Farmers are more likely to adopt technologies that improve the efficiency of traditional practices (Denashurya et al., 2023; Palis, 2006). Technologies based on local information systems may also be easier to implement and align with cultural attitudes (Adade Williams et al., 2020; Makate, 2020). Cultural sensitivity can also refer to technical communication and advertising. In communist cultures, community-level interventions such as demonstrations or peer teaching have proven to be more effective than individualistic approaches (Bader et al., 2023; Dutta, 2007; McElfish et al., 2017). Involving local leadership's opinions and adhering to culture in the design and implementation of technology increases the chances of acceptance and utilisation (Alderwick et al., 2021; Questa et al., 2020).

Institutional sensitivity to climate change on technology adoption

Institutional sensitivity refers to farmers' perceptions of how institutions such as research organisations, extension services, and co-operatives respond to climate change events. These institutions influence a farmer's willingness to embrace new technology, particularly by providing content, services, and support. Examples include agricultural extension services, which provide farmers with training and/or technical support to help them understand and implement new technologies (Danso-Abbeam et al., 2018; Makate, 2020). Support from institutions in research, development and extension boosts farmers' confidence in the use of innovations (Danso-Abbeam et al., 2018; Kapgen & Roudart, 2023).

Farmers' attitudes towards the credibility and reliability of these institutions influence their willingness to embrace technology. As a result, positive experiences with trustworthy institutions increase the likelihood of technology adoption. Furthermore, financial institutions that provide loans and/or grants increase farmers' options for allocating resources towards new technologies. This is critical because these mechanisms provide farmers with hope for a solution to their problems, and make them more willing to embrace new technologies (Geng et al., 2024; Xie et al., 2024).

Institutional conditions such as access to extension services, credit, and regulatory support influence farmers' technology adoption decisions under climate change. Within the rational choice theory framework, these institutional conditions shape the decision environment in which farmers assess expected costs, benefits, and risks associated with adoption. Differences in institutional sensitivity therefore lead to variation in adoption decisions across farmers.

4.3 Influence of climate change sensitivity on adaptive capacity

Climate change is unavoidable, and people and societies must be prepared to cope and adapt to these changes. Economic, political, cultural, and institutional sensitivities can all contribute to the development of these capacities. These areas are critical in developing strategies to mitigate and prevent the effects of

climate change. This section examines how each of the domains, namely economic, political, cultural, and institutional sensitivity, improves one's capacity to deal with climate change.

Economic sensitivity to climate change on adaptive capacity

Economic sensitivity to climate change refers to the ability to distinguish the effects of climate variability on people's income and livelihoods. This awareness improves individuals' and households' ability to plan for and invest in their futures, thereby increasing resilience. For example, those who are aware of potential climatic shocks may seek insurance coverage, look for alternative sources of income, or take appropriate precautions to reduce vulnerability (Adger, 2000; Smit & Wandel, 2006). This awareness also leads to the development of financial instruments like climate bonds and green investments, which aid in adaptation (Henderson et al., 2016).

Economic sensitivity encourages risk culture and the development of technologies and practices that can mitigate the effects of climate risk. They include drought-resistant crops in agriculture and energy-efficient buildings in architecture (Pelling & High, 2005). The economic resilience approach also allows individuals, firms, and countries to better prepare for and cope with the effects of climate variability and change (Tol et al., 2008). Similarly, economic sensitivity promotes cooperation and the exchange of resources among governments, businesses, and society. This collaboration is critical for mobilising resources and skills for effective adaptation measures (Agrawal, 2010). Some examples include public-private partnerships that can assist with investment in critical infrastructure such as flood defences or water systems, which can then help protect people from climate change and increase their resilience (Sovacool et al., 2015).

Economic sensitivity, including income variability and asset constraints, affects farmers' adaptation decisions by limiting the resources available for building adaptive capacity. From a rational choice theory perspective, these economic conditions influence how farmers make decisions by balancing short term livelihood needs against longer term adaptation benefits. As a result, adaptive capacity outcomes reflect differences in economic sensitivity across decision makers.

Political sensitivity to climate change on adaptive capacity

Political sensitivity to climate change refers to the understanding of how political processes and decisions influence climate change mitigation. This sensitivity increases adaptive capacity, causing people to become more politically active and demand stronger climate change policies (O'Brien et al., 2010). People are more likely to support community-based adaptation and policy changes if they believe their political leaders and community representatives are concerned about how climate change affects farmers' livelihoods and well-being. Political sensitivity has an impact on resource distribution and governance efficiency in climate risk management. It includes recognising the role of politics, improving action coordination, and developing a comprehensive adaptation strategy (Pelling, 2010). Political leadership is essential to implement policies that address the welfare of vulnerable groups and promote sustainable development (Naess et al., 2005).

Political sensitivity promotes accountability and transparency in climate governance. It enables individuals and societies to hold leaders accountable for their actions (Bulkeley & Betsill, 2013; Bulkeley & Newell, 2010). This can improve policy implementation and ensure that the adaptation measures proposed are both appropriate and equitable (Ayers & Forsyth, 2009). In this way, political sensitivity leads to a more effective and integrated approach to climate change, increasing society's overall adaptability (Pelling, 2010).

Political conditions influence farmers' adaptation decisions by shaping expectations regarding policy stability and institutional support under climate change. Consistent with rational choice theory, these political conditions are incorporated into decision making when farmers evaluate the potential outcomes of adaptive actions. Variation in political sensitivity thus contributes to differences in adaptation decisions and outcomes.

Cultural sensitivity to climate change on adaptive capacity

Cultural sensitivity to climate change is the assessment of how climate change affects cultural systems and social relationships. It increases adaptive potential by incorporating indigenous knowledge and practices

into adaptation measures (Adger et al., 2013a). Indigenous and local communities have wisdom on how to deal with environmental challenges, which can be applied to current adaptation efforts (Turner & Clifton, 2009). Cultural sensitivity also strengthens societal unity and encourages individuals to participate in collective activities required for adaptation. When people understand the cultural dimensions of climate change effects, they will be better able to work together to address these issues. Strong social networks assist in the exchange of resources, information, and support during climate events (Pelling & High, 2005), thereby contributing to the strengthening of community resilience and preparedness to climate change (Tompkins & Adger, 2004).

Furthermore, cultural sensitivity plays an important role in the conservation and modification of cultural property in response to climate change. The appreciation of cultural assets enables the development of measures to ensure the preservation of a specific region's cultural features (Cruikshank, 2001). This protects not only the heritage, but also, more importantly, the people's identity, which is critical to their psychological stability (O'Brien et al., 2009). Cultural sensitivity helps to understand that the adaptation measures are appropriate for the local culture and respect its values and identities (Adger et al., 2013a,b).

Cultural norms and beliefs influence farmers' adaptation decisions by shaping preferences and acceptable practices under climate change. Within the rational choice theory framework, these cultural factors affect how farmers evaluate the costs and benefits of adaptive choices. Differences in cultural sensitivity therefore help explain variation in adaptation decisions across farmers.

Institutional sensitivity to climate change on adaptive capacity

Institutional sensitivity to climate change refers to an institution's ability to understand its role in mitigating climate disasters and facilitating adaptation. This sensitivity increases adaptive potential by instilling confidence in institutions' responses to climate change (Adger et al., 2005a,b). When people see that institutions such as government agencies and non-governmental organisations (NGOs) are well-positioned to address climate risks, they are more likely to support such efforts (Gupta et al., 2010). People's perceptions of institutional sensitivity influence the success of policy formulation and implementation in terms of community resilience to climate extremes. Enhanced coordination between government sectors and agencies tends to accelerate people's adaptation (Agrawal, 2010).

Organisations that are more aware and sensitive to climate risks are more likely to focus their resources on adaptation, research and development funding, and creating conditions that encourage innovation and adaptive management (Eakin & Lemos, 2006). Furthermore, this ensures that all affected populations, including vulnerable groups, are considered when implementing adaptation planning measures (Folke et al., 2005). This improves the credibility and efficiency of adaptation policies, increasing the likelihood of success and long-term implementation (Smit & Wandel, 2006). Climate-responsive institutions will increase people's trust, collaboration, and inclusiveness by assisting communities in anticipating and dealing with climate variability and change (Adger et al., 2005a,b).

Institutional sensitivity affects adaptation decisions by shaping access to information, support mechanisms, and institutional reliability. From a rational choice theory perspective, these institutional conditions influence how farmers make decisions regarding adaptive capacity under climate change. Consequently, variation in institutional sensitivity contributes to differences in adaptive decisions and capacity outcomes.

5 Methodology

The study location, independent and dependent variables used in the study, and the validity and reliability of the study instrument are described in the following subsections. It also explains how data is collected and analysed.

5.1 Study location

This study was conducted on farmers in six districts of the KRB: Pasir Mas, Kota Bharu, Tanah Merah, Machang, Kuala Krai, and Gua Musang. The KRB is one of Malaysia's largest, covering more than 80% of

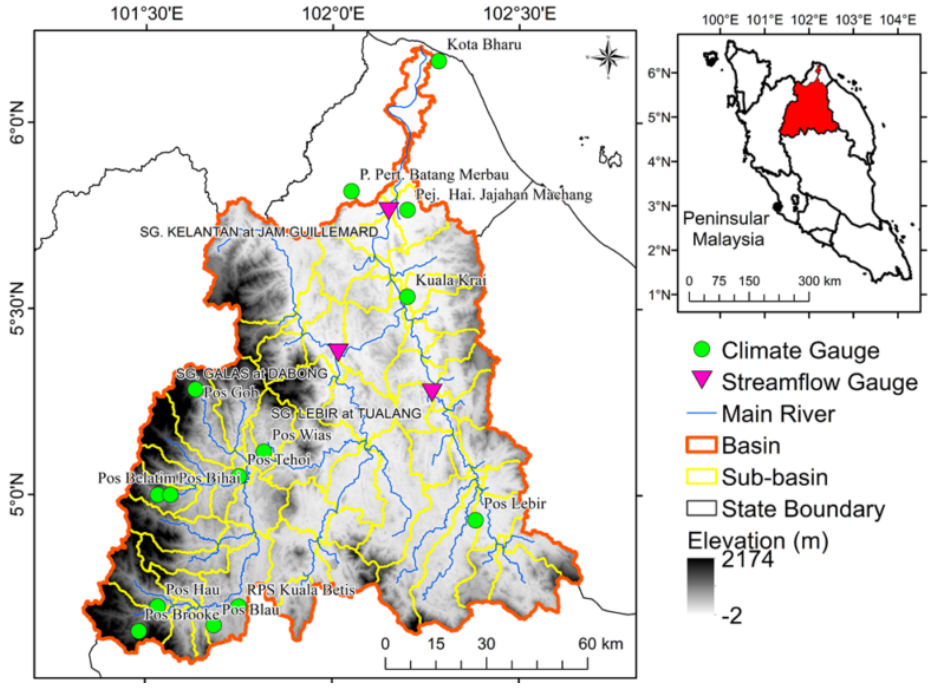

Figure 2: The Kelantan River Basin, situated in the northeast of Peninsular Malaysia.

the state of Kelantan in the north-eastern region of Peninsular Malaysia (Figure 2).

5.2 Survey instrument

The data for this study were gathered through a survey, using questionnaires. The questionnaire was written in Malay and consisted of two main parts. The first section covered the demographic characteristics of the respondents. The second section included a number of items designed to assess the study's constructs or variables. These construct-related items were developed by the researchers or adapted from previous studies to fit the context of Malaysia's rural and agricultural populations.

5.3 Variables and measures

Primary variables

This study focusses on seven major variables or constructs: economic well-being, adaptive capacity, technology adoption, and sensitivity variables in economic, political, cultural, and institutional dimensions. These constructs are measured using a set of items or statements on a 5-point Likert scale ranging from 1 ('Strongly disagree') to 5 ('Strongly agree').

Economic wellbeing. Yassin et al. (2015) developed a set of indicators to assess people's economic status and financial standing, which served as the foundation for the economic well-being measure. These indicators account for a variety of factors that define an individual's economic status in Malaysian society. In the current study, an eight-item scale was developed to assess an individual's belief that their income and savings are sufficient to meet current and future financial demands, deal with any financial crisis, live a comfortable life, enjoy leisure and entertainment, and support themselves in times of retirement or unemployment. A higher score on the five-point Likert scale indicates better economic wellbeing. Two examples of the items used in this construct are:

- "I am satisfied with my monthly income." (In Malay: *"Saya berpuas hati dengan pendapatan bulanan saya."*)

- "I can cope with the current financial stress." (In Malay: *"Saya mampu menghadapi tekanan kewangan semasa."*)

Adaptive capacity. This study adapted Shaffril et al.'s (2013, 2017) social adaptation measures to climate change, which were based on Marshall et al.'s (2010) sixteen domains of individual adaptive capacity (see Table A1 in Appendix A). This resulted in 36 items that represent the sixteen aspects of social adaptation to climate change. The respondents' scores are measured on a five-point Likert scale (1 to 5), with higher scores indicating a greater adaptive capacity. This capacity can be defined as an individual's ability to prepare for and manage more frequent climate extremes using knowledge, skills, community support, networks, financial assets and, as needed, the willingness to learn new skills for a sustainable life in the context of climate change. Examples of adaptive capacity items include the following three:

- Domain 2 – Ability to cope with change: "I can deal with minor changes in the effects of extreme weather in my current field of work." (In Malay: "*Saya boleh menangani perubahan kecil dalam kesan cuaca melampau dalam bidang kerja saya sekarang."*)
- Domain 6 – Employability: "I have other options if I don't want to work in this field due to the extreme weather." (In Malay: *"Saya mempunyai pilihan lain jika saya tidak mahu bekerja dalam bidang ini kerana cuaca yang melampau."*)
- Domain 15 – Formal and informal networks: "I'm in contact with an agency/third party to assist with my current job." (In Malay: *"Saya sedang berhubung dengan agensi/pihak ketiga untuk membantu pekerjaan saya sekarang."*)

Technology adoption. Twenty items were developed to assess the concept of technology adoption, which was derived from Roger's (2003) Innovation Diffusion Theory. This theory identifies five key characteristics that describe how innovations are adopted in society: relative advantage, compatibility, complexity, trialability, and observability. Four items were developed for each of these domains in this study. Previous studies on technology adoption have used similar items, including Sattler and Nagel (2010), Atkinson (2007), Sharifzadeh et al. (2017), Emani et al. (2018), and Yuen et al. (2021). The responses were quantified using a five-point Likert scale (1–5), with '5' representing the highest level of technology adoption. The following are three examples of the items used to build the construct:

- Domain 1 – Relative advantage: "Adopting innovative technology improves my farm's overall efficiency." (In Malay: *"Mengguna pakai teknologi inovatif meningkatkan kecekapan keseluruhan ladang saya.*")
- Domain 3 – Complexity: "I find it simple to learn how to use the new technology." (In Malay: *"Saya rasa mudah untuk belajar cara menggunakan teknologi baharu"*)
- Domain 5 – Observability: "The results of using the technology are apparent in improved crop yields." (In Malay: *"Hasil daripada penggunaan teknologi ini dapat dilihat dalam peningkatan hasil tanaman*")

Climate change sensitivity. The conceptual frameworks of Fenton et al. (2007) and Marshall et al. (2010) were used to create 30 items to assess economic (9 items), cultural (7 items), political (7 items), and institutional (7 items) sensitivities. The level of climate change sensitivity was assessed using a five-point Likert scale (1-5). A higher score indicates greater sensitivity to climate change, implying that respondents believe extreme weather has a greater economic and cultural impact on them, as well as that political entities and institutions are more responsive in addressing the impact of climate change. The examples below show items from each of the four sensitivity categories:

- **Economic sensitivity**: "Extreme weather has hampered the quality of my agricultural production." (In Malay: "*Cuaca yang melampau telah menjejaskan kualiti pengeluaran pertanian saya."*)

- **Political sensitivity**: "The extreme weather caused politicians and representatives to visit more often and ask how the residents and farmers in my area are doing." (In Malay: "*Cuaca melampau menyebabkan ahli politik dan wakil rakyat peka dengan lebih kerap berkunjung dan bertanya khabar penduduk dan petani di kawasan saya."*)
- **Cultural sensitivity**: "The extreme weather prevented me from joining together with the villagers." (In Malay: "*Cuaca melampau menghalang saya menyertai gotong- royong bersama-sama penduduk kampung."*)
- **Institutional sensitivity**: "Government agencies actively run programs to help farmers/people due to extreme weather." (In Malay: "*Agensi kerajaan giat menjalankan program membantu petani/penduduk disebabkan cuaca melampau."*)

Control variables

The study used five control variables, including respondents' income level, gender, age, and perceptions of the severity of climate extremes and the health impact of climate change.

- **Income.** To determine income level, respondents were asked to provide the actual figure of their monthly earnings in Malaysia Ringgit. The income figures were then log-transformed for inferential purposes.
- **Female.** The term 'female' is used to distinguish the sex of respondents. In the analysis, men are assigned a value of one and women a value of two.
- **Age.** This is the respondent's age in years.
- **Climate severity.** A person's perception of 'climate severity' can be defined as their personal assessment of the seriousness of climate extremes in their surroundings. This is measured using a 10-point Likert scale (1 - strongly disagree, 10 - strongly agree) for the following statement: "The weather patterns in my area are quite extreme, with erratic and alarming occurrences of both rainfall and heat events." This translates into Malay as: "*Corak cuaca di kawasan saya agak melampau, dengan kejadian hujan dan panas yang tidak menentu dan membimbangkan*." A higher score from a respondent indicates that the respondent is significantly more concerned and anxious about severe weather conditions.
- **Health adversity.** A 10-point scale, with 1 indicating 'strongly disagree' and 10 representing 'strongly agree', was used in this study to collect respondents' perceptions of whether and how extreme weather conditions have negatively impacted their health. The statement presented to them read: "The extreme weather has adversely affected my health." (In Malay: "*Cuaca yang melampau telah menjejaskan kesihatan saya*."). A high score indicates the farmer's perception that severe weather conditions have impacted on his/her health.

5.4 Validity and reliability

In this study, expert validation was used to evaluate the items used to assess the components of the research tool. The research instrument for this study was evaluated and validated by specialists in climate change, agricultural extension, and agricultural economics. In addition, the questionnaire was piloted with 100 respondents to determine its reliability. The pilot test consisted of enumerator interviews with respondents from the KRB's farming villages. During the survey, the enumerators were in charge of administering questionnaires. Cronbach's alpha coefficients for all multi-item scales used in the pilot test exceeded 0.75: economic well-being (0.84), adaptive capacity (0.86), technology adoption (0.92), economic sensitivity (0.87), political sensitivity (0.78), cultural sensitivity (0.86), and institutional sensitivity (0.87). With regard to Hays and Revicki (2005), this study's items measure an appropriate construct because

they provide very close numerical or score values every time they are used when all other factors remain constant.

5.5 Sampling and data collecting

The current study used non-probability sampling, specifically homogeneous convenience sampling, to collect data from respondents. This method was used because it is very useful for targeting subgroups that share characteristics such as culture or occupation, in our case those who rely on agriculture for a living. Although convenience sampling was appropriate for accessing farmers within the Kelantan River Basin, this approach may limit the representativeness of the sample and the generalisability of the findings beyond the study area. However, as noted by Jager et al. (2017), while probability samples are typically more generalised than convenience samples, homogeneous convenience sampling has several advantages. Some of the benefits include cost, time savings, ease of use, and faster results than probability sampling methods. Jager et al. observed that convenience samples can be made more representative by selecting participants who share a high degree of similarity in certain characteristics. This is the case in our study of the agricultural communities in the KRB, thus increasing the study's external validity. All respondents are in the same environment within the same river basin, so they are exposed to the same environmental factors, including those related to climate change. This means that the agricultural communities in the KRB are fairly similar, and thus the study's findings can be generalised to the rest of the population in this environment.

Most of the participants were farmers who were approached at their farms or at social facilities in town. This allowed easy recruitment of farmers from various areas and districts in KRB. The enumerators were in charge of distributing questionnaires during the survey, and participation was entirely voluntary. All subjects were informed about the nature and purpose of the study, as well as the fact that the data collected would be used solely for analysis and never disclosed to any other party. All participants provided informed consent, and all data was collected in a manner that ensured their anonymity, with sample identities handled in accordance with the institution's data management policies.

The power calculation for the current study was performed using G-Power software version 3.1.9.4, which employs the sample size formula developed by Faul et al. (2007). A convenience sampling technique was used to determine the number of participants needed for the study, taking into account factors such as the number of independent variables, average estimated effect size of the predictors (f^2),

level of significance (α), and level of power (1 - β). Initially, it was estimated that at least 178 participants would be required for the study with a medium effect size of f^2 = 0.15, because the current study includes 11 predictor variables (along with control variables), an alpha error probability of 0.05, and a statistical power of 0.95. Nonetheless, to increase the statistical power of the results, the level of significance (alpha) was raised from 0.05 to 0.01, and the power was increased from 0.95 to 0.99. As a result, G-Power software recommended an updated minimum sample size of 287 respondents to ensure statistical power of 99%.

5.6 Data analysis technique

This study used Partial Least Squares Structural Equation Modelling (PLS-SEM) to investigate the relationships between climate change sensitivity, adaptive capacity, technology adoption, and economic well-being. PLS-SEM was chosen because it can handle complex models with multiple latent constructs and mediating relationships and does not require normally distributed data. This technique is appropriate for prediction-oriented research with survey data measured on Likert scales.

The analysis was carried out using SmartPLS software. A two-stage modelling procedure was used. First, the measurement model was evaluated for indicator loadings, internal consistency reliability (composite reliability), convergent validity (average variance extracted), and discriminant validity using the heterotrait-monotrait ratio (HTMT). The structural model was evaluated by analysing path coefficients, R^2, and mediation effects.

The significance of hypothesised relationships was tested using a bootstrapping procedure with 10,000 resamples. All constructs in the study were modelled as reflective constructs, which aligned with the theoretical framework and measurement design.

6 Results

This section presents the results for descriptive statistics, as well as the measurement and structural models. The aim is to validate the measurements and items used in the current study. The structural model assessment is used to estimate the direct and indirect effects of the variables in the path model.

6.1 Descriptive analysis

The sample for this study includes 400 farmers, 357 male and 43 female, all of whom living in the KRB's agricultural settlements. Table 1 shows the demographic information of the respondents and the variables used in this study. The variables in this study were measured using a Likert scale of 1-5, and the mean scores obtained for economic well-being, technology adoption, and adaptive capacity were 3.12, 3.59, and 3.56. This study discovered that among the four aspects of sensitivity, political sensitivity (3.36) was the highest, followed by institutional sensitivity (3.25) and economic sensitivity (3.27), with cultural sensitivity (1.62) being the lowest. Furthermore, this study found that perceived 'climate severity' was high, with an average score of 8.62, while perceived 'health adversity' was low, at 4.37 on a Likert scale of 1 to 10.

Table 1: Descriptive statistics for all variables

	Likert Scale 1–5							Likert Scale 1–10		Total income (RM/month)	Age (years)
Variable	Econ. well.	Econ. sens.	Pol. sens.	Cult. sens.	Inst. sens.	Adap. cap.	Tech. adop.	Clim. sev.	Health adv.		
Mean	3.12	3.27	3.36	1.62	3.25	3.56	3.59	8.62	4.37	3551	48.89
SD	0.74	0.63	0.82	0.69	0.85	0.46	0.88	1.30	2.64	4355	13.42

Note. SD = Standard deviation; Econ. well. = Economic wellbeing; Econ. sens. = Economic sensitivity; Pol. sens. = Political sensitivity; Cult. sens. = Cultural sensitivity; Inst. sens. = Institutional sensitivity; Adap. cap. = Adaptive capacity; Tech. adop. = Technology adoption; Clim. sev. = Climate severity; Health adv. = Health adversity.

6.2 Findings for the measurement model

The purpose of this study was to determine the mediating role of adaptive capacity and technology adoption in the relationship between climate change sensitivity and farmers' economic wellbeing in the KRB. As suggested by Hair et al. (2022), Ringle et al. (2024), and Henseler et al. (2015), the measurement model should be evaluated through 1) convergent validity and reliability, and 2) discriminant validity using the HTMT ratio.

Convergent validity and reliability. Table 2 shows the average variance extracted (AVE), composite reliability (CR), and Cronbach's alpha (CA) for all seven constructs used in this study. The first step in evaluating reflective measurement models is to assess the reliability of the indicators. An outer loading or factor loading greater than 0.71 is recommended, indicating an acceptable level of indicator reliability (Hair et al., 2022; Malhotra, 2010). This means that the construct accounts for more than half (50%) of the variance of the indicator ($0.71^2 = 0.5$). Nonetheless, Hair et al. (2022), Hair et al. (2019) stated that items with outer loadings less than .70 but greater than .40 should not be removed unless the removal results in an increase in composite reliability (CR) and average variance extracted (AVE).

Table 2: Convergent validity, internal consistency, and variance inflation factor

Construct	Item	Factor loading	AVE	CR	Cronbach's alpha
Economic wellbeing	EW1	0.806	0.655	0.938	0.925
	EW2	0.849			
	EW3	0.821			
	EW4	0.834			
	EW5	0.807			
	EW6	0.762			
	EW7	0.791			
	EW8	0.800			
Economic sensitivity	ES1	0.424	0.463	0.848	0.839
	ES2	0.699			
	ES3	0.817			
	ES4	0.426			
	ES7	0.885			
	ES8	0.486			
	ES9	0.839			
Political sensitivity	PS1	0.520	0.459	0.829	0.827
	PS2	0.557			
	PS3	0.627			
	PS4	0.868			
	PS6	0.860			
	PS7	0.536			
Cultural sensitivity	CS1	0.640	0.663	0.931	0.922
	CS2	0.864			
	CS3	0.888			
	CS4	0.928			
	CS5	0.923			
	CS6	0.766			
	CS7	0.627			
Institutional sensitivity	IS1	0.740	0.711	0.945	0.934
	IS2	0.811			
	IS3	0.882			
	IS4	0.862			
	IS5	0.891			
	IS6	0.888			
	IS7	0.817			
Adaptive capacity	AC3	0.798	0.407	0.946	0.941
	AC4	0.793			
	AC5	0.718			
	AC6	0.583			
	AC7	0.692			
	AC8	0.638			
	AC9	0.637			
	AC10	0.568			
	AC11	0.603			
	AC13	0.597			

Continued on next page

Table 2 (continued)

Construct	Item	Factor loading	AVE	CR	Cronbach's alpha
	AC15	0.630			
	AC16	0.605			
	AC17	0.582			
	AC18	0.710			
	AC19	0.627			
	AC21	0.727			
	AC22	0.578			
	AC23	0.447			
	AC27	0.583			
	AC28	0.633			
	AC29	0.680			
	AC31	0.660			
	AC32	0.649			
	AC33	0.545			
	AC35	0.679			
	AC36	0.504			
Technology Adoption	TA1	0.757	0.678	0.975	0.973
	TA2	0.773			
	TA3	0.764			
	TA4	0.777			
	TA5	0.861			
	TA6	0.866			
	TA7	0.879			
	TA8	0.866			
	TA9	0.868			
	TA10	0.888			
	TA11	0.877			
	TA12	0.880			
	TA13	0.889			
	TA14	0.874			
	TA15	0.852			
	TA16	0.858			
	TA17	0.662			
	TA18	0.691			
	TA19	0.707			

Note. AVE = average variance extracted; CR = composite reliability.

Table 2 presents the measurement model's results. It shows that all constructs used in this study have factor loadings greater than .40, after eliminating the items with low factor loadings of less than 0.4, particularly for economic sensitivity (ES5 and ES6) and adaptive capacity (AC1, AC2, AC12, AC14, AC20, AC24, AC25, AC26, AC30, and AC34) (for the adaptive capacity variable, see Table A1 of Appendix A). As a result, as shown in Table 2, all constructs received high AVE scores of more than .5, the minimum threshold value proposed by Hair et al. (2022), with the exception of adaptive capacity, which had an AVE of .41. This is the case because a number of the items have factor loadings less than .71. However, Fornell and Larcker (1981) contended that an AVE score of less than 0.5 is acceptable if the composite reliability (CR) values exceed 0.6. This is used in a variety of other studies, including Lam (2012)'s study, which faced the same situation. As shown in Table 2, the CR value of adaptive capacity is 0.95, which is significantly higher than 0.6, indicating that the construct's convergent validity is still acceptable. Table 2 shows that CR

values for other constructs exceed the minimum cut off point of 0.6.

The next step is to evaluate the constructs' internal consistency and reliability. Table 2 shows that the Cronbach's alpha coefficients for all constructs range from .83 to .97, all of which are significantly higher than the minimum recommended by Hair et al. (2009) and Hair et al. (2022). Overall, the results of factor loading, AVE, CR, and Cronbach's alpha confirmed the convergent validity and reliability of all constructs in this study.

Discriminant validity. This study used the HTMT criterion to assess discriminant validity. According to Henseler et al. (2015), the HTMT criterion outperforms the Fornell and Larcker criterion and the assessment of partial cross-loadings in terms of discriminant validity. According to Hair et al. (2022) and Ringle et al. (2024), all HTMT values must be less than 0.9 to meet the requirement. Except for control variables, Table 3 shows that all HTMT ratios for constructs are less than 0.9, with values ranging from 0.04 to 0.62, indicating that discriminant validity between two reflective measured constructs has been confirmed.

Table 3: HTMT discriminant validity result with the inclusion of control variables in the analysis

No.	Variable	1	2	3	4	5	6	7	8	9	10	11
1	Adaptive capacity											
2	Age	0.159										
3	Climate severity	0.328	0.007									
4	Cultural sensitivity	0.327	0.035	0.102								
5	Economic sensitivity	0.333	0.106	0.129	0.175							
6	Economic wellbeing	0.620	0.072	0.355	0.148	0.162						
7	Female	0.123	0.044	0.004	0.053	0.043	0.124					
8	Health adversity	0.178	0.054	0.245	0.181	0.276	0.122	0.022				
9	Income	0.166	0.043	0.102	0.192	0.045	0.204	0.171	0.116			
10	Institutional sensitivity	0.287	0.035	0.105	0.205	0.227	0.140	0.083	0.219	0.105		
11	Political sensitivity	0.299	0.060	0.193	0.173	0.255	0.176	0.084	0.317	0.111	0.579	
12	Technology adoption	0.669	0.141	0.123	0.252	0.286	0.320	0.149	0.061	0.215	0.332	0.253

6.3 Findings for the structural model

This section reports the structural model results after examining the measurement model results. To that end, as suggested by Hair et al. (2022), multicollinearity was investigated and it was determined that the model had no multicollinearity issues. Table 4 shows all of the independent variables and their corresponding dependent variables, as well as their variance inflation factor (VIF). The VIF values range from 1.027 to 2.246. This is less than 2.5, indicating that there is no issue with multicollinearity.

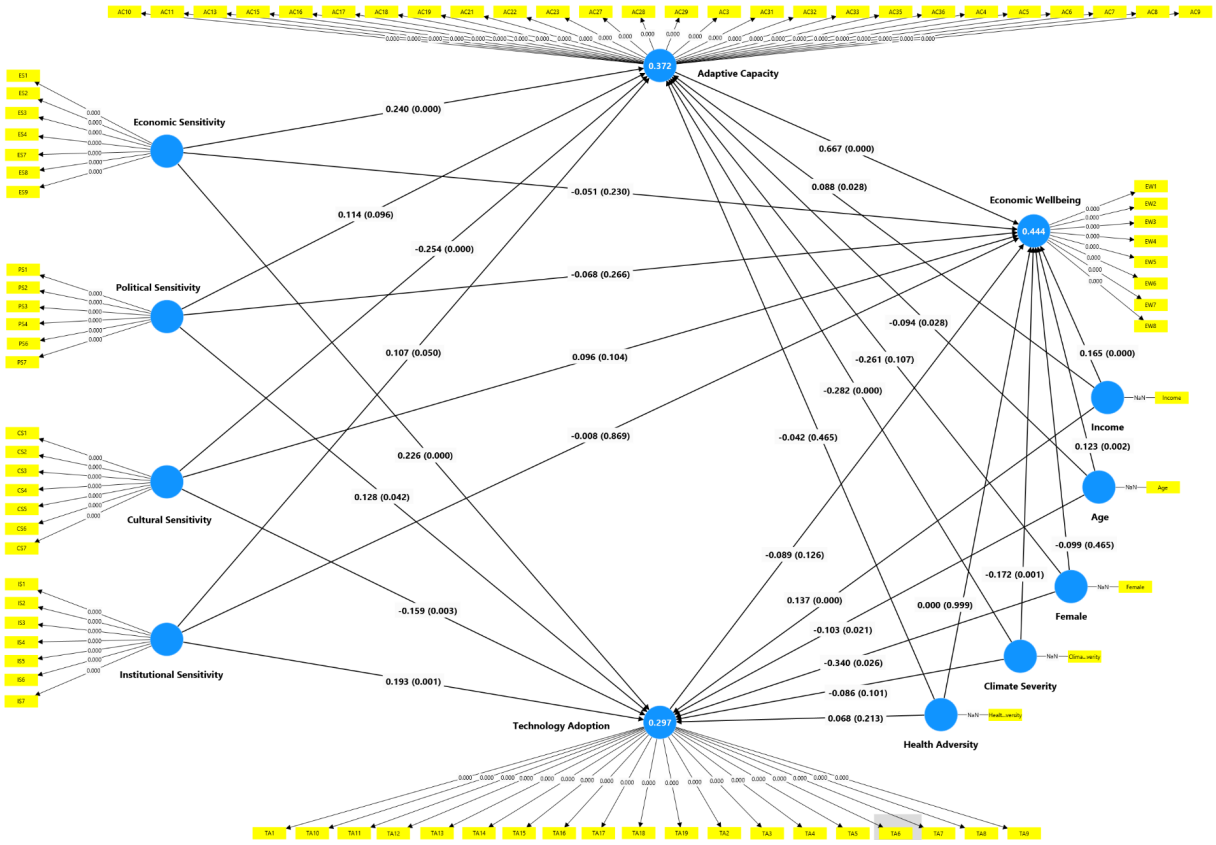

Figure 3: The finalized graphical output of path analysis for the interrelationships between all variables influencing the economic well-being of farmers' communities in the Kelantan River Basin as a result of climate change sensitivities caused by climate extremes.

Table 4: Collinearity assessment of independent variables as predictors of adaptive capacity, economic well-being, and technology adoption

Variable	Variance Inflation Factor (VIF)		
	Adaptive capacity	Technology adoption	Economic wellbeing
Female	1.041	1.041	1.058
Age	1.027	1.027	1.046
Income	1.087	1.087	1.115
Climate severity	1.148	1.148	1.286
Health adversity	1.429	1.429	1.448
Economic sensitivity	1.154	1.154	1.262
Political sensitivity	1.738	1.738	1.767
Cultural sensitivity	1.154	1.154	1.257
Institutional sensitivity	1.491	1.491	1.544
Adaptive capacity	NA	NA	2.246
Technology adoption	NA	NA	2.006

Figure 3 shows a diagrammatic representation of the structural model's results. The R^2 values for the dependent variables are displayed in the ovals, while the beta coefficient and p-value (in brackets) for each of the independent variables are shown alongside the arrows that connect the independent variables to the dependent variable.

Table 5 shows the structural model's R^2 values for each dependent variable, as well as the direct effects of all variables in the path model. Economic well-being has the highest R^2 value of .444, followed by adaptive capacity and technology adoption at .372 and .297, respectively. R^2 values of .25, .50, and .75 are classified as low, medium, and high, depending on the field of social science research (Hair et al., 2011). However, the values of R^2 that are currently deemed reasonable vary depending on the research context, and in some fields, the R^2 value that is considered reasonable may be as low as .10, particularly for studies that have not previously been published or when using new independent variables, such as the current study. For example, Raithel et al. (2012) claimed that R^2 values as low as .10 are sufficient for forecasting profits from stock returns.

Table 5: Direct effects for all variables specified in the path model.

Dependent variable	Direct effect	β coeff.	SD	*t* stat.	*p* value	R^2
Economic wellbeing	Adaptive capacity → Economic wellbeing	0.667	0.062	10.711	0.000	0.444
	Technology adoption → Economic wellbeing	-0.089	0.058	1.531	0.126	
	Economic sensitivity → Economic wellbeing	-0.051	0.042	1.201	0.230	
	Political sensitivity → Economic wellbeing	-0.068	0.061	1.113	0.266	
	Cultural sensitivity → Economic wellbeing	0.096	0.059	1.627	0.104	
	Institutional sensitivity → Economic wellbeing	-0.008	0.051	0.165	0.869	
	Income → Economic wellbeing	0.165	0.039	4.191	0.000	
	Female → Economic wellbeing	-0.099	0.135	0.731	0.465	
	Age → Economic wellbeing	0.123	0.040	3.090	0.002	
	Climate severity → Economic wellbeing	-0.172	0.054	3.194	0.001	
	Health adversity → Economic wellbeing	0.000	0.052	0.002	0.999	
Adaptive capacity	Economic sensitivity → Adaptive capacity	0.240	0.052	4.614	0.000	0.372
	Political sensitivity → Adaptive capacity	0.114	0.069	1.665	0.096	
	Cultural sensitivity → Adaptive capacity	-0.254	0.047	5.467	0.000	
	Institutional sensitivity → Adaptive capacity	0.107	0.054	1.962	0.050	
	Income → Adaptive capacity	0.088	0.040	2.201	0.028	
	Female → Adaptive capacity	-0.261	0.162	1.611	0.107	
	Age → Adaptive capacity	-0.094	0.043	2.202	0.028	
	Climate severity → Adaptive capacity	-0.282	0.052	5.414	0.000	
	Health adversity → Adaptive capacity	-0.042	0.057	0.730	0.465	
Technology adoption	Economic sensitivity → Technology adoption	0.226	0.046	4.881	0.000	0.297
	Political sensitivity → Technology adoption	0.128	0.063	2.037	0.042	

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Dependent variable	Direct effect	β coeff.	SD	*t* stat.	*p* value	R^2
	Cultural sensitivity → Technology adoption	-0.159	0.054	2.940	0.003	
	Institutional sensitivity → Technology adoption	0.193	0.058	3.345	0.001	
	Income → Technology adoption	0.137	0.038	3.614	0.000	
	Female → Technology adoption	-0.340	0.153	2.231	0.026	
	Age → Technology adoption	-0.103	0.045	2.317	0.021	
	Climate severity → Technology adoption	-0.086	0.052	1.640	0.101	
	Health adversity → Technology adoption	0.068	0.054	1.244	0.213	

Note. The direction of arrows indicates the direction of effects. The path coefficients and *t*-statistics were calculated using bootstrapping with 10,000 replications.

Table 5 shows that adaptive capacity (β = .67, p < .01) positively influenced economic wellbeing, while technology adoption (β = -.09, p > .10) did not. Thus, an increase in adaptive capacity resulted in improved economic well-being for farmers, whereas technology adoption did not. The coefficient estimate of adaptive capacity was extremely large, indicating that adaptive capacity is critical for the economic well-being of farmers in the KRB.

This study also investigated the outcomes of four different types of social system sensitivity. Controlling for other variables, it was discovered that the direct effects of economic, political, cultural, and institutional sensitivity were not significant on farmers' economic well-being, with p-values greater than 10%. This evidence suggests that farmers who are economically, politically, culturally, and institutionally sensitive to climate change did not feel deprived in terms of economic well-being.

The effects of control factors on economic well-being were also examined. Age (β = .12, p < .01) and income (β = .17, p < .01) had positive effects on economic well-being, while climate severity (β = -.17, p < .01) had a negative impact. Table 5 shows that, at the 10% level of significance, health adversity had no effect on economic wellbeing. Thus, the elderly and high-income earners were found to have better economic well-being than their counterparts, whereas farmers who believed that climate change had exacerbated their lives reported poor economic conditions.

This study sought to determine whether farmers' sensitivity to climate change has led to the adoption of technology and improved adaptation in their work. Table 5 shows that institutional sensitivity (β = .11; p > .05) and political sensitivity (β = .11; p > .05) did not significantly affect adaptive capacity. These findings show that the perceived responsiveness of institutions and political representatives to climate change impact did not influence farmers' adaptive capacity. Economic sensitivity (β = .24; p < .01) had a significant positive effect, while cultural sensitivity (β = -.25; p < .01) had a negative effect on adaptive capacity. The effect sizes were similar. The findings of this study show that farmers tend to improve their adaptive capacity when they believe climate change has harmed their economy. However, if they believe that extreme climate had had a negative impact on their sociocultural activities, their adaptive capacity decreases.

This implies that farmers who have been affected by extreme weather conditions, resulting in the loss of physical socialisation and cultures, have become less prepared — or have always been less prepared — to deal with the effects of climate change in their lives. This is because social capital, in the form of good networks and community relations, contributes to the availability of resources and improves the community's coping and adaptive measures to the effects of climate change (Nelson et al., 2007; Pelling & High, 2005). As a result, the overall deterioration of this function in the community can be attributed to climate change, which has limited face-to-face information exchange and hampered learning among farmers, both of which are critical for improving their adaptive capacity.

There are some control factors that are critical to determining adaptive capacity. High income earners are more likely to adjust their working style and take adaptive measures during climate change events, indicating a positive relationship between income and adaptation. This study found no significant relationship between gender and farmer adaptive capacity (β = .09; p < .05). Age had a negative effect on adaptive capacity (β = -.09; p < .05), suggesting that young farmers were more adaptable than older farmers. Perceived climate severity significantly reduced adaptive capacity (β = -.28; p < .01), while health adversity had no significant effect (β = -.04; p > .10). These findings imply that health consequences attributed to climate extremes did not persuade farmers to take actions to improve their adaptive capacity for dealing with climate change. Farmers who believed that climate change was worse became less adaptive in dealing with it, indicating a strong negative relationship.

Perhaps, farmers who consider extreme climate events to be worse can be said to suffer from climate anxiety, which makes them more likely to choose incorrect strategies for dealing with the effects of climate change. Climate anxiety, also known as eco-anxiety, is the fear that people today have about climate change and the stress that comes with it. Stress, hopelessness in the face of climate change, and a variety of other issues all have an impact on mental health. Individuals with pre-existing mental health vulnerabilities or low stress tolerance may be more prone to developing climate anxiety when exposed to severe climate events. Similar patterns have also been observed among younger populations exposed to repeated media coverage of climate risks in Western contexts. Mental stress can also weaken an individual's cognitive processes, limiting one's ability to understand climate change and its implications. This fear of climate uncertainty and the future that climate change brings results in a lack of innovation and risk-taking. Such an attitude will lead farmers to overlook innovative approaches that could increase their flexibility, adaptability, and productivity. The term 'climate anxiety' refers to the difficulty people have in getting up and acting against the negative effects of climate change. Climate anxiety may also lead to self-centredness, which may prevent the community structure from collectively addressing climate change issues. Climate anxiety may also impair cooperation within communities by reinforcing withdrawal or self-focused behaviours, thereby reducing collective responses to climate challenges. Similarly, these factors contribute to negative dynamics in the sociocultural relationship and reduce the potential for community-based adaptation (Albrecht, 2011; Berry et al., 2010; Clayton et al., 2014; Clayton et al., 2017; Cunsolo & Ellis, 2018; Hickman, 2020; Hickman et al., 2021). While anxiety may promote defensive behaviours aimed at avoiding perceived risks, effective adaptation requires proactive strategies that build resilience and enable positive outcomes beyond immediate crisis response.

Farmers who perceive extreme climate events as becoming more severe may experience increased stress, concern, and uncertainty about future climate conditions, influencing their decision-making processes. Prolonged exposure to extreme events and uncertainty can put a strain on people's cognitive and emotional systems, potentially limiting their ability to evaluate long-term options and engage in proactive adaptation strategies. Under such circumstances, farmers may prioritise short-term coping responses and risk avoidance, discouraging innovation and experimentation with new practices.

Increased concern about climate uncertainty may have an impact on social and collective dynamics. When people focus solely on immediate livelihood risks, cooperation and collective problem-solving within communities may suffer, reducing the effectiveness of community-based adaptation efforts. Reduced trust, withdrawal from collective action, and a reluctance to share risks can all erode sociocultural relationships that facilitate adaptive responses. These dynamics have been extensively discussed in the literature on the social and emotional dimensions of climate change impacts, particularly in terms of stress, uncertainty, and perceived loss of control (Albrecht, 2011; Berry et al., 2010; Clayton et al., 2014; Clayton et al., 2017; Cunsolo & Ellis, 2018; Hickman, 2020; Hickman et al., 2021). While increased concern may encourage defensive and risk-averse behaviours, effective adaptation necessitates decision-making environments that promote learning, collaboration, and long-term resilience.

In addition, the effect of sensitivity on technology adoption was investigated. The findings, included in Table 5, revealed that all aspects of sensitivities had a significant impact on technology adoption. Economic sensitivity (β = .23; p < .01) had the greatest impact on technology adoption, followed by institutional (β = .19; p < .01), cultural (β = -.16; p < .01), and political (β = .13; p < .05) sensitivity. While cultural sensitivity

had a negative impact on technology adoption, other sensitivities had a positive effect. These findings indicate that farmers who are more economically sensitive to extreme weather conditions, as well as those who believe that institutions and politics are effective in dealing with climate extremes, are more likely to use technology in their agricultural activities. Farmers who believed that climate change had a negative impact on their sociocultural activities were less likely to incorporate technology into their work. From these perspectives, it can be argued that sociocultural activities are critical to KRB communities, particularly to farmers who require new ideas and technological knowledge about agriculture as a result of climate extremes. Sociocultural activities could have been the means by which farmers gathered new technological information to help them understand and deal with the consequences of climate events.

An analysis of control variables' effects on technology adoption was also conducted. Income had a positive effect on technology adoption (β = .14; p < .01). High-income farmers are more likely to adopt technology in their agricultural activities. This finding is plausible because agricultural technology is often expensive, particularly at the outset, and thus more affordable to higher-income farmers. However, it is also possible that technology adoption itself contributes to higher income over time. Distinguishing between these causal directions would require longitudinal data, which was beyond the scope of this study and represents a limitation that should be acknowledged. Table 5 shows that older age (β = -.10; p < .05) and being female (β = -.34; p < .05) had a significant negative impact on farmers' technology adoption at the 5% level. Male and younger farmers were more capable of implementing technology to improve their agricultural activities. However, self-reported health adversity (β = .07; p > .10) and climate severity (β = -.09; p > .10) had no significant impact on technology adoption, even at the 10% level. This finding contradicts the strong negative association (β = -.28; p < .01) between perceived climate severity and adaptive capacity found in this study. It suggests that 'climate anxiety' among farmers in KRB did not influence their likelihood to adopt technology for coping with climate extremes.

As previously stated, one of the primary questions raised in this study is whether adaptive capacity and technology adoption can help to mediate the impact of climate change sensitivities on economic wellbeing. As previously stated in Table 5, economic, political, cultural, and institutional sensitivity had no significant effect on farmers' economic well-being. Table 6 shows the indirect effect analysis, which tests the hypothesis that adaptive capacity and technology adoption mediate the effects of climate change sensitivities on economic wellbeing.

Table 6: Specific indirect effects for all variables specified in the path model.

Mediator	**Specific indirect effect**	β **coefficient**	**Std. dev.**	***t* stat.**	***p* value**
Adaptive capacity	Economic sensitivity → Adaptive capacity → Economic wellbeing	0.160	0.042	3.852	0.000
	Political sensitivity → Adaptive capacity → Economic wellbeing	0.076	0.047	1.614	0.107
	Cultural sensitivity → Adaptive capacity → Economic wellbeing	-0.170	0.035	4.821	0.000
	Institutional sensitivity → Adaptive capacity → Economic wellbeing	0.071	0.037	1.919	0.055
	Income → Adaptive capacity → Economic wellbeing	0.059	0.027	2.153	0.031
	Female → Adaptive capacity → Economic wellbeing	-0.174	0.110	1.585	0.113
	Age → Adaptive capacity → Economic wellbeing	-0.063	0.030	2.134	0.033
	Climate severity → Adaptive capacity → Economic wellbeing	-0.188	0.035	5.423	0.000
	Health adversity → Adaptive capacity → Economic wellbeing	-0.028	0.039	0.721	0.471

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Mediator	Specific indirect effect	β coefficient	Std. dev.	*t* stat.	*p* value
Technology adoption	Economic sensitivity → Technology adoption → Economic wellbeing	-0.020	0.014	1.400	0.162
	Political sensitivity → Technology adoption → Economic wellbeing	-0.011	0.010	1.141	0.254
	Cultural sensitivity → Technology adoption → Economic wellbeing	0.014	0.011	1.245	0.213
	Institutional sensitivity → Technology adoption → Economic wellbeing	-0.017	0.013	1.309	0.190
	Income → Technology adoption → Economic wellbeing	-0.012	0.009	1.378	0.168
	Female → Technology adoption → Economic wellbeing	0.030	0.027	1.127	0.260
	Age → Technology adoption → Economic wellbeing	0.009	0.008	1.227	0.220
	Climate severity → Technology adoption → Economic wellbeing	0.008	0.007	1.041	0.298
	Health adversity → Technology adoption → Economic wellbeing	-0.006	0.007	0.916	0.360

Note. The direction of arrows indicates the direction of effects. The path coefficients and *t*-statistics were calculated using bootstrapping with 10,000 replications.

Table 6 shows that adaptive capacity mediated the effect of economic sensitivity (β = .16; p < .01) and cultural sensitivity (β = -.17; p < .01) on economic well-being. However, effects of political sensitivity (β = .08, p > .10) and institutional sensitivity (β = .07, p > .05) on economic well-being were not significantly mediated by adaptive capacity. Adaptive capacity significantly mediated the effects of control variables, including climate severity (β = -.19; p < .01), income (β = .05; p < .05), and age (β = -.06; p < .05), on economic well-being. Among these, climate severity had the largest effect size. Nonetheless, even at the 10% level, the expected role of adaptive capacity as a mediator for the relationship between farmer gender and economic well-being was not statistically significant.

The role of technology adoption as mediator was also investigated. According to Table 6, all dimensions of climate change sensitivity did not channel their effects towards economic well-being via technology adoption. This is because the direct effect of technology adoption was not statistically significant (refer to Table 5).

7 Discussion

Climate change affects agricultural communities in the Kelantan River Basin (KRB). This study used Rational Choice Theory (RCT) to determine how climate change sensitivity, particularly economic, political, cultural, and institutional sensitivity, affects farmers' ability to cope with climate extremes and to adopt technology in agriculture. Path analysis was used to investigate if and how adaptive capacity and technology adoption mediate the relationship between climate change sensitivity and economic well-being. In general, farmers in KRB agricultural communities perceived moderately high levels of political (3.36), economic (3.27), and institutional (3.25) sensitivity, while cultural sensitivity was the lowest (1.62) on a Likert scale of 1 to 5.

The rational choice theory used in this study assumes that farmers are rational individuals capable of thinking rationally while taking into account available knowledge and their awareness of climate extremes. Knowledge, belief and rational thinking led farmers to select the strategies they considered best to secure and improve their livelihoods, which includes high agricultural productivity and economic sustainability, both of which can be achieved through high adaptive capacity and technology adoption. Without external stimuli, such as climate shocks, farmers will not change or advance because intentional development of enhanced

adaptive capacity or adoption of technology is labour-intensive and expensive. As a result, an individual's ability to take the initiative or think for himself or herself when it comes to climate change adaptation is influenced by the trigger factor, which is defined as the vulnerability or sensitivity that one experiences during climate events, as highlighted by Fenton et al. (2007) and Marshall et al. (2010) as economic, political, cultural, and institutional sensitivities. These sensitivities are viewed in this study as sources of awareness, information, or knowledge of uncertainties that will lead farmers to develop strategies based on the options available to them, such as investing more effort in gaining higher adaptive capacity or adopting technology to manage the adverse effects of climate extremes, with the goal of achieving the best outcome in their farming or business.

The findings of this study show that adaptive capacity had a positive and significant impact on farmers' economic well-being, whereas technology adoption did not. This may be because technology adoption does not always generate immediate economic returns, especially when associated with adjustment costs and learning periods. Adaptive capacity, by contrast, represents a broader ability to manage risks and respond to change, which may have a more direct influence on economic well-being. Furthermore, higher economic sensitivity increased adaptive capacity, whereas cultural sensitivity decreased it. Political and institutional sensitivity had no significant effect on adaptive capacity. Thus, farmers who believe they are economically impacted are more likely to develop the ability to adapt to changes in their surroundings. Furthermore, it is worth noting that sociocultural practices have been instrumental in passing knowledge to farmers, which is an important source of climate change adaptation strategy. It may be argued that when extreme climate events disrupt social relationships and cultural practices, farmers' ability to adapt is weakened because these networks play an important role in sharing knowledge and supporting collective coping strategies. Furthermore, path analysis revealed that adaptive capacity significantly mediated the effects of economic and cultural sensitivities on farmers' economic wellbeing in KRB.

Importantly, all dimensions of sensitivity had a significant impact on technology adoption. Economic, political, and institutional sensitivity favoured technology adoption, whereas cultural sensitivity had a negative impact. Among these, economic sensitivity had the greatest impact. However, technology adoption did not mediate the impact of sensitivities. As a result, this study confirmed that farmers' perceptions of political and institutional responsiveness and efficiency in addressing climate change are critical for encouraging the adoption of technology but not adaptive capacity development among farmers in KRB. Adaptive capacity is shaped primarily by individual and community-level efforts, whereas technology adoption is often promoted by external actors such as government agencies, extension services, and technology providers. As a result, technology adoption may be more influenced by conformity or deference to authority, while adaptive capacity relies more on local initiative and community collaboration. Farmers who observe strong and credible support from institutions and political leaders are therefore more likely to follow these cues and adopt new technologies. Furthermore, it is possible to argue that adaptive capacity is difficult to develop among farmers in the KRB. However, when farmers see strong efforts from the government's political and institutional sides, they are more likely to incorporate technology into their agricultural activities rather than becoming more adapted to climate extremes.

Farmers in the KRB, on the other hand, will become more resilient to climate change as economic and cultural sensitivities act as triggers. In this case, it is reasonable to propose that institutional and political sensitivities are simply based on what farmers perceive superiors (e.g., institutions, politicians, or government) to be doing, whereas economic and cultural sensitivities are based on what farmers themselves have suffered or experienced (economically or culturally) during the climate extreme, both of which have been channelled to adaptive capacity. However, it should be noted that there are numerous ways to become more adaptive, including the sixteen dimensions identified by Marshall et al. (2010) and utilised in this study. However, the current study did not look into the specifics of each dimension and how they relate to sensitivities.

According to the findings, it is appropriate to focus on the development of adaptive capacity among farmers in order to ensure the sustainability of the agricultural community in the KRB, as adaptive capacity had a significant impact on economic well-being while technology adoption did not. The term 'adaptive capacity' is consistent with the community's empowerment concept, which in this study is fuelled by farmers'

economic and cultural sensitivity to climate change. In this study, relevant climate change sensitivities appear to serve as push factors that motivate farmers, as rational individuals, to prepare themselves by developing their adaptive capacity and adopting technology. To equip and protect local farming communities from current and future climate change risks, long-term adaptation and coping strategies must be advocated for. To address these challenges, governments, research institutions, and other stakeholders must work together to ensure economic sustainability and the well-being of farmers in the KRB.

Beyond the individual relationships studied, the findings of this study add to the larger climate change adaptation literature by emphasising the importance of adaptive capacity in shaping economic well-being under climate stress. Rather than treating technology adoption as a stand-alone solution, the findings show that adaptation outcomes are dependent on how farmers perceive and respond to multiple dimensions of climate change sensitivity. This integrated perspective contributes to a better understanding of adaptation as a socioeconomic process influenced by economic, cultural, political, and institutional contexts, rather than just technical interventions.

From a policy and institutional standpoint, these findings emphasise the importance of prioritising capacity-building measures that improve farmers' ability to manage risk, make informed decisions, and sustain livelihoods in the face of climate uncertainty. Strengthening adaptive capacity through financial support, institutional trust, and locally appropriate interventions may produce more long-term benefits than technology promotion alone. For farmers, the findings highlight the importance of adaptive skills, collective support, and resilience-oriented strategies in dealing with the effects of climate change, providing insights that can be applied to other climate-vulnerable agricultural regions.

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Author contributions

NASB conceptualised the study, analysed the data, and wrote the initial draft. ARAL and SD analysed the data. HAMS, AAS, HAR, SFAS, SFS, NA, JAS, NAK, LJ, and FT conceptualised the study. All authors reviewed, revised, and approved the final manuscript.

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APPENDIX

Table 7: List of domains included in the data collection and final analysis stages.

No.	Domains of adaptive capacity at the scale of the individual (Marshall et al., 2010)	Inclusion of domain (Yes / No)	
		Stage of data collection	Stage of final analysis
1.	Perception of risk	Yes	No
2.	Ability to cope with change	Yes	Yes

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No.	Domains of adaptive capacity at the scale of the individual (Marshall et al., 2010)	Inclusion of domain (Yes / No)	
		Stage of data collection	Stage of final analysis
3.	Level of interest in change	Yes	Yes
4.	Ability to plan, learn, reorganize	Yes	Yes
5.	Attachment to occupation	Yes	Yes
6.	Employability	Yes	Yes
7.	Family characteristics	Yes	Yes
8.	Attachment to place	Yes	Yes
9.	Business size and approach	Yes	Yes
10.	Financial status, access to credit	Yes	Yes
11.	Income diversity	Yes	No
12.	Local environmental knowledge	Yes	Yes
13.	Environmental awareness, attitudes and beliefs	Yes	Yes
14.	Access to technology, climate information and skills	Yes	Yes
15.	Formal and informal networks	Yes	Yes
16.	Perception of equity in accessing resources	Yes	Yes