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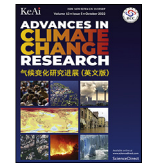

Assessing household perception, autonomous adaptation and economic value of adaptation benefits: Evidence from West Coast of Peninsular Malaysia

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Abstract

Climate change is causing sea-level rise, intense and frequent storm surge flooding, and significant shoreline erosion in Malaysian coastal areas. Consequently, coastal properties, infrastructure, and livelihoods are threatened. It has become apparent that adaptation at the household and community level is necessary to offset the adverse impacts of coastal hazards. The community needs to be made aware of the risks, acquire knowledge about adaptation options, and be empowered to take their own actions. Public perception and preference are therefore crucial for design and implementation of effective planning for climate change. Thus, this study assesses households' perception, adaptation measures and empirically estimates willingness to pay and preference for planned adaptation measures to guide policy instruments through public engagement. In Malaysia, ten highly vulnerable coastal areas in the Selangor coast were surveyed at the household level ($n = 1016$) through face-to-face interviews using a structured questionnaire. Regarding households' perception and adaptation methods, most of the households in the highly exposed areas perceived less risk of inundation and sea-level rise threat and adopted less proactive adaptation and limited risk reduction behaviours during the extreme event. The study found that 66.9% of households were willing to pay for planned adaptation measures despite the limited income capabilities and in favour of moderate adaptation (23.9%). The binomial and ordinal regression results indicated that the probability of willingness to pay for planned adaptation measures significantly increases with age, prior exposure to coastal hazards, awareness, risk perception, community participation, being affected by property damage and loss of income due to extreme events. With increased monthly household income and access to telecommunication services, households will probably pay higher for better adaptation measures. A significant amount of perceived yearly adaptation benefits in the coastal districts revealed the economic value of extensive (22,969.50 MYR/5462.43 USD), moderate (21,853.20 MYR/5196.96 USD) and minimal adaptation measures (8022.90 MYR/1907.94 USD) that can be utilised to incentivise coastal adaptation plans. The findings suggest policies to incorporate social values to reduce vulnerability, enhance community resilience, and contribute to the knowledge gap of adaptation research in the coastal areas.

Keywords: Risk perception; Climate awareness; Public engagement; Factors affecting adaptation; Willingness to pay

1. Introduction

The global climate is changing the geophysical, biological and socio-economic systems and is a mounting threat to the community's well-being and livelihoods (IPCC, 2018). Increased climate-related risk and vulnerability at the different

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levels are cascading across sectors and regions, especially to infrastructure and low-lying coastal settlements due to slow-onset events of sea-level rise, ocean acidification and salinisation and frequent intense extreme events (e.g., storm surge, flooding, and erosion) (IPCC, 2022). The consequence of inaction would pose long term detrimental effects by causing damages to coastal properties and critical infrastructure, irreparable damages to the ecosystem services, several mangrove functions, aquaculture, cultural resources, livelihood and public health and safety (Ehsan et al., 2019, 2022; Oppenheimer et al., 2019). These problems aggravate the potential susceptibility, risk, and hazard to developing a sustainable coastal township (Ahmad et al., 2021). Empirical evidence reflects the considerably high economic cost of climate change impacts (Roy and Haider, 2019; Saginor and Ge, 2017; Van-Putten et al., 2014).

Given climate change's current and projected adverse impacts at varying spatial and temporal scales, mitigation and adaptation are necessary to reduce and manage the risks and vulnerability. Whereas mitigation aims to retard the global warming process by cutting greenhouse gas emissions, adaptation aims to build resilience to the impacts that cannot be avoided (Khatibi et al., 2021). In the coastal context, adaptation will provide immediate and longer-term risk reductions at the local scale and plays a key role in reducing exposure and vulnerability to climate change (IPCC, 2014, 2018, 2022). Adaptation of climate change refers to any adjustments to human activities that reduce the vulnerability of humans and ecosystems to climate change impacts and increase resilience to climate change (IPCC, 2014). There are different feasible and effective adaptation options (Sinay and Carter, 2020), which are commonly adopted by the households and the authorities (Rahman and Hickey, 2019) at different intervals such as before (anticipatory adaptation), during (concurrent adaptation) or after coastal hazards (reactive adaptation).

As IPCC (2014) estimated, without adaptation, hundreds of millions of people will be affected by coastal hazards by the year 2100; most of those affected are from the South-East Asian regions. WEF (2019) ranked extreme weather events and failure to adapt to the likely impacts of climate change as the two most significant threats to humanity. Factors of household-level adaptation and their preference for planned adaptation are crucial because households contribute to greenhouse gas emissions and are severely affected by climate change (González-Hernández et al., 2019a, 2019b). Policy actions to address climate change need to consider public perceptions and be understood for successful implementation of adaptation (Khatibi et al., 2021; Jamshidi et al., 2018; Lebbe et al., 2021). Therefore, assessing household adaptation from several dimensions is critical to understanding how households perceive and adapt to climate change as a part of an integrated adaptation framework for vulnerable coastal areas to enhance policy towards tackling the challenges of changing climate.

A growing body of literature has focused on investigating public engagement in policy planning, autonomous adaptation, factors affecting household adaptation, willingness to pay and quantification of adaptation benefit for planned measures. Prevailing studies on household adaptation assessment can be broadly categorised into two spectrums. On the one hand, several studies assessed households' perception, autonomous adaptation, preference of planned adaptation measures and the factors affecting their choice without empirically quantifying their willingness to pay for adaptation (e.g. Abid et al., 2015; Huong et al., 2017; Jellason et al., 2019; Baba and Tanaka, 2019; Uddin et al., 2014; Wang et al., 2014; Samah et al., 2019; Shaffril et al., 2017; Bawakyillenuo et al., 2016; Carlton et al., 2016; Castañeda et al., 2020; Eitzinger et al., 2018; Frondel et al., 2017; Koerth et al., 2017; Lawrence et al., 2014; Lazrus, 2015; Luís et al., 2018; Mersha and van Laerhoven, 2018; Pandey et al., 2018; Pecl et al., 2019; Rodríguez-Cruz and Niles, 2021; Shukla et al., 2019).

On the other hand, some studies attempted to quantify the households' willingness to pay for planned adaptation measures and the factors affecting their willingness to pay (e.g. Al-Amin et al., 2020; Akter, 2020; Masud et al., 2015). Studies indicate that households' willingness to pay for adaptation and value differ among communities. For instance, Masud et al. (2015), Ahmed et al. (2015), Acquah (2011) found that majority of the respondents are willing to for a planned adaptation programme. In contrary, several studies showed significantly low willingness to pay for adaptation measures (Begum et al., 2016; Gravitiani et al., 2018; Tapsuwan et al., 2014).

Climate-related hazards are prominent in Malaysian coastal areas; coastal flooding and high tide impacts are also evident in low-lying areas (Saudi et al., 2015). Coastal erosion significantly affects the coastal system and infrastructure such as mangroves, residential properties and roads in Selangor and Batu Pahat (Selamat et al., 2017; Maulud and Rafar, 2015). Effective adaptation measures are urgently needed and public support for climate change measures is a critical factor in influencing the willingness or reluctance of policymakers to adopt such measures (Carattini et al., 2017). However, research into the household adaptation to climate change in Malaysia primarily focuses on the agricultural sector (Al-Amin et al., 2020; Masud et al., 2015) and fishing context (Samah et al., 2019; Shaffril et al., 2017). There is limited empirical evidence of households' adaption preferences, willingness to pay for planned coastal adaptation measures, and households' perceived adaptation benefits in Malaysia. In addition, researches related to various dimensions of adaptation such as the autonomous actions adopted by the households, awareness, risk perception and factors influencing willingness to pay for planned adaptation remain inadequate. Malaysia's Third National Communication to the UNFCCC also addresses the research gap and needs to assess adaptation measures to enhance resilience to protect its development gains (Government of Malaysia, 2018). In addition, IPCC (2014) also indicates insufficient information on the assessment of adaptation options at the local level and the under-researched area coastal adaptation from an economic viewpoint for valuing adaptation benefits.

Thus, understanding and assessing household adaptation and valuing the benefits of adaptation provide insights into the household perspective and guide policy and development of adaptation strategies at the local level towards coastal community resilience. This study aims to assess household adaptation to climate change impacts associated with rising sea level, coastal flooding and inundation, integrating risk perception, autonomous adaptation and estimate willingness to pay for planned adaptation measures and perceived adaptation benefit. In addition, this study also identifies explanatory factors that contribute to the households' willingness to pay and choice of coastal adaptation measures to recommend policy and enhance efficient, cost-effective adaptation process. Based on the study findings and recommendations, policymakers can formulate and implement effective coastal adaptation strategies in Malaysia.

2. Methodology

2.1. Study area

Malaysia is experiencing an increasing trend in annual mean surface temperature, mean sea level and occurrences of extreme weather events (Tang, 2019). Coastal regions are constantly facing climate-related hazards; among the total coastline of 8840 km, 1349.3 km of coastline is continuously being eroded (Government of Malaysia, 2018). The adverse impacts of climate change on the coastal resources are evidenced as reduced fish density and yearly production (DoF, 2017), mass coral reef bleaching (NRE, 2016), and decreased agricultural productivity and profitability (Alam et al., 2011, 2014; Vaghefi et al., 2016). Throughout the 21st century, the climate in Malaysia is projected to observe a further unfavourable impacts (NAHRIM, 2021).

The study area is along the Selangor coastline from Tanjung Sepat to Bagan Nakhoda Omar, which is located at the west coast of Peninsular Malaysia facing the Straits of Melaka. Malaysian National Coastal Erosion Study (NCES, 2015) identified several critically eroded coastal areas in the Selangor coastline. Initially, the researchers visited these coastal areas to assess the fundamentals of the settlements to have better and broader comprehension of the economic activities and to appraise exposures from the sea. The observation carried out at the coast of Selangor indicates that coastal erosion, flooding and storm surges are the dominant factors damaging the infrastructures near the coastal regions. These pose severe damage threats to the households close to the coastline, making them vulnerable. Hence, the study area has been restricted to 1 km from the seashore towards the land. Based on the field survey and country-wide erosion report, the ten major eroding coastal areas in three coastal districts have been selected specifically. These areas are prone to receive the worst outcome of the high impact of coastal vulnerability. They are Tanjung Sepat and Kampung Batu Laut in Kuala Langat district, Bagan Sungai Janggut, Pantai Jeram and Bagan Pasir in Kuala Selangor district, Sungai Nibong, Kampung Haji Dorani, Bagan Sungai Burong, Sungai Pulai and Bagan Nakhoda Omar in Sabak Bernam district. A recent study suggests that 2558 hm^2 areas eroded in these coastal areas between 1984 and 2013 (Ahmad et al., 2021). Fig. 1 indicates the study areas at the Selangor coast of Malaysia.

2.2. Data collection

A survey questionnaire was designed incorporating the statistics needed for analysing household characteristics (socio-economic and housing), the experience of coastal hazard, awareness of coastal hazard impact, perceived risk of climate change, and household adaptation actions. Additionally, the questionnaire included a hypothetical scenario based on the contingent valuation method to elicit the willingness to pay. The particular question was subjected to verification through a series of instrumental development meetings by several experts. Then, it was put forth to be pretested among the members of fifty households located at Selangor. The preliminary survey suggested several corrections. For instance, rephrasing of the scientific linguistic term sea-level rise, climate change to related standard local dialect such as flood, long-term changes in the weather, avoidance of open-ended questions for fewer complications, and limitation of Likert scale into three points for less confusion were needed to comprehend the respondents better. The final phase of data was collected using the improvised structured questionnaire. Face-to-face interviews were carried out by ethnic enumerators who have been initially informed about the climate change issues in coastal areas. The sample size is based initially on Cochran's (1977) formula at 95% confidence interval, ±0.03 precision level and estimating 50% variability of the population as presented:

$$n = Z^2 \times pv\,(1 - pv)\,/\,e^2) \tag{1}$$

where n is sample size required, Z^2 is critical value of the desired level of confidence, pv is estimated population variability, e is margin of error. The final sample size is adjusted based on finite population correction as:

$$an' = n \Bigg/ \left(1 + \frac{n-1}{P}\right) \tag{2}$$

Where an' is adjusted sample size, n is initial sample size, P is population. The calculation resulted in at least 846 household respondents. The researcher increased the sample size to 1050 households to obtain reliable population presentations. A random sampling method was used to randomly select 1050 households situated in areas within 1 km proximity from the seashore along the Selangor coastline. 34 questionnaires of 1050 were not included in the analysis due to partial incompletion. The final study included 1016 households resulting in a 97% response rate. The reliability of the questionnaire was verified using Cronbach's alpha test. Cronbach's alpha was 0.801 for household awareness variables and 0.789 for household adaptation action variables. These indicate a high level of internal consistency for the scale as the values are

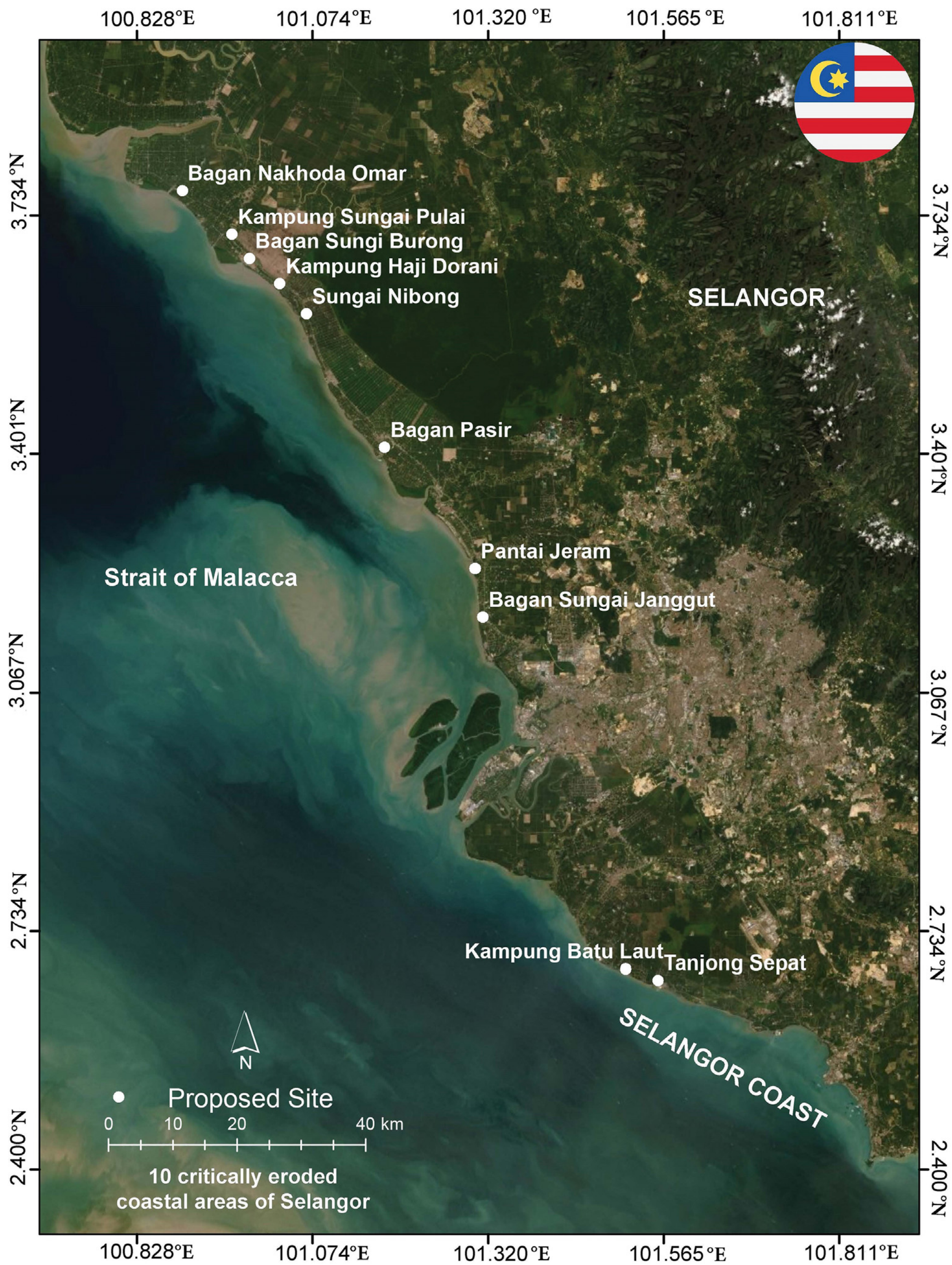

Fig. 1. Aerial map of the study area at Selangor Coast, Peninsular Malaysia.

higher than 0.7 (Kline, 2005). Fig. 2 illustrates the research framework adopted for households' perceived adaptation benefit assessment.

2.3. Hypothetical scenario, elicitation of WTP and perceived adaptation benefit

Households' willingness to pay for planned adaptation measures is assessed based on the contingent valuation method (CVM). Previous studies of willingness to pay for adaptation (Ivčević et al., 2021; Masud et al., 2015) or improved environmental quality (Trang et al., 2017; Nakano et al., 2016) extensively used several models of CVM to evaluate the stated preferences of individuals' willingness to pay. Willingness (and ability) to pay is the foundation of the economic theory of value. Halkos et al. (2020) argued that a non-market valuation technique such as CVM is vital to estimate the monetary value of a community's benefits from public services. The significant advantages of CVM include its ability to assess an individual's WTP of the present conditions and value their WTP with hypothetical changes (Hezaji, 2014).

This study employs single bound dichotomous choice contingent valuation to estimate WTP for coastal protection. WTP is the amount that must be taken away from a person's

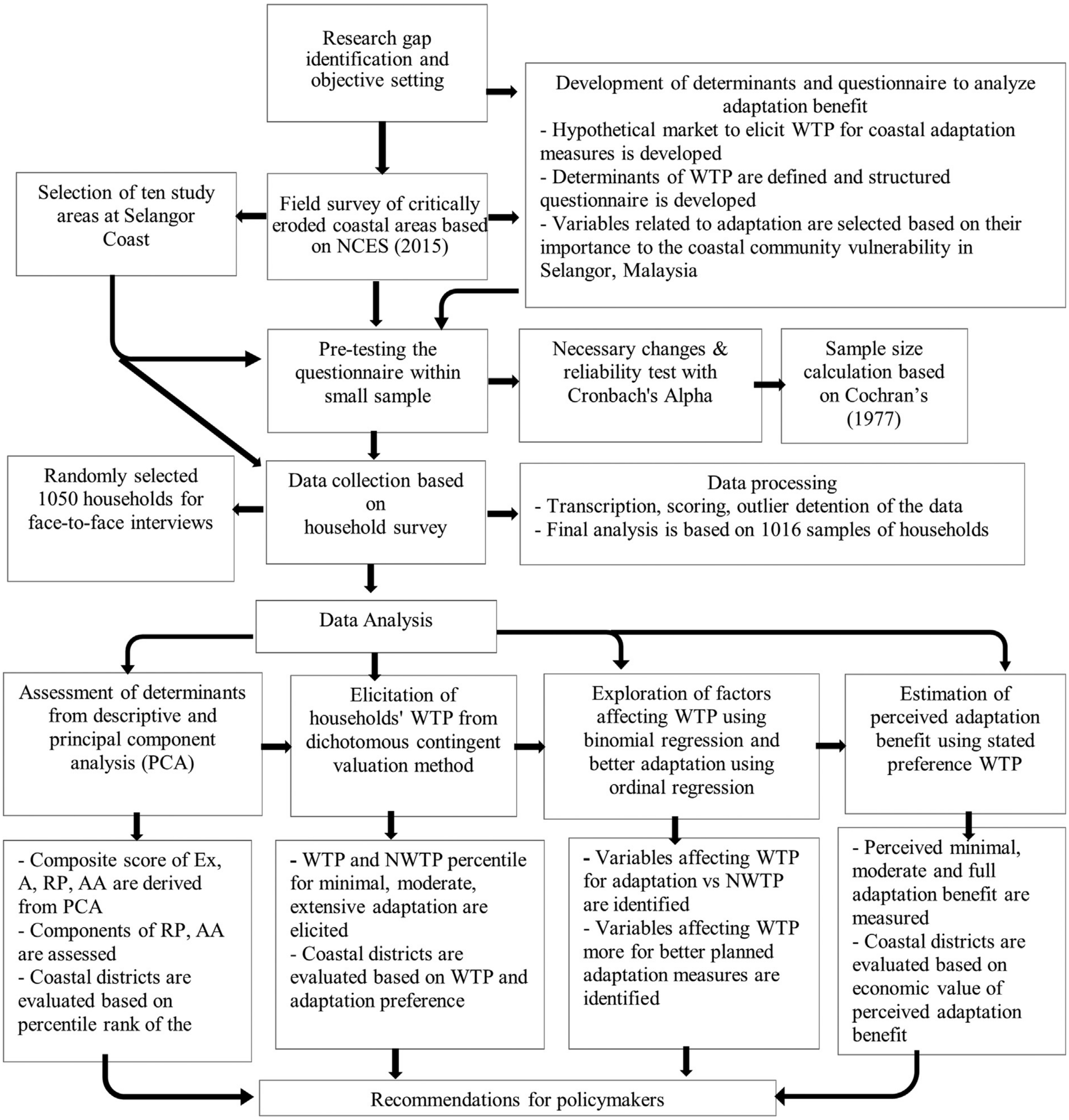

Fig. 2. Schematic diagram of households' perceived adaptation benefit assessment (Ex = Exposure and experience of coastal hazard, A = Awareness, RP = Risk, AA = Autonomous adaptation, WTP= Willingness to pay, NWTP= Not willing to pay).

income while keeping his utility constant. The indirect utility function of the status quo or situation without adaptation can be expressed as follows.

$U_0 = V\,(y, q_0) + e_0$, where $q_0 = 0$, $y =$ income.

On the other hand, the indirect utility function of a planned adaptation program can be stated as below.

$U_1 = V\,(y{-}WTP, q_1) + e_1$, where $q_1 = 1$, $y =$ income.

In this case, q_0 and q_1 are alternative levels of quality, with $q_1 > q_0$ referring to improved environmental quality.

Hence, the households in the study area were presented with a hypothetical scenario of climate change impacts without a planned adaptation program and with a planned adaptation program (complete/moderate/minimal) for protecting coastal communities to evaluate their WTP and monetary valuation of their preferences by ascertaining the value attached with specific attributes to avoid the potential damage or not willing to pay and accept the status quo. Visualisation imagery was utilised to increase communication effectiveness about climate change risks (O'Neill and Smith, 2014; Nicholson-Cole, 2005). Households were informed about the potential damages associated with the coastal hazards, the options of planned coastal adaptation measures (building sea walls, restoration of mangrove and coastal wetlands, house elevation, road elevation, investment avoidance and public purchases), and the importance of planned adaptation program to reduce the impacts. Then they were asked if an adaptation program could be proposed through community association or NGO whether they were willing to pay an annual contribution. Table 1 describes the attributes of each planned adaptation program.

Finally, the perceived adaptation benefits of each adaptation program by the coastal community in three coastal districts of Selangor are measured from the following equations.

$$PAB_{\text{minimal}} = WTP_{\text{minimal}} \times HWTP_{\text{minimal}} \times H \quad (3)$$

$$PAB_{\text{moderate}} = WTP_{\text{moderate}} \times HWTP_{\text{moderate}} \times H \quad (4)$$

$$PAB_{\text{extensive}} = WTP_{\text{extensive}} \times HWTP_{\text{extensive}} \times H \quad (5)$$

Where *PAB* is the perceived adaptation benefit, *WTP* is the willingness to pay for each adaptation program, *HWTP* is the percentage of households willing to pay for each adaptation program, *H* is the number of households in the coastal districts of Selangor.

2.4. Model specification

Households' risk averting behaviour to offset the damage of coastal hazard and willingness to pay for planned adaptation for coastal areas depend on perception and awareness related to coastal hazard, socio-economic and housing characteristics, access to climate-related information and several other variables. Logit models are used in this study, which is commonly used by previous studies to analyse the factors determining the adaptation preference (Huong et al., 2017; Abid et al., 2015; Uddin et al., 2014). A binomial logistic model was employed to examine the factors influencing the households' decision of willingness to pay for planned adaptation in the study area. The binomial logistic model used in this study can be expressed as follows:

$$1\text{ogit } Y = \log\left(\frac{Y}{1-Y}\right) = \beta_0 + \beta_i X_i \quad (4)$$

$$\frac{Y}{1-Y} = \frac{\text{Probability (Willing to pay)}}{\text{Probability (Not willing to pay)}} = \exp\left(\beta_0 + \beta_i X_i\right) \quad (5)$$

Where logit *Y* is the probability of willingness to pay for planned adaptation; *Y* is a binary dependent variable (0 = not willing to pay, 1 = willing to pay), X_i are a set of independent variables (binary/continuous), β_i represents the slope parameter for independent variables and β_0 is a constant. The odds ratio in Eq. 5 reflects the probability of willingness to pay (event happening) compared to non-willing to pay for planned adaptation (event not happening).

Additionally, an ordinal logistic model with proportional odds was employed to predict the households' preference for extensive, moderate, minimal, and no planned adaptation based on several independent variables with a statistically significant effect. The ordinal logistic model used in this study can be expressed as follows:

$$\text{logit } Y = in\left(\frac{prob(cat. \le j)}{prob(cat. \ge j)}\right) = \alpha_i + \left(\beta_i \times X_i\right) \quad (6)$$

Where *Y* represents the levels of adaptation program and associated willingness to pay at ordered categories such as no adaptation (not willing to pay = 0), minimal adaptation (willing to pay 10 MYR = 1), moderate adaptation (willing to pay 20 MYR = 2), and complete adaptation (willing to pay 30 MYR = 3); *j* represents the categories of ordinal dependent variable and $j-1$ is the cumulative logit, α is the constant, β is the parameter and X_i are a set of independent variables (binary/continuous). This ordinal response of *Y* represents levels of log odds of an event occurring where that event is an amalgamation of one or more cumulative probabilities (categories) of an ordinal dependent variable.

2.5. Explanatory variables of willingness to pay (WTP)

The determinants of willingness to pay are selected from an extensive literature review and specific characteristics of the local coastal community. Seventeen independent variables were included in the analyses, such as socio-economic characteristics (age, gender, education, household size, household head, monthly household income, climate-related occupation), housing characteristics (homeownership, proximity to coast), impact and experience of coastal hazard, access of information

Table 1
Attributes of proposed planned adaptation measures.

Attributes	Extensive adaptation measures	Moderate adaptation measures	Minimal adaptation measures	No adaptation measures
Coverage	All vulnerable coastal settlements	Vulnerable large residential areas	Critically vulnerable shoreline	No protection program
Properties and infrastructure	Protected	Protected	Protected	Damages and risk of inundation
Crops and livestock	Protected	Protected	Protected	Risk of destruction
Coastal hazard	Reduces the risk	Reduces the risk	Reduces the risk	Increases the risk
Health (waterborne diseases)	Reduces the risk of deterioration	Reduces the risk of deterioration	Reduces the risk of deterioration	Deterioration
Business revenue and employment	Supports to sustain	Supports to sustain	Supports to sustain	Unviable
Timing	21–40 years	10–20 years	0–10 years	No period
Annual payment	30 MYR/7.15 USD[a]	20 MYR/4.77 USD	10 MYR/2.38 USD	No payment

Note: [a] Based on the exchange rate as of March 2022: 1 USD = 4.1955 MYR.

Table 2
Explanatory variables used in the analysis.

Variable		Description	Expected relationship	Reference
Socio-economic characteristics	Age	Age of the respondents	+	Esteban et al. (2017); Ivčević et al. (2021); Liu et al. (2013); Mohammadpajooh and Aziz (2014)
	Gender	0 = Female, 1 = Male	+/−	Ivčević et al. (2021); Nakano et al. (2016); Trang et al. (2017)
	Years of completed formal education	No formal education = 0, Primary school = 6, Lower secondary certificate = 9, Secondary school certificate = 11, High school certificate = 12, Bachelor = 16, Masters/PhD = 18	+	Abdullah and Jeanty (2011); Abid et al. (2015); Al-Amin et al. (2020); Bigerna and Polinori (2014); Ivčević et al. (2021); Masud et al. (2015); Nakano et al. (2016); Huong et al. (2017); Trang et al. (2017); Yang et al. (2014)
	Household size	Number of a household member	+/−	Al-Amin et al. (2020); Masud et al. (2015); Huong et al. (2017)
	Household head	The respondent being Household head = 1 Respondent being family member = 0	+	This study
	Income	Monthly household income	+	Abdullah and Jeanty (2011); Al-Amin et al. (2020); Bigerna and Polinori (2014); Fahad and Jing (2018); Ivčević et al. (2021); Liu et al. (2013); Masud et al. (2015); Nakano et al. (2016); Trang et al. (2017); Yang et al. (2014)
	Occupation	Climate-related occupation = 1 Others = 0	+/−	This study
Housing characteristics	Homeownership	Owner = 1 Renter = 0	+	Abdullah and Jeanty (2011); Abid et al. (2015); Ivčević et al. (2021); Huong et al. (2017)
	House location proximity to the coast	within 0−200 m = 5 within 201−400 m = 4 within 401−600 m = 3 within 601−800 m = 2 within 801−1000 m = 1	+	
Coastal Hazard	Coastal hazard experience	Experience score of coastal flooding, storm surge and erosion	+	Fahad and Jing (2018); Huong et al. (2017)
	Coastal hazard Impact	Impact on properties = 1 Not impacted = 0 Impact on income = 1 Not impacted = 0 Impact of asset = 1 Not impacted = 0	+	Al-Amin et al. (2020)
Awareness	Awareness of coastal hazard impact	Awareness score		Ivčević et al. (2021); Trang et al. (2017); Veronesi et al. (2014)
Risk Perception	Perceived frequency of inundation risk, perceived consequences	Risk perception score	+	Al-Amin et al. (2020); Eberechukwu et al. (2018); Ivčević et al. (2021); Masud et al. (2015)
Access of information	Distance source: Exposure to media (television/radio/internet)	Access to any telecommunication service = 1 No available telecommunication = 0	+	Abid et al. (2015); Ivčević et al. (2021); Huong et al. (2017)
	Local source: Adaptation	Participated in any community-	+	Ivčević et al. (2021)

Table 2 (*continued*)

Variable		Description	Expected relationship	Reference
	related community participation	based adaptation program = 1 No participation = 0		
Household Preparedness	Adaptation action	Adaptation activities score	+	

(distant source of telecommunication service and local sources from participation in community adaptation), risk perception (perceived frequency and consequence of climate change), awareness of the coastal hazard and household adaptation activities. Table 2 represents the description and expected signs of the explanatory variables that are likely to affect the willingness to pay and the preferences of the adaptation program.

2.6. Data reduction for explanatory variables

The composite scores of awareness, risk perception and adaptation action independent variables were derived based on principal components analyses (PCA) to include in the regression analyses. PCA was run on the three questionnaires related to coastal hazard experience, ten questionnaires about awareness of coastal hazard impacts, four questionnaires related to risk perception and seven questionnaires related to adaptation action. Before the analysis process, the PCA's plausibility was appraised thoroughly. The correlation matrix inspection reveals that at least one correlation coefficient in all variables had a value greater than 0.3. As for the measurements concerning coastal hazard experience, awareness, along with adaptation action dimension, the Kaiser-Meyer-Olkin (KMO) method produced the values 0.708, 0.848 and 0.761, respectively, confirming that individual KMO measure values were all greater than the 0.7 classifications of 'middling' to 'meritorious', in accordance to Kaiser (1974). Subsequently, the risk perception dimension disclosed a mediocre value Kaiser Kaiser-Meyer-Olkin (KMO), measuring 0.629. The output from Bartlett's test of sphericity was statistically fundamental ($p < 0.0005$), as all dimensions indicated that the data was most likely factorisable.

Furthermore, in the experience and risk perception dimension, PCA revealed a single component with eigenvalues greater than one, which explained 72.5% and 53.0% of the total variance. Consequently, one component was retained in each dimension to present the composite score for measuring experience and risk perception variables. On the other hand, concerning awareness and adaptation action dimension, PCA disclosed two separate components with eigenvalues greater than one. However, an overall visual inspection of the scree plot indicated that one component in each dimension should be retained. In addition, one component solution has successfully met the interpretability criterion; thus, the

Table 3
Composite score derivation from PCA.

Dimension	Variable	Data	Component matrix
Experience	Storm surge	Ordinal	0.875
	Erosion		0.840
	Coastal flooding		0.839
Awareness of coastal hazard impact	Affecting health of the population	Ordinal	0.790
	Harmful to residents		0.784
	Interfere with mental peace		0.774
	Increases cost of spending		0.773
	Causes disease outbreak		0.739
	Causes loss of life		0.702
	Affecting living standard		0.668
	Damages the property		0.594
	Affecting day to day activities		0.580
	Affecting property value		0.579
Risk perception	Perceive intensity of current impact	Ordinal	0.841
	Perceive intensity of future impact		0.774
	Perceived frequency of inundation risk		0.727
	Perceive sea level rise threat		0.531
Adaptation action	Build home higher to deter flooding	Nominal	0.773
	Replace door/windows with waterproofing materials		0.754
	Strengthen home using concrete		0.738
	Move to the safer area during coastal hazard		0.696
	Shut down electricity during coastal hazard		0.692
	Move belongings higher during coastal hazard		0.647
	Take temporary measures to protect the property		0.622

component described above was included, which explained 49.4% and 49.7% variance in awareness and adaptation action dimension. The component matrix of each dimension is presented in Table 3.

3. Results and discussion

3.1. Household socio-economic characteristics

The analysis of household characteristics reveals that 66% are male, and the average age of the respondent is 47 years old. 14% of the respondents do not have any formal education, while 29% and 26% have completed primary and secondary school certificates. Most of the households are involved in fishing (25%), followed by private sector employment (16%), business (14%) and, self-employment (10%), agriculture (7%). Overall, 32% of households are dependent on climate-related occupations such as fishing and agriculture. The monthly gross household income is analysed based on the range set by the Department of Statistics Malaysia (DoSM, 2019). The results indicated that 90% of the households in Selangor coastal areas are from the low-income group, 9.4% belongs to the middle-income group, and only 0.1% are in the high-income group. The median monthly household income is 2000 MYR. As per the housing characteristics, results show that most households (84.7%) have property ownership and live within 600 m from the coastline (33.2%). Fig. 3 illustrates the households' essential socioeconomic and housing characteristics in Selangor coastal areas.

3.2. Risk perception towards the sea-level rise and climate change

Households' perceived risk of climate change and sea-level rise are assessed from different dimensions. Fig. 4 illustrates household risk perception related to sea-level rise and climate change impacts. Results indicate that most households are indecisive of sea-level rise threats and inundation risk. Contrarily, 5.2% and 19.6% of households perceive sea level rise as a severe and moderate threat, respectively, while 15.1%

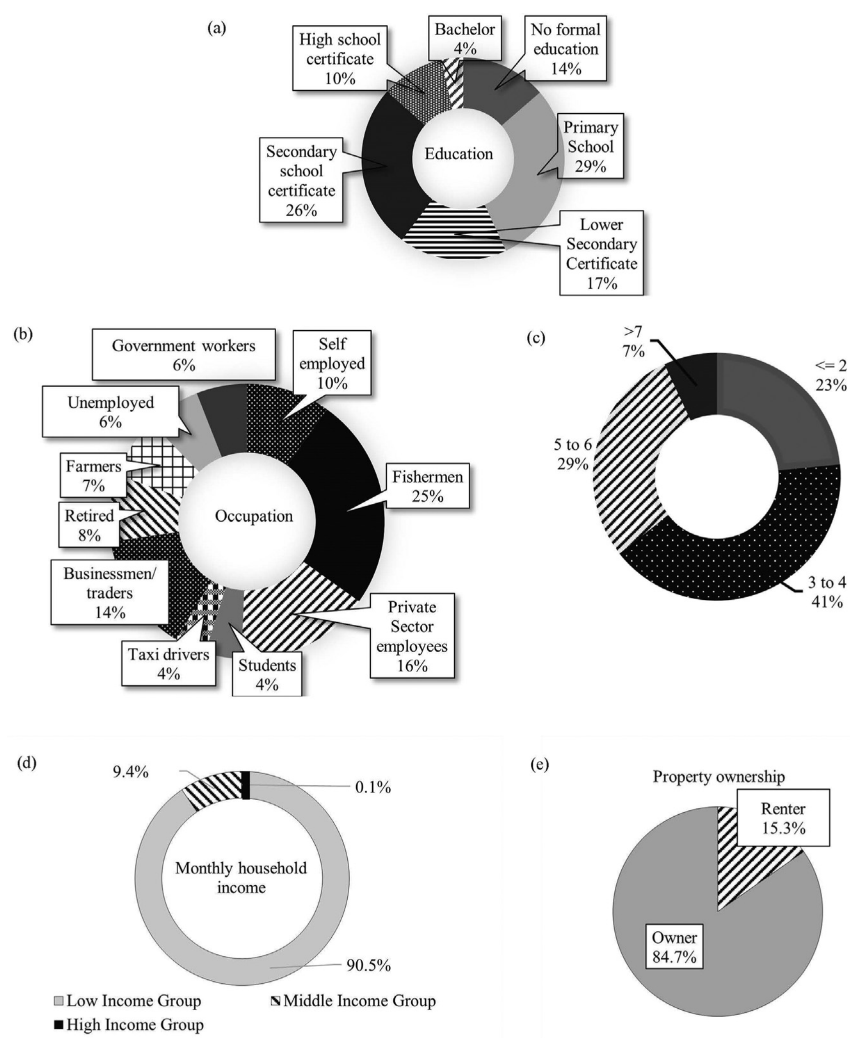

Fig. 3. Percentages of households based on socio-economic characteristics of the households at Selangor coastal areas, (a) educational attainment, (b) occupational distribution, (c) household size distribution, (d) income distribution, and (e) ownership distribution.

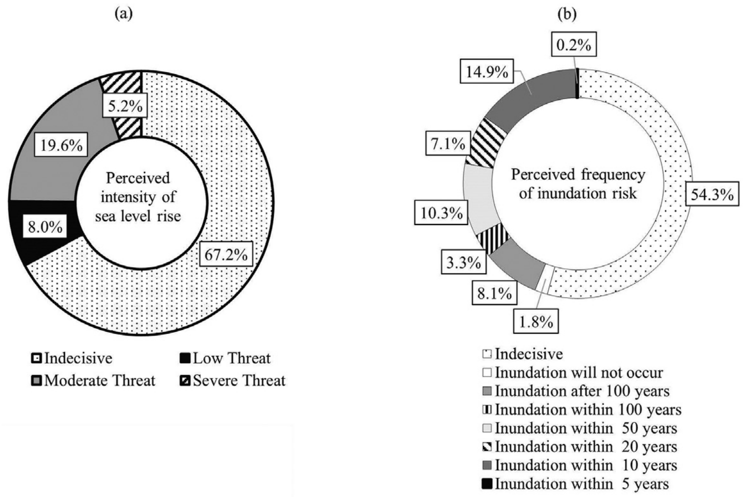

Fig. 4. Risk perception related to sea-level rise, (a) perceived intensity of sea-level rise threat, (b) perceived frequency of inundation risk due to sea-level rise.

perceived immediate inundation risk within 5–10 years. Majority of the households' perception of low hazard risk indicates low-risk awareness that may result in low preparedness and inadequate response (Bradford et al., 2012) as risk perception is closely linked to the decision making of adaptation that leads to non-adaptive, proactive or reactive adaptation behaviour (Smith, 2018). Bollettino et al. (2020) also argued an association between disaster preparedness and risk perception in the Philippines and found that Filipinos who perceived climate change directly impacting their households reported taking more significant action to prepare for disasters. Community education and public awareness shape the knowledge, abilities and skills that influence risk perception (Hoffmann and Blecha, 2020). Therefore, efficient awareness campaigns to educate households about the forthcoming adverse impacts of the slow onset events (e.g. rising sea levels) are necessary to awaken human cognition and promote timely decisions for proper measures.

Comparative analysis of risk perception as illustrated in Fig. 5 reveals that most households (74.06%) perceived future impact as serious while 59.05% perceived current impact as severe. However, only 29% of households perceive sea level rise as a threat. Households in Kuala Langat perceived a higher risk of current (52%) and future impact (89%) of climate change compared to households in other districts. Contrarily, Kuala Selangor perceived a higher sea level rise threat (52%) and inundation risk (32%). Even though Selangor coastal areas are frequently affected by shoreline erosion and storm surge flooding, households did not perceive the highest climate change risk regarding sea level rise. Taylor et al. (2014) reasoned about the optimism bias and the perception of low probability of experiencing adverse events that could explain these differences in risk perception. These varying interpretation of hazard risk needs to be integrated into formal decision-making to implement risk management plans (Fuchs et al., 2017).

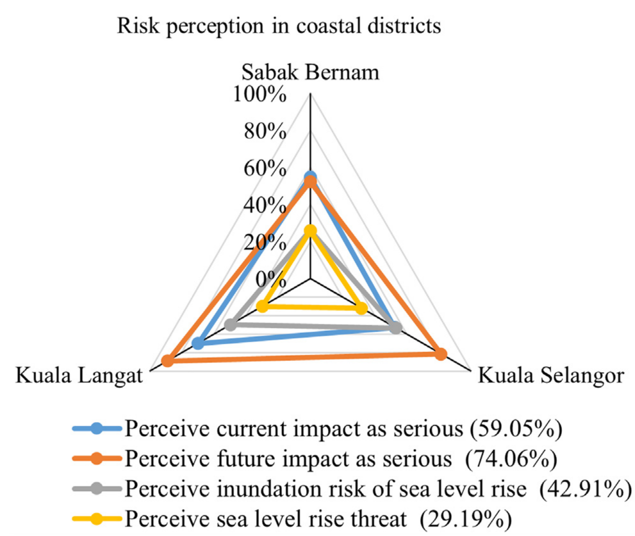

Fig. 5. Comparative analysis of risk perception in coastal districts of Selangor.

3.3. Autonomous adaptation

The study assesses several household adaptation actions related to coastal hazards based on the local scenario. Fig. 6 demonstrates household adaptation to coastal hazards in Selangor coastal areas. Results reveal that 30% of households did not adopt any actions. The majority of the households (39%) adopted less than four actions, while 10% adopted more than seven actions to reduce coastal hazard impacts. Among several adaptation actions, households autonomously adopted risk reduction behaviours during coastal hazards such as shutting electricity (55.7%), moving content to a higher place (54.9%) and moving to a safer place (44.1%). Contrarily, only 0.3% of households have subscribed to property insurance to recover the damage from coastal hazard, and 3.4% has accessible emergency supplies kit ready.

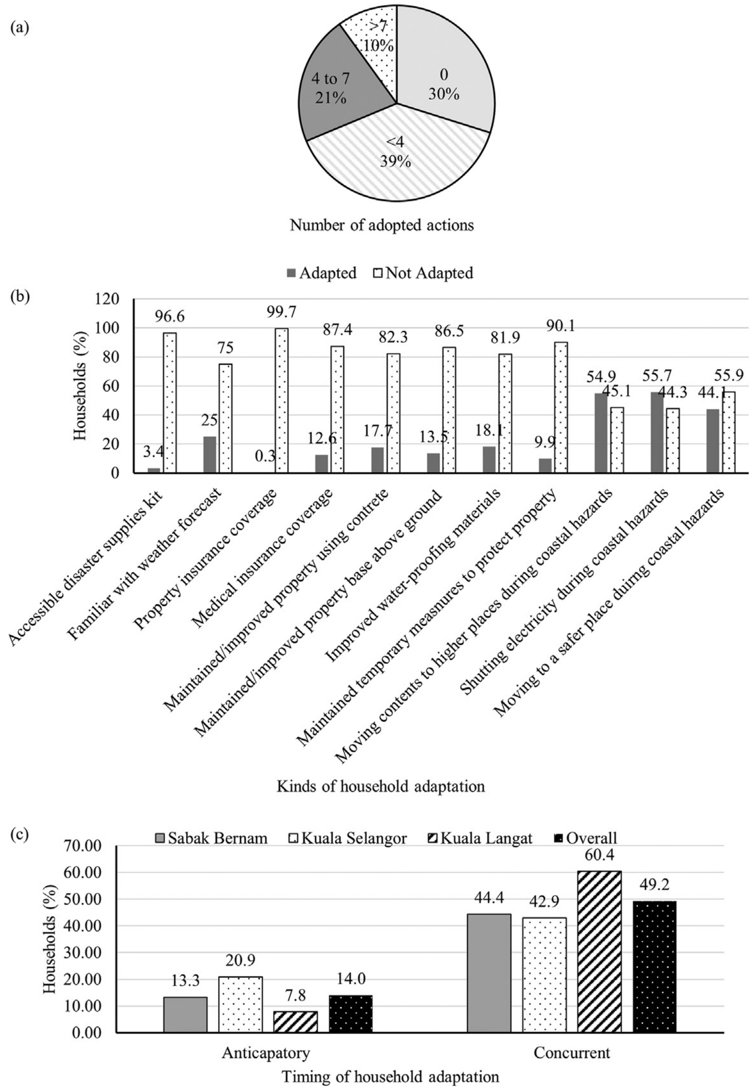

Fig. 6. Household autonomous adaptation in Selangor coastal areas, (a) number of adopted actions, (b) different kinds of household adaptation, and (c) categories of household adaptation based on timing.

Autonomous adaptations are further analysed based on timing. Overall, the results show that households' adaptation of con-current actions during coastal hazards is comparatively higher (49.2%) than anticipatory actions before coastal hazards (14.2%). Households in Kuala Langat reflected comparatively higher con-current autonomous adaptation (60.4%). Contrarily anticipatory autonomous adaptation is relatively higher in Kuala Selangor (20.9%) than in other districts. The findings reveal that households have taken moderate level autonomous adaptation mainly focused on risk reduction behaviours during extreme events.

In contrast, households that take precautionary measures beforehand are relatively low, reflecting low disaster preparedness. Community education and awareness play essential roles in improved adaptive behaviour necessary for disaster preparedness and recovery (Hoffmann and Blecha, 2020). In addition, national education effort, indigenous knowledge, and enhanced information sharing can build resilience and reduce maladaptation risks (Roy et al., 2018). Anticipatory adaptation measures, e.g. insurance coverage and reinforcement property infrastructures (Wardekker et al., 2010; Hino et al., 2017), hazard mapping and warning systems (Kelman and Glantz, 2014) should be promoted to off-set damage impact. For instance, insurance availability at affordable premiums and its promotion by educating about adverse impacts of extreme events can provide financial incentives during recovery (Thomas and Leichenko, 2011), and financial incentives to secure properties (Sidle et al., 2017) can help low-income groups bear the expense of reconstructing vulnerable houses.

3.4. Willingness to pay (WTP) values for planned adaptation

Using a contingent valuation method, this study elicits the households' willingness to pay (WTP) values for extensive, moderate and minimal adaptation measures in Selangor coastal areas. The results of WTP values are illustrated in Fig. 7. It reveals that 66.1% of the households are willing to pay for planned adaptation measures, while 33.9% are unwilling to pay for any adaptation program. Additionally, among the households unwilling to pay, most stated that government agencies (90.8%) and local authorities (80.7%) should bear the payment responsibility of initiating a planned adaptation program. Households that are willing to pay for planned adaptation measures, about 20.9% agreed to pay for minimal adaptation (10 MYR per year), 23.9% agreed to pay for moderate adaptation (20 MYR per year). 21.3% agreed to pay for extensive adaptation measures (30 MYR per year). The findings imply that the local households perceive the adaptation benefit and favour extensive, moderate or minimal protection measures. These findings are similar to the earlier studies done in Malaysia (Masud et al., 2015) and Pakistan (Ahmed et al., 2015), where the majority of the farmers were willing to pay for planned adaptation measures to reduce their vulnerability. The results also indicate that households in Kuala Selangor, Kuala Langat and Sabak Bernam preferred minimal adaptation (payment 10 MYR per year), moderate adaptation (payment 20 MYR per year), and extensive adaptation measures (payment 30 MYR per year), respectively.

3.5. Estimation of binomial and ordinal models for factors affecting willingness to pay

The binomial and ordinal models are verified for significance, the goodness of fit, and predictions' accuracy. The linearity of the continuous variables was assessed via the Box and Tidwell (1962) procedure regarding the logit of the dependent variable. The assessment brought forth the understanding that continuous independent variables are linearly related to the logit of the dependent variable. Notably, there were several outliers, among which those with standardised residual with a value of more than three were omitted. The multicollinearity test showed significantly high multicollinearity of the impact on asset variables (VIF > 10, Tolerance = 0.00), thus excluding the final model. Again, the binomial logistic regression model proved to be statistically significant, that is, $\chi^2(17) = 345.17$, $p < 0.0005$. The model explained 41% (Nagelkerke R^2) of the variance in willingness to pay and accurately classified 79.3% of cases. Sensitivity

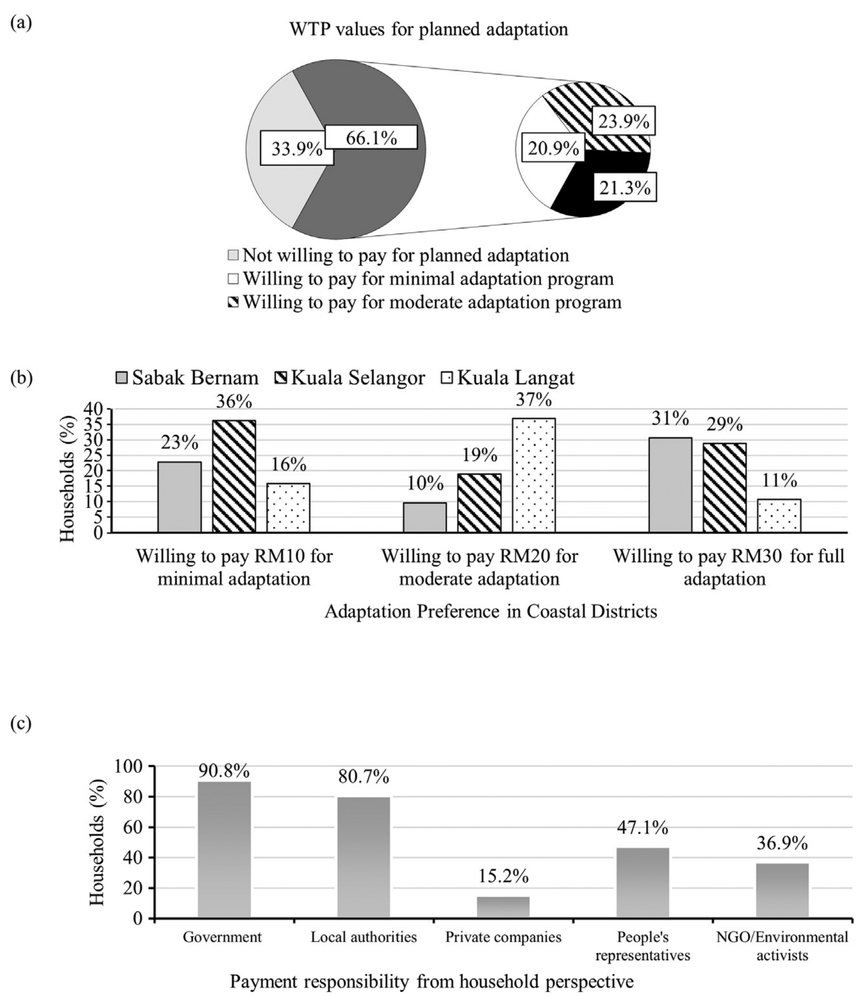

Fig. 7. Willingness to pay (WTP) for adaptation measures, (a) WTP values/yearly, (b) comparative analysis of yearly WTP in the coastal districts, and (c) Payment responsibility from the household perspective.

was 58.3%, specificity was 89.5%, positive predictive value was 81.53%, and negative predictive value remained 72.97%. The area under the ROC curve was calculated at 0.838 (95% CI, 0.812−0.865), which can be deemed an excellent level of discrimination according to Hosmer et al. (2013). As for the ordinal model, the deviance good of fit contraindicates that the model proves to fit the observed data, $\chi^2(2548) = 2435.020$, $p = 0.945$, although most cells were sparse with zero frequencies observed in 75% of cells. However, with apparent success, the final model statistically predicted the dependent variable over and above the intercept-only model, $\chi^2(17) = 277.209$, $p < 0.001$. Thus, considering the calculations and relevant assessments, the study concludes that the models with predicts fit distinctively better than the intercept-only mode. Instead of the deduction, the null hypothesis (H_0) can be forgone to embrace the alternative hypothesis (H_1) that at least one of the regression coefficients is not zero. Based on the results from the model fitness in Table 4, it can be assumed that the models fit the data and estimate the significant factors with superior accuracy, affecting the willingness to pay and preference of different adaptation measures.

This study employed a binomial and ordinal logistic regression to quantify the impact of explanatory factors such as socio-economic characteristics, housing characteristics, coastal hazard experience, and access of information, risk perception, awareness of the coastal hazard and household adaptation action affecting households' adaptation preference and willingness to pay for planned adaptation. Binomial logistic regression analyses the factors influencing households' decision on willingness to pay compared to non-willingness to pay for planned adaptation. Ordinal logistic regression analyses the factors influencing households' decision on willingness to pay higher for better-planned adaptation measures. Coefficients of logistic regressions explaining the direction of the effect of independent variables are presented in Table 5.

The results of binomial logistic regression reveal that nine predictor variables (age, climate-related occupation, household head, proximity to coast, hazard experience and awareness, impact on property, risk perception and community participation) had a statistically significant effect on households' decision of willingness to pay for adaptation. Ordinal logistic regression results indicate that 12 predictor variables (age, income, climate-related occupation, household head, proximity to coast, hazard experience and awareness, impact on property, loss of income, risk perception, community participation and access to telecommunication services)

Table 4
Model fitness.

Regression		Chi-square	Degree of freedom	Significance
Binomial	Omnibus tests of Model Coefficients	345.170	17	0.000
	Hosmer and Lemeshow Test	8.8448	8	0.391
Ordinal	Final	277.209	17	0.000
	Deviance	2435.020	2548	0.945

significantly influence households' decision of willingness to pay higher for better adaptation.

Respondent's age significantly increases the probability of WTP for adaptation. Results indicate that increasing age was associated with an increased probability of willingness to pay for adaptation ($B = 0.019$, $p < 0.05$). A 1 unit increase in age has a 0.07 times higher probability of WTP for adaptation. This study also found a positive relationship between age and WTP for adaptation. Results reveal that an increase in age was also associated with an increase in the probability of willingness to pay more for better adaptation, with an odds ratio of 1.011 ($\chi^2 = 3.149$, $p < 0.10$). As age increases by 1 unit, the probability of willingness to pay more for better adaptation also increases by 1.011 times. The significant positive impact of age is consistent with the empirical findings of Nakano et al. (2016), who investigated the age and WTP for climate change policy. Age significantly influences climate change awareness (Fahad et al., 2020; Ajuang et al., 2016). Thus, it can be concluded that elderly respondents are likely to expose to and experience more coastal hazards in their lifetime and are more likely to remain cognizant regarding past climatic occurrences and their subsequent impacts, creating an innate willingness to pay for planned adaptation. It may also result in informed consent from their side to pay a higher amount to battle the hazard impact.

Contrarily, gender did not significantly influence the probability of WTP or the probability of WTP higher amount for better adaptation. Gender is found to be negatively related to WTP. This association between WTP and female respondents is consistent with the findings of Ivčević et al. (2021), who found a significant impact of females on the readiness to invest in climate change policy for risk reduction monetarily. According to IPCC (2014), coastal hazard impacts results in higher workloads for women, occupational hazards indoors and outdoors, psychological and emotional stress. Adzawla et al. (2019) also showed that severer climate impacts on the livelihoods of females than males. Therefore, there is likely a higher probability of females willing to contribute monetarily for adaptation and risk reduction, although such impact is insignificant.

Income and education are two critical factors of WTP for adaptation. Results show that an increase in household monthly income and years of completed education did not significantly increase the probability of WTP for adaptation. However, the coefficient of income and education had positive signs. Contrarily, ordinal regression results suggest that monthly household income ($\chi^2 = 1.00$, $p < 0.05$) significantly affects the probability of higher WTP for planned adaptation. In this study, a 1 unit increase in income has a higher probability of WTP for a better adaptation program. Nakano et al. (2016) also showed that being wealthier indicates a higher WTP. Increasing income is linked to the financial ability of the households to invest in anticipatory planned adaptation to reduce the hazard impact. Thus, this study argues that increasing income will likely increase WTP probability for better adaptation.

Additionally, education is positively associated with WTP, indicating that increasing education and a higher probability of

Table 5
Logistic regression predicting the likelihood of willingness to pay for planned adaptation.

	Binomial logistic regression				Ordinal logistic regression			
	B	Odds ratio	95.0% CI.		*B*	Odds ratio	95.0% CI.	
			Lower	Upper			Lower	Upper
Constant	−2.666	0.070						
Age	0.019*	1.019	1.003	1.035	0.011*	1.011	0.999	1.023
Gender	−0.140	0.869	0.522	1.446	−0.108	0.898	0.630	1.280
Income	0.000	1.000	1.000	1.000	0.00004**	1.000	1.000	1.000
Education	0.033	1.034	0.983	1.088	0.021	1.021	0.983	1.061
Occupation	1.026**	2.790	1.816	4.285	0.709**	2.032	1.474	2.802
Household size	−0.021	0.980	0.887	1.082	0.022	1.022	0.946	1.104
Head	0.630*	1.877	1.110	3.173	0.610**	1.840	1.258	2.691
Ownership	0.205	1.228	0.761	1.981	−0.018	0.982	0.692	1.393
Proximity to coast	0.236*	1.266	1.042	1.539	0.252**	1.286	1.107	1.494
Experience	0.303**	1.354	1.137	1.613	0.313**	1.367	1.196	1.563
Impact on property	0.759**	2.137	1.332	3.428	0.517**	1.677	1.177	2.390
Impact on income	0.447	1.564	0.964	2.537	−0.445*	0.641	0.455	0.903
Awareness	0.294**	1.342	1.124	1.601	0.355**	1.427	1.232	1.652
Risk perception	1.069**	2.913	2.343	3.622	0.554**	1.740	1.512	2.002
Community participation	1.290**	3.632	2.033	6.487	−0.538**	0.584	0.423	0.806
Access to telecommunication service	0.061	1.063	0.578	1.956	0.357*	1.429	0.945	2.160
Household adaptation actions	−0.038	0.963	0.772	1.201	−0.082	0.922	0.792	1.072

Note: *$p < 0.05$, **$p < 0.01$.

WTP for planned adaptation are linked. However, education did not significantly impact WTP. This finding is consistent with Trang et al. (2017) and Masud et al. (2015), who empirically evidenced that increasing income and education positively impact respondents' willingness to pay for improved management and climate change adaptation programmes. These findings are also expected theoretically, and this study provides evidence to support the theory.

Respondents involved in a climate-related occupation such as fisheries and agriculture significantly increases the probability of WTP for adaptation. The significant coefficient of climate-related occupation ($B = 1.026$, $p < 0.01$) shows that the probability of WTP for adaptation is 2.79 times higher than respondents involved in non-climate related occupations. Ordinal results reveal that households involved in climate-related occupation also exhibited higher probability ($\chi^2 = 2.032$, $p < 0.01$) by a factor of 2.032 of being willing to pay a higher amount for better adaptation than households in non-climate related occupations. Fahad et al. (2020), Talanow et al. (2021) and Arnall and Kothari (2015) found a significant positive relationship between climate-related occupation, awareness and adaptation. Respondents involved in the climate-related occupation are likely more aware of climate change and coastal hazard impact, thus are more likely to pay for planned adaptation or a higher amount for better adaptation.

The household head also significantly positively influences WTP for planned adaptation. A household head ($B = 0.630$, $p < 0.05$) increases the probability of WTP for adaptation by 1.89 times compared to other household members. The probability of household heads considering to pay a higher amount for better adaptation was also 1.84 times higher (95% CI, 1.258−2.691) compared to household members ($\chi^2 = 9.88$, $p < 0.05$). This can be explained by the kinship structure in household decision-making authority, as the household head more often makes certain household decisions (Anderson et al., 2017; Meijer et al., 2015). It is an implied understanding that in such households, the head of the family will be expectant a more dominant role in any decision-making process of adaptation. Therefore, they are more likely to have the final say in decision making as to the willingness to pay and regarding the higher amount for better-planned adaptation in comparison to any other members of the family. This study found that households' proximity of coast ($B = 0.236$, $p < 0.05$) significantly affects WTP for adaptation. The households living closer to the coast have an increased likelihood of WTP for adaptation by 0.018 times.

Similarly, proximity to the coast ($\chi^2 = 10.844$, $p < 0.01$) had a statistically significant effect on the households' willingness to pay more for better adaptation. The likelihood of choosing better adaptation increases by 1.022 times for households living closer to the coast. Previous studies showed that hazard proximity could influence risk perception (Arias et al., 2017; Lindell and Hwang, 2008). Thus, the positive relationship between proximity to coast and WTP for planned adaptation implies that households living closer to the shoreline are more likely to experience frequent extreme events, directly affected and higher risk perception; thus are more likely to willing to pay for adaptation or willing to pay a higher amount for better adaptation.

Households affected by property damage ($B = 0.759$, $p < 0.01$) also exhibit a 0.002 times higher probability of willingness to pay for adaptation than the unaffected households. In addition, property damage ($\chi^2 = 6.472$, $p = 0.011$) due to coastal hazards statistically affected whether the household is willing to pay more for better adaptation.

Households directly affected by property damage were willing to pay 0.641 times higher for better-planned adaptation than households not impacted by property damage. Similarly, households directly affected by the loss of income ($B = 0.447$, $p < 0.10$) due to coastal hazards also showed a 1.564 times higher willingness to pay for planned adaptation. However, households impacted by income loss have a decreased likelihood of paying more for better adaptation by 1.677 ($\chi^2 = 8.184$, $p = 0.004$). This study argues that the negative relationship between income impact and WTP higher amount reflected the lack of financial resources to invest in the better adaptation program. Entorf and Jensen (2020) found that prior experience with hazard is crucial for willingness to pay for risk reduction. Therefore, the results are consistent as the initial intensity of hazard experience due to the impact on property and income significantly impact the WTP for planned adaptation.

Additionally, the experience of coastal flooding, storm surge and shoreline erosion ($B = 0.303$, $p < 0.01$), risk perception ($B = 1.069$, $p < 0.01$) and awareness of coastal hazard impact ($B = 0.294$, $p < 0.01$) significantly affect WTP for planned adaptation. Results show that with an increasing experience, perceived risk and higher awareness of impacts, there are higher probabilities of willingness to pay. Experience ($\chi^2 = 20.91$, $p < 0.001$), awareness of coastal hazard ($\chi^2 = 22.58$, $p < 0.001$), and risk perception ($\chi^2 = 59.629$, $p < 0.001$) also had statistically significant effect at 1% level ($p < 0.01$) on the households' willingness to pay more for better adaptation. The household with more exposure to coastal hazards are more aware of the impact and perceived higher risks of climate change showed 1.367, 1.427, and 1.74 times increased probability of paying more for better adaptation, respectively, compared to households with less exposure, awareness and low-risk perception. These findings are broadly consistent with the studies investigating the links between experience, risk perception, awareness and adaptation. The significant positive relationship between hazard experience and willingness to pay for risk reduction adaptation measures is also argued by Entorf and Jensen (2020) and Akter (2020). Increased intensity and frequency of hazards are likely to shape households' sense of urgency to which adaptation measures should be undertaken. Hence, they are willing to contribute to the welfare gain associated with reduced impact and risk of coastal hazards. Todaro et al. (2021) argued that risk attitudes are a significant decision-making factor under climate uncertainty. Talanow et al. (2021) showed that farmers' adaptive behaviour is influenced by previous experience of climatic stresses and internal factors, including risk perception, which can explain the significant positive impact of high-risk perception and WTP for planned adaptation. Valenzuela et al. (2020) indicated that households with experiences of coastal hazards are associated with high awareness of coastal hazards, while Ivčević et al. (2021) argued that willingness to invest in climate change policy is positively predicted by awareness (belief in climate change). Thus, this study reasons that prior experience, awareness of potential damages caused by such climatic hazards would make people more aware of the risks and threats they may experience, resulting in their collective enthusiasm to participate in public endeavours and campaigns.

Households that participated in any community-based adaptation measures ($B = 1.29$, $p < 0.01$) have a 3.63 times higher probability of WTP for planned adaptation than the households that did not participate. These findings are supported by Nakano et al. (2016), showing that inclined to participate in community activities exhibits greater WTP. However, households that participated in community adaptation exhibited a decrease in the probability of willingness to pay more for better adaptation by a factor of 0.584 ($\chi^2 = 10.715$, $p = 0.001$), which implies that increased voluntary participation in community adaptation may not likely improve the probability of WTP higher amount for better adaptation. This different opinion is also evidenced by Jones et al. (2015), who found that social networks negatively influenced WTP for sea defences in a low-lying coastal area of south-east England. Contrarily, households with access to telecommunication services have a 1.429 times higher probability of willingness to pay more for better adaptation than households with no access to telecommunication services ($\chi^2 = 2.87$, $p = 0.09$). Access to telecommunication services likely plays a vital role in accessing climate-related information and increasing awareness (Sim et al., 2018), motivating households to WTP more for better adaptation. A negative coefficient of household size and autonomous adaptation with WTP for planned adaptation indicates that as household size and household adapted actions increase, households have a lesser probability of WTP for planned adaptation. However, household size and autonomous adaptation exhibit an insignificant effect on WTP in both models. The negative relationship between household size and WTP may imply that financial responsibility increases as the household size increases, resulting in a lack of ability and willingness to pay for adaptation (Huong et al., 2017). This study also suggests a negative association between household autonomous adaptation and WTP for planned adaptation that can be explained by looking deeper into the variations of household adaptation actions. The majority of the households in Selangor coastal areas have adapted to concurrent autonomous adaptation. Contrarily, planned adaptation is an anticipatory response to climate change. Thus, households' autonomous adaptation, mainly based on concurrent adaptation actions, is negatively associated with WTP for the anticipatory planned adaptation.

Based on the analysis of the factors affecting willingness to pay for planned adaptation, several strategies to enhance household participation can be recommended. Community engagement and participation (Taylor et al., 2013) can strengthen local adaptation programs' social linkage and efficiency. Resilience programs should include community-based adaptation activities such as flood-related meetings and voluntary community adaptation. They are found to significantly influence the probability of willingness to pay for planned adaptation. However, the necessity of adaptation and awareness of direct and indirect coastal hazard impacts in the short-term, and long-term should be dialogued, especially for the younger generation and those involved in non-climate related occupations and living further to coast as these groups are found to have less participation. Telecommunication services such as TV, radio, and the internet can be utilised as practical communication tools to disseminate climate-related information that can influence knowledge and behaviour by enhancing awareness and capacity building in community-based disaster management (Barua et al., 2020).

3.6. Economic value of perceived adaptation benefit

This study measured the households' welfare gain from coastal hazard risk reduction by the economic value of adaptation benefit based on the willingness to pay values derived from the contingent valuation method and household data from the Department of Statistics Malaysia (DoSM, 2019). The results are presented in Table 6. It shows that the perceived yearly economic value of the extensive adaptation program in Sabak Bernam is 12,341.10 MYR, which is comparatively higher than Kuala Langat (8061.90 MYR) and Kuala Selangor (2566.50 MYR). An extensive adaptation program is estimated to be implemented within 21–40 years; thus, as a market-based instrument, perceived adaptation benefit can finance adaptation planning of 0.48 million MYR to 0.92 million MYR in the selected ten coastal areas in the three coastal districts of Selangor. Likewise, the perceived yearly economic value of the moderate adaptation program in Kuala Langat is 18078.20 MYR, which is comparatively higher than Sabak Bernam (2654 MYR) and Kuala Selangor (1121 MYR). Moderate adaptation program is estimated to implement within 10–20 years; thus, as a market-based instrument, perceived adaptation benefit can finance 0.22 MYR million to 0.44 million MYR within these periods. Contrarily, the perceived yearly economic value of the minimal adaptation program in Kuala Langat is 3908.80 MYR, which is comparatively higher than Sabak Bernam (3052.10 MYR) and Kuala Selangor (1062 MYR). Minimal adaptation program is estimated to implement within 1–10 years; thus, as a market-based instrument, perceived adaptation benefit can finance up to 80,229 MYR within these periods in the highly eroded coastal areas of Sabak Bernam, Kuala Selangor and Kuala Langat districts.

The economic benefit results imply that households in Selangor coastal areas perceived a comparatively higher value of adaptation benefit associated with extensive, moderate and minimal adaptation measures. The finding is similar to the studies where the adaptation benefits were also high (e.g. Karner et al., 2019; Nguyen et al., 2013). These estimated perceived values of adaptation benefit provide insights to the adaptation policy as the availability of data related to adaptation cost, and benefit is very limited in the context of Malaysia. Additionally, the Government of Malaysia (GoM, 2018), in its National Communication (NC3) Report to UNFCCC, noted the finance requirement of 104 million USD (425.93 million MYR) for initial enhancement of adaptation measures and development of a comprehensive National

Table 6
The economic value of perceived adaptation benefit.

Location	Number of Household	Minimal planned adaptation timing: 1–10 years		Moderate planned adaptation timing: 10–20 years			Extensive planned adaptation timing: 21–40 years		
		Perceived benefit (yearly)	Perceived benefit (in 10 years, MYR)	Perceived benefit (yearly, MYR)	Perceived benefit (in 10 years, MYR)	Perceived benefit (in 20 years, MYR)	Perceived benefit (yearly, MYR)	Perceived benefit (in 21 years, MYR)	Perceived benefit (in 40 years, MYR)
Sabak	$n^a = 371$	853.3	8533	742	7420	14840	3450.3	72456.3	138012
Bernam	$N^b = 1327$	3052.1	30521	2654	26540	53080	12341.1	259163.1	493644
Kuala	$n^a = 159$	572.4	5724	604.2	6042	12084	1383.3	29049.3	55332
Selangor	$N^b = 295$	1062	10620	1121	11210	22420	2566.5	53896.5	102660
Kuala	$n^a = 486$	777.6	7776	3596.4	35964	71928	1603.8	33679.8	64152
Langat	$N^b = 2443$	3908.8	39088	18078.2	180782	361564	8061.9	169299.9	322476
Total	4065	8022.9	80229	21853.2	218532	437064	22969.5	482359.5	918780

Note: Based on the exchange rate as of March 2022: 1 USD = 4.1955 MYR. [a] Surveyed household. [b] Total households in the study areas.

Adaptation Plan. Based on the findings, the economic value of adaptation benefits is projected considering the population *(N)* in the respective coastal districts as presented in Fig. 8, which reflected that yearly perceived adaptation benefit could facilitate 23%, 18% and 9% of financing for National Adaptation Plan by adopting extensive, moderate and minimal coastal adaptation program respectively in Sabak Bernam, Kuala Selangor and Kuala Langat districts, respectively.

The formation and implementation of the National Adaptation Policy are under process in Malaysia (GoM, 2018). The study findings have several implications for National Adaptation Policy suggesting to integrate climate change adaptation with the Sustainable Development Goals (United Nation, 2015) and the Sendai Framework for disaster risk reduction (UNISDR, 2015) to reduce vulnerability and enhance resilience in the coastal areas (UNFCCC, 2017). This study explored the connection between planned and autonomous adaptation, including anticipatory and con-current disaster risk reduction activities for coastal hazard, indicating the need for financial instruments and resilience building. The common theme of resilience interlinks the adaptation, Sustainable Development Goals (SDGs) and disaster risk reduction. The scope of National Adaptation Policy for coastal areas should include SDG 1 (eradicating poverty) by providing diversified income opportunities and financial instruments such as grants, debt swaps, insurance instrument to build financial capacity for tackling climate change impact, SDG 4 (quality education) by ensuring climate literacy for public understanding of the local dimensions of climate change in traditional classroom setting as well as in the practical setting using effective edutainment tools of telecommunication services, SDG 11 (sustainable cities and communities) by protecting coastal regions and communities with sustainable growth of settlements and economic activities based on the coast, SDG 13 (climate action) by ensuring the urgent implementation of efficient planned and autonomous adaptation, SDG 15 (sustainable use of ecosystem and forests) by focusing ecosystem-based adaptation approaches such as reforestation and management of mangrove and coastal wetlands and SDG 17

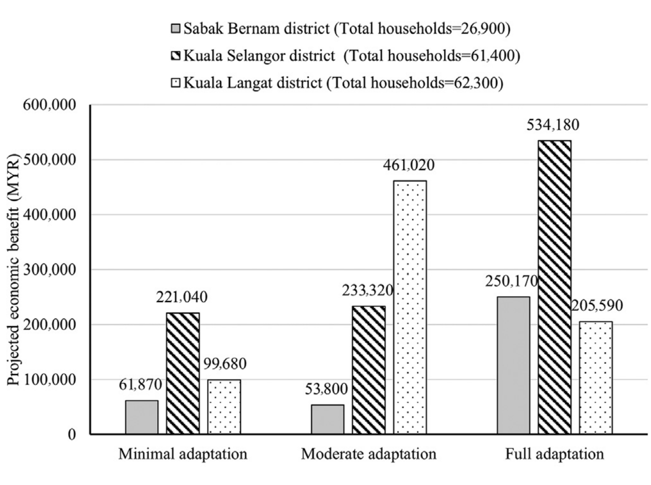

Fig. 8. Projected yearly adaptation benefit in coastal districts of Selangor.

(revitalizing partnerships for sustainable development) by assimilating a cross-sectoral, top-down and bottom-up approach from multi-stakeholder perspective.

Attributes of adaptation plans and policies should be communicated within the coastal communities. Awareness and adaptive capacity building programs between higher education institutes and local communities are conducted by the initiative of the Malaysian government. Such knowledge-sharing platforms should also bring policymakers and financial institutions into the dialogue. Early analysis and engagement of existing local institutional frameworks is one possible entry point for meaningful local deliberation in national adaptation planning and global climate change policy-making processes (Ayers, 2011). Thus, the capacity of local institutions relevant to adaptation needs to be ensured through transfers of information, financial, and technical resources by increasing local autonomy to decentralise adaptation planning and implementation and improving accountability of local decision-makers to their constituents (Agrawal et al., 2012). The critical importance of good institutional governance also acts as a prerequisite for effective national adaptation (Berrang-Ford et al., 2014).

4. Conclusion

The study is intended to comprehend current conditions of household adaptation, perceived adaptation benefit and factors affecting the willingness to pay for planned adaptation. A micro-level analysis of the household adaptation integrating household risk perception was conducted on the coastal areas of Selangor, representing the districts of Sabak Bernam, Kuala Selangor and Kuala Langat. The study reveals that households perceived low risk of sea-level rise threat and associated inundation and high risk of future climate change impact. The majority of the households have taken some kind of adaptation actions autonomously; however, they have mainly focused on con-current autonomous adaptation to reduce the risk during coastal hazards rather than choosing anticipatory adaptation actions that indicate a low disaster preparedness among the coastal districts. Households have a positive attitude towards willingness to pay for planned adaptation despite the limited income capabilities. Most households are willing to pay in favour of moderate adaptation, indicating that households perceived the necessity and benefits of adaptation to reduce the hazard impact. A significant amount of perceived adaptation benefits in the coastal districts of Selangor revealed the economic value of an extensive, moderate and minimal adaptation program that can be utilised as a market-based instrument to facilitate funding and incentivise coastal adaptation plans. Residents who are elderly, involved in the climate-related occupation, household head, living closer proximity to the coastline, had prior exposure of coastal hazard, higher awareness of coastal hazard impact, directly affected by property damage, perceived higher risk and participated in community adaptation probably are willing to pay for planned adaptation. Increasing monthly household income, and with access to telecommunication services alongside the above factors, residents are likely to pay a higher amount for better adaptation measures. Due to prior coastal hazards, residents directly affected by the loss of income have lesser financial abilities and are less likely to pay a higher amount for better adaptation measures. It can be safely assumed that prior experiences of local sufferers of climatic hazards would create awareness among people about potential damages and risks that might be inevitable. Moreover, it may urge them to participate in public endeavours significant to coastal adaptation.

The findings can be deemed momentous; it justifies several implications in formulating effective community-based adaptation policies through public engagement by understanding households' perspectives on the adaptation process, perceived adaptation benefit and factors affecting planned adaptation. Moreover, the study is applicable to assess the household adaptation process in other local coastal areas and national level. Further studies could focus on economic costs and benefits associated with specific adaptation measures based on future climate scenarios to implement the coastal action plans and policy in maximal effectiveness to enhance coastal resilience, preserve and improvise the functionality of the climate management in the entire Peninsula region of Malaysia.

Declaration of competing interest

The authors declare no conflict of interest.

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