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Evaluation Of Rural Community Adaptation and Mitigation to Climate Change Using a Discrete Choice Experiment

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Abstract

The agricultural sector is one of the most vulnerable to the impacts of climate change, necessitating adaptation and mitigation strategies to safeguard farmers' livelihoods, which heavily rely on natural conditions and climate factors. This study aims to evaluate the knowledge and perceptions of farming households regarding the impacts of climate change in the agricultural sector using a Discrete Choice Experiment (DCE). The study was conducted in Batu Dulang Village, Batulanteh Subdistrict, Sumbawa Regency. The approach utilized both quantitative and qualitative methods. Quantitative data were collected through a survey of 100 farming households, while qualitative data were obtained through in-depth interviews. The DCE method was employed to determine farmers' preferences for selecting the most suitable adaptation and mitigation strategies. The study results indicate that the preferred attributes of climate change adaptation and mitigation activities of rural communities from the most preferred are forest conservation schemes through agroforestry systems, followed by emission reduction, increased food security, natural disaster control, and waste management. Attributes with greater direct utility for respondents, such as forest conservation and emission reduction, have higher marginal utility coefficients than others. Individuals are willing to pay for preferred attributes, indicating that climate conditions are an integral part of their livelihoods because the agricultural sector is highly dependent on climate and natural conditions.

Keywords: adaptation, climate change, discrete choice experiment, farmer preferences, mitigation

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INTRODUCTION

Global climate change is one of the most pressing challenges facing the world today, including Indonesia. This change is not only a natural phenomenon that occurs naturally, but also the result of human activities that continue to change the composition of the earth's atmosphere (WMO 2023). Increasing global temperatures, changes in rainfall patterns, and increasingly frequent extreme weather events are some of the real symptoms of climate change that have a broad impact on various aspects of life, especially the agricultural sector which is the backbone of the economy of many developing countries such as Indonesia (Komarudin et al. 2024). In Indonesia, the impact of climate change is very much felt in various sectors, especially in the agricultural sector which is the mainstay of most rural communities. Batu Dulang Village, located in Batu Lanteh District, Sumbawa Regency, West Nusa Tenggara, is one example of an area in Indonesia that is vulnerable to climate change (Komarudin et al. 2024). This village is known for its coffee and candlenut production, two commodities that are highly dependent on stable climate conditions. However, global climate change has threatened the sustainability of the agricultural system in this village, which in turn has the potential to reduce the welfare of the local community (Hidayatullah et al. 2022).

Climate change has a wide impact on biodiversity and ecosystems around the world (Dueñas et al. 2021). Changes in temperature and rainfall patterns can cause habitat shifts, which in turn can lead to the extinction of various species. In addition, climate change can also disrupt the life cycles of plants and animals and affect interactions between species, which ultimately impacts the balance of ecosystems (Dueñas et al. 2021).

Global warming is one of the most prominent aspects of climate change, and it is caused by increasing concentrations of greenhouse gases (GHGs) in the atmosphere. These gases, including carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), absorb and re-emit infrared radiation, causing an increase in the Earth's average temperature. The increase in GHG concentrations is largely due to human activities, such as the burning of fossil fuels for energy, deforestation, and changes in land use. In the agricultural sector, global warming can impact a variety of aspects, from crop productivity to the spread of pests and diseases. In Batu Dulang Village, for example, rising temperatures and changes in rainfall patterns have increased the risk of pest and disease attacks on coffee and candlenut plants. This adds to the economic burden on farmers, who have to spend more money on pest and disease control.

In dealing with climate change, there are two main approaches that can be taken, namely adaptation and mitigation. Adaptation strategies aim to reduce vulnerability to the negative impacts of climate change by making adjustments to natural and social systems. Meanwhile, mitigation strategies focus on efforts to reduce greenhouse gas emissions and increase carbon sinks, with the aim of slowing the rate of climate change (Heryani 2023; Apariyana et al. 2023). Adaptation is very important for the people of Batu Dulang Village, given their dependence on agriculture which is greatly influenced by climate conditions. Some forms of adaptation that can be done include changes in cropping patterns, the use of plant varieties that are more resistant to climate change, and more efficient management of water resources. However, these adaptation efforts need to be balanced with effective mitigation strategies, so that climate change does not get worse and adaptation efforts are not in vain (Apariyana et al. 2023). Mitigation, on the other hand, requires a cross-sectoral approach involving various stakeholders, both at the national, regional, and local levels. For example, the use of renewable energy, increasing energy efficiency, and sustainable forest management are some mitigation steps that can be taken. In Batu Dulang Village, mitigation efforts can also be carried out through sustainable agricultural land management, one of which is by implementing an agroforestry system that not only increases agricultural production but also absorbs more carbon from the atmosphere (Heryani 2023).

To develop effective adaptation and mitigation strategies, a deep understanding of community preferences and behaviors in dealing with climate change is needed. Discrete Choice Experiment (DCE) is one method that can be used to evaluate community preferences for various adaptation and mitigation options (García-Llorente et al. 2012). DCE allows researchers to identify the factors that most influence community decisions in choosing certain actions, as well as assess the extent to which they are willing to sacrifice to reduce the risks of climate change (Jotaworn et al. 2023). DCE can be used to evaluate community preferences for various adaptation options, such as changing cropping patterns or using crop varieties that are more resistant to climate change. In addition, DCE can also be used to measure the level of community support for various mitigation policies, such as reducing the use

of fossil fuels or increasing energy efficiency García-Llorente et al. 2012).

This research has high relevance, especially in the context of the Indonesian government's efforts to achieve sustainable development goals. Batu Dulang Village, with its unique social and economic characteristics, is an important case study to understand how rural communities adapt to climate change and how they can be involved in mitigation efforts. The results of this study are expected to provide significant contributions to policy formulation, which are not only relevant to Batu Dulang Village, but also to other regions in Indonesia facing similar challenges. Climate change is a major challenge that requires a comprehensive and integrated response. In Batu Dulang Village, the impact of climate change on coffee and candlenut farming systems shows the importance of effective adaptation and mitigation efforts. Through the Discrete Choice Experiment approach, this study seeks to evaluate community preferences and behaviors in dealing with climate change, and provide policy recommendations that can support sustainable development.

METHODS

Research Location

This research was conducted in the Batu Lanteh KPH area, namely in Batu Dulang Village, Batulanteh District, Sumbawa Regency (Figure 1), which is famous for its agroforestry farming practices with the commodities planted being coffee, candlenuts and cinnamon (Hidyatullah et al. 2022). This research was conducted in May-August 2024 using research grant funds from the DRTPM Kemendikbudrikstek DIKTI through penelitian dosen pemula scheme (PDP) for the 2024 fiscal year.

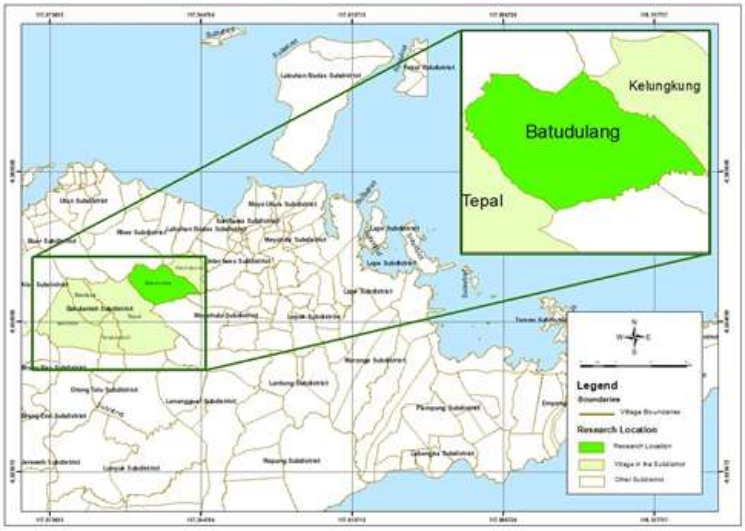

Figure 1. Research location

Research Design

The survey was conducted using the DCE approach, where respondents were presented with a series of alternative hypotheses and asked to choose the scenario of adaptation and mitigation efforts carried out by the community in dealing with the phenomenon of climate change that they most preferred. The alternatives in each set of choices presented adaptation and mitigation practices in dealing with climate change using different levels of attributes. Attributes are components of goods that need to be managed and have two or more levels. Levels are alternative manifestations of each attribute (García-Llorente et al. 2012; Carlsson et al. 2003).

Identification of attributes and their levels is the first step of DCE (Johnson et al. 2022). The selection of attributes was carried out through several stages starting from literature review, consultation with climate change adaptation and mitigation researchers and key informant interviews with Batulanteh KPH Officers. In addition, FGDs were conducted with local communities. The purpose of the FGDs was to understand community knowledge and perceptions about climate change adaptation and mitigation (Komarudin et al. 2024). Communities were encouraged to interact freely with each other and use Indonesian or their local language. Several forms of adaptation and mitigation activities were mentioned including natural disaster control, increasing food security, waste management, efforts to reduce emissions, and forest conservation. Communities were asked to identify several key attributes from the list generated. The selected socio-economic and climate change adaptation and mitigation attributes and their levels related to climate change adaptation and mitigation are described in Table 1.

Table 1. Attributes and levels

Attributes	Information	Level
Natural Disaster Management	Activities carried out by the community to control natural disasters	0: Nothing to do in disaster management efforts 1: Making rainwater reservoirs, water preparation, building drainage channels; terracing and multiculturalism
Improving Food Security	Activities carried out by the community to increase food security	0: No improvement efforts are made for food security 1: Implementing irrigation systems, cropping patterns and integrated farming, Utilization of biomass and yard land for biopharmaceutical plants.
Waste Management	Types of activities carried out by the community to manage waste	0: No community contribution in waste management 1: Carrying out waste sorting and collection and 3R independently and conventionally and using MRF.
Efforts to reduce emissions	Types of activities carried out by communities to reduce emissions	0: No efforts made to reduce emissions 1: No burning of straw on land, reduced use of chemicals.
Forest Conservation	Types of activities carried out by communities for forest conservation	0: Communities do not practice forest conservation. 1: Practice agroforestry and replanting
Payment/Donation (IDR)	A one-time payment or donation by the respondent if the alternative is selected	IDR. (0); (100.000); (150.000)

The next attribute is used to build a choice set using the web-based software “ngene”, and produces 36 alternatives that are grouped into twelve choice sets. The choice set is determined into three random blocks of four sets each. An example of a choice card is shown in Figure 2. Each choice set has three alternatives: the status quo and two other options that provide improvements at the attribute level. The payment for the basic alternative (status quo) is zero because it does not involve any changes to the existing conditions. The questionnaire was tested on 100 randomly selected residents in Batu Dulang Village, Batulanteh District, Sumbawa Regency.

The questionnaire was administered face-to-face to 100 randomly selected individuals from the target population. According to Pearmain et al. (1990), a sample size of 100 can provide a basis for modeling preference data, in a DCE design (Bekker-Grob et al. 2015). The research team considered 100 individuals sufficient given budget constraints. A multi-stage sampling technique was used to identify respondents to be interviewed. Respondents were purposively selected due to their high involvement in agroforestry farming. The

research team worked with the Batulanteh FMU to obtain a list of respondents in Batu Dulang Village who were selected for the study. Each respondent answered four sets of choices from the same randomly assigned block. The research team clearly explained to the respondents the purpose of the study, and its attributes and levels in a language that was most understandable to the respondents, namely Indonesian or the local Sumbawa language. Respondents were reminded that there were no right or wrong answers, but rather their opinions on various climate change adaptation and mitigation scenarios were sought. Additional information on socio-economic and demographic characteristics of respondents was also obtained from respondents, including gender, age, highest level of education, household size, monthly income, existence of alternatives and income. The questionnaire took an average of 50 minutes to complete. Respondents' attitudes and perceptions towards government interventions have the potential to bias survey responses. This source of bias was minimized by continually reminding and reassuring respondents that the data collected would be used for academic purposes only.

Table 2. Alternative options

Which alternative do you choose?			
Attributes	Alt 1	Alt 2	Alt 3
Natural Disaster Management	Nothing is willing to be done in an effort to control natural disasters	Making rainwater reservoirs, water absorption, and construction of drainage channels	Anticipate landslides with terracing, combining several types of trees to prevent natural disasters
Improving Food Security	No improvement efforts are made for food security	Implementing irrigation systems, cropping patterns and integrated farming	Utilization of biomass and yard land for biopharmaceutical plants
Waste Management	There is no community contribution in waste management	Carrying out waste sorting and collection and 3R independently and conventionally	Using material recovery facilities to process waste
Efforts to reduce emissions	No efforts are being made to reduce emissions	Do not burn straw on the land	Reducing the use of chemical fertilizers and pesticides
Forest Conservation	Communities do not carry out forest conservation	Practice agroforestry (planting agricultural crops and woody plants)	Replanting trees that have been cut down
Payment (IDR)	0	100.000	150.000
Which alternative do you choose?	Alternative 1	Alternative 2	Alternative 3

Model Specifications

In a choice situation, choosing one particular alternative among several options implies that the chosen alternative provides the maximum utility to the individual (Lukuma et al. 2020; Hole et al. 2007). Using random utility theory (RUT), it is assumed that the utility (Urj) obtained by an individual r from climate change adaptation and mitigation alternative j (jϵJ , J = 1,2,3,…12) is a function of the observed components (Vrj) known to the researcher up to some parameters and the unobserved components (εrj) that the researcher treats as random (often called disturbances):

$$Urj = Vrj + \varepsilon rj \; \forall \; j \quad (1)$$

Since the deterministic component, V rj , is defined by the attributes for alternative j , Equation (1) can be written as:

$$Urj = \beta akurj + \delta akurj + \gamma Sr + \varepsilon rj \quad (2)$$

where A rj is a vector of climate change adaptation and mitigation attributes presented to respondent r ; C rj is the cost associated with a particular climate change adaptation and mitigation alternative

presented to respondent r ; S r is a vector of respondents' socio-economic characteristics; and β , δ , and γ are the estimated coefficients (marginal utilities), respectively.

RESULTS AND DISCUSSION

Respondent characteristics

A total of 100 respondents have filled out the questionnaire and most of them gave protest answers regarding their choice of status quo. The protesting respondents explained that they were not willing to pay because it was not their responsibility but the government's responsibility to manage the resources. Table 3 shows descriptive statistics of the respondents' characteristics for all those who completed the questionnaire as a whole. The majority of respondents have small households (with no more than 5 members). About two-thirds of the respondents are male. Most respondents are under 40 years old and have achieved secondary education as their highest level of education. Most (81%) of the respondents are actively involved in Agroforestry farming. About two-fifths of the participants have more than one source of income; however, the majority (almost 75%) of them earn no more than IDR 2,500,000. per month.

Table 3. Respondent characteristics

Respondent characteristics	Frequency of respondents willing to pay (%)
Gender	
Male	40.0
Female	60.0
Age (Year)	
18-20	0.5
21-39	61.4
40-60	33.8
>60	4.3
Monthly Income (IDR)	
<1.000.000	12
1.000.000 - 2.999.999	50
3.000.000 - 5.999.999	33
6.000.000 - 10.000.000	4.6
>10.000.000	0.4
Is there other income?	
Yes	56.4
No	43.6
Size of Household	
5	59.0
5-10	31.5
11+	9.5
Education	
No formal education	13.9
Elementary School	28.6
Secondary School	37.0
High Education	20.5
Distance to the land farming	
3 km	43.1
4-5 Km	41.6
5-10 Km	14.7
> 10 Km	0.6

Source: Processed data (2024)

Respondents' Preferences for Climate Change Adaptation and Mitigation Attributes

Disagree responses were excluded from the attribute preference analysis because they would bias the WTP estimates. The researchers were optimistic that selectivity bias was not large because disagree responses only constituted a small portion (4%) of the overall sample. Consequently, further analysis considered responses from the 96 agreeing individuals.

Socio-economic characteristics for individuals willing to pay (Table 3) were regrouped into two classes per characteristic. Age was categorized as follows: 40 years and above, to represent the elderly population who are less engaged in active agricultural work and those under 40 years (18–39), who are the most active working age group (Lakuma et al. 2020). Regarding income, the area found that the average monthly income was around IDR 2,500,000. In addition, during informal interviews, respondents reported that they would spend an average of around IDR 2,500,000 to meet their basic monthly needs. Therefore, IDR 2,500,000 was taken as the benchmark for this study population. Regarding household size, on average, each household in Batudulang Village has 4.5 people. The author estimated this to be 5 people per household and created two categories: households with five or fewer people and households with more than five people. A distance of 5 km was inferred during the study (Table 3) because it was the average walking distance for most respondents from their households to their farmland. Table 4 shows the descriptive statistics of the 100 respondents and the attributes used for the attribute preference analysis.

Table 4. Attribute preferences

Respondent characteristics	Percentage (%)
Male Respondents	64.74
Respondents aged > 40 years	38.15
Monthly Income > Rp. 2,500,000	25.43
Availability of alternative income	43.64
Respondents who do Agroforestry	81.21
Household Size (5 or more people)	41.04
Education > High School Equivalent	57.51
Proximity to agricultural land more than 5 Km	15.32
Attributes	**Average (SD)**
Natural Disaster Management	0.52 (0.50)
Improving Food Security	0.61 (0.49)
Waste Management	0.53 (0.50)
Efforts to reduce emissions	0.60 (0.49)
Forest Conservation	0.62 (0.49)
Payment (IDR)	0.69 (0.73)

Sumber: Data olahan (2024)

The marginal coefficients for various climate change adaptation and mitigation attributes are shown in Table 5. All coefficients for the attributes as well as cost and ASC are significant. This implies that respondents already have very good adaptation and mitigation strategies. The preferences are natural disaster control schemes, increasing food security, waste management, efforts to reduce emissions and forest conservation, in descending order. The cost attribute has a negative sign indicating that respondents tend not to choose better but expensive alternatives for climate change adaptation and mitigation efforts. This is consistent with economic theory (Hole et al. 2007). Farmers tend to prefer adaptation strategies that can be integrated with existing farming practices, such as increasing the use of environmentally friendly technologies and crop diversification, but are less interested in solutions that require major changes in established practices. The coefficients of the attributes in the two models are very close to each other. However, the standard errors in the mixed logit are larger than those in the conditional logit model. Consequently, the authors chose to use the conditional logit rather than the mixed logit for further analysis.

Table 5. Estimated marginal coefficients for climate change adaptation and mitigation

Attributes	Logit conditional		Mixed logit	
	Coeff	Std Error	Coeffi	Std Error
Mean				
Natural Disaster Management	0,748***	0,094	0,774 ***	0,148
Improving Food Security	0,965***	0,088	0,909***	0,158
Waste Management	0,671***	0,090	0,723***	0.142
Efforts to reduce emissions	1.193***	0,093	1.172***	0.193
Forest Conservation	1.379***	0,093	1.430***	0,199
Payment (IDR)	-1,009***	0,064	-1.515***	0.205
Alt. Specific constant (ASC)	-1.490***	0.196	-2,332***	0.421
SD				
Natural Disaster Management			0,584 *	0.297
Improving Food Security			-0,584 *	0.310
Waste Management			0,915***	0.261
Efforts to reduce emissions			1.522***	0.296
Forest Conservation			0.751	0.291
Payment (IDR)			0,652***	0.201
ASC			1.194***	0.445
Number of observations	2152		2152	
Log-likelihood	-1247,16		-818.467	
Prob > chi2	0.000		0.000	
LR chi2 (7)	1799.23		36.93	

Significance codes: * p < 0.1, *** p < 0.01 *Source: Processed data (2024)*

The Influence of Respondent Characteristics on Attribute Preferences

Table 6 shows the results of the interaction of socio-economic and demographic characteristics of respondents with various attributes of climate change adaptation and mitigation. In general, socio-economic factors of respondents influence their choices differently. Preferences for disaster control and increasing food security are positively influenced by respondents' income. Individuals who earn at least IDR 2,500,000 per month have a positive log probability of supporting natural disaster control and increasing food security compared to those who earn below IDR 2,500,000. However, respondents who at the time of the study used agricultural land for natural disaster control such as making drainage refused because they preferred to adapt to their local wisdom, namely the agroforestry system. For waste management, respondents' preferences are positively influenced by household size and negatively influenced by gender. Large households with five or more members have higher log odds of supporting waste management programs compared to small households with less than five members. In addition, male respondents are less likely to support waste management programs compared to female respondents. Preferences for emission reduction efforts are positively influenced by respondents' age and income alternatives and negatively influenced by household size and current farming activities for coffee and candlenut farming. Respondents aged 40 years and above, and those with income alternatives are more likely to support emission reductions. Finally, preferences for forest conservation schemes are negatively influenced by respondents' education level and positively influenced by the availability of income alternatives. Having more than one source of income increases respondents' odds of choosing forest conservation.

Respondents' Willingness to Pay for Climate Change Adaptation and Mitigation Attributes

By estimating the changes in climate change adaptation and mitigation that

would be caused by implementing different scenarios of climate change adaptation and mitigation efforts, the marginal value of each adaptation and mitigation attribute was calculated. From the marginal utility coefficients for the attributes in the model with interactions (Table 4), the willingness to pay was derived using the delta method (Hole 200). Table 6 reports the estimated marginal willingness to pay of respondents per household for a one-unit increase in the attribute level from the status quo. All WTP values are positive, implying that the attribute increases the average utility of adaptation and mitigation activities (Doherty et al. 2014; Lee et al. 2024). Therefore, respondents are willing to pay, on average, IDR 0.9 for increased natural disaster control efforts, IDR 1.29 for increased food security, then IDR 0.64 for waste management, IDR 1.06 for emission reduction efforts and IDR 1.04 for forest conservation.

Table 6. Interaction of climate change adaptation and mitigation attributes with respondent characteristics

Attributes and Interactions	coeff	SD	Confidence Interval 95%	
Natural Disaster Management x Income	0,504 **	0.209	0,094	0.914
Natural Disaster Management x Agriculture	-0,480 *	0.248	-0,966	0,005
Increasing Food Security x Income	0,334 *	0.198	-0,054	0.722
Waste Management x Gender	-0,321 *	0.19	-0,694	0.052
Waste management x Household size	0,428 **	0.216	0,005	0.851
Efforts to reduce emissions x Age	0,429 **	0.214	0,010	0.848
Efforts to reduce emissions x alternative income	0,355 **	0,178	0,006	0.704
Efforts to reduce emissions x agriculture	-0,492 **	0.242	-0,966	-0,017
Efforts to reduce emissions x Household Size	-0,706***	0.21	-1,116	-0,295
Forest Conservation x Alternative income	0,508***	0,174 tahun	0,168	0.848
Forest Conservation x Education Level	-0,317 **	0.182	-0,673	0,039
Income (IDR)	-1,026 ***	0,07	-1,163	-0,889
Number of Observations		4152		
LR chi2		-		
possibility > Chi2		0.000		
Semu R2		0.4197		
Log possibility		-1245,71		

Table 7. Willingness to pay

Attributes	Household marginal WTP (Rp) in hundreds of thousands	Confidence Interval 95%	
Natural Disaster Management	0,91	0.31	1.51
Improving Food Security	1.29	0.69	1.88
Waste Management	0.64	0,05	1.24
Efforts to reduce emissions	1.06	1.15	2.38
Forest Conservation	1.04	0,94	2.14

Source: Processed data (2024)

The main objective of this study is to assess attribute preferences for climate change adaptation and mitigation efforts in Batu Dulang Village, Batulanteh District, Sumbawa Regency. By using DCE to survey the population and analyzing the results with a conditional logit model, it was found that the most preferred climate change adaptation and mitigation attributes were forest conservation activities through agroforestry systems, followed by emission reduction, food security enhancement, natural disaster control and waste management. All coefficients for climate change adaptation and mitigation effort attributes were significant and

positive, implying that respondents highly valued these attributes.

CONCLUSION

This study attempts to identify the preferred attributes of climate change adaptation and mitigation activities of rural communities. In descending order, the attribute preferences are forest conservation schemes through agroforestry systems, followed by emission reduction, food security enhancement, natural disaster control and waste management. Attributes that have greater direct utility for respondents (forest conservation and emission reduction) have higher marginal utility coefficients than others. Respondents' socioeconomic and demographic factors such as gender, age, income, and education level, among others, have an influence on attribute preferences. This should be considered when designing policy interventions for climate change adaptation and mitigation efforts in rural communities for sustainable agricultural management. Individuals are willing to pay for preferred attributes indicating that climate conditions are an integral part of their livelihoods since the agricultural sector is highly dependent on climate and natural conditions. Therefore, policymakers should support this objective by involving stakeholders (including local communities) in developing policies and action plans related to climate change adaptation and mitigation.

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