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Farmers' Adaptation to Climate Change in Developing Countries

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Abstract:

This paper reviews and analyzes determinants of adaptive capacity, coping strategies and adaptation to climate change of farmers in developing countries, and determines difficulties applying these strategies. In developing countries, farmers apply a variety of strategies in response to climate change and variability, dependent on individual adaptive capacity which is determined based on their socio-economic characteristics and resources as well as characteristics of the institutional and technological conditions. It is concluded that the policies on climate adaptation need to be designed as an integral part of the development policy and adaptation to climate change should be included in all related sectors.

Keywords: *Climate change, developing countries, agriculture, adaptive capacity, coping strategies*

1. Introduction

Climate change has emerged as one of the most threatening global issues. Climate change is causing more extreme and unpredictable variations in weather, affecting all regions and sectors and poses a significant threat to our societies as well as the ecosystem. Climate-related disasters have brought about adverse impacts on human health, livelihood assets, food security and infrastructure therefore deteriorating the human ability to guarantee their lives and protect themselves (Vietnam Ministry of Natural Resources and Environment, 2008). Especially, the consequences of climate change directly affect achievement of poverty reduction goal in developing countries. Therefore, there is now increased attention paid to climate change issues to gain better understanding of causes, including natural and human causes, risks and impacts of climate change and human's coping strategies.

Although the problems related to concentrations of various greenhouse gases in the atmosphere have mainly come from industrialized countries, developing countries and poor countries, with limited resources and lack of capacity to cope with, will suffer more from the impacts of climate change (Mertz et al., 2009). Developing countries are particularly vulnerable to the adverse impacts of climate change due to some reasons, these being, (i) agricultural sector plays a pivotal role in the economy of developing countries and this is also the most vulnerable sector to climate change, (ii) the economy of developing countries rely heavily on natural resources and climate change negatively affects many of the services that natural resources provide such as water quality and supply or forestry; in addition, climate change causes scarcity of most of natural resources, (iii) developing countries are characterized by high percentage of poor people who are generally more vulnerable and have less ability to protect themselves, (iv) limited economic and technological capacity hinders adaptation to climate change in these countries (Barbier et al., 2009; Mertz et al., 2009; Yohe and Tol, 2002). Despite increased efforts on mitigating impacts of climate change, building resilience and enhancing adaptive capacity, the climate change consequences have continued and tend to be more serious in developing countries, and this has led to the need for more attention paid on adaptation to reduce the vulnerability and risks related to climate change.

Smallholder farmers have been found to be one of the most vulnerable stakeholders who are disproportionately affected by climate change due to their high dependence on agriculture for their livelihoods and socially and economically disadvantaged characteristics. According to Smit and Pilifosova (2001), impacts of climate change are unevenly distributed and the people who are highly exposed to climate variation will generally be the ones with limited capacity to cope with risks and impacts of climate change. However, several studies showed that farmers in developing countries are not victims of climate change but they apply various strategies to cope with climate hazards (Adger et al., 2001; Huq et al., 1999). Based on reviewing empirical studies on climate change in developing countries, this paper critically analyzes and summarizes adaptation and coping strategies applied by farmers to respond to climate variability and change in these countries. Understanding responses of the affected people as well as the conditions to apply adaptive strategies is necessary to propose targeted policy for vulnerable groups in order to enhance adaptive capacity, strengthen resilience and reduce vulnerability to climate change.

2. Determinants of Adaptive Capacity to Climate Change

Adger et al. (2003) stated that nearly all human societies and their activities are sensitive to climate somehow because where they live and how they build a livelihood and make a living is affected by surroundings. Meanwhile, variability is an inherent attribute of climate, therefore humans need to anticipate and adapt to adverse impacts of climate variations or weather extremes. The Intergovernmental Panel on Climate Change (IPCC) (2007) defined adaptation as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". Adaptive capacity was defined as "a vector of resources and assets that represents the asset base from which adaptation actions and investments can be made" (Vincent, 2007). Although high adaptive capacity may not automatically translate into effective adaptation, enhancing adaptive capacity is still essential for a successful adaptation. Previous studies in developing countries have shown that adaptive capacity of farmers to climate change are mainly determined by features such as demography characteristics (education, gender, household size), economic wealth, social capital, perception of climate change (Below et al., 2012; Bohensky et al., 2013), institutions and equity (Smit et al., 2001). The study of Ofoegbu et al. (2016) on impacts of social and demographic characteristics of affected communities on their adaptive capacity and adaptive strategies also showed that demographic characteristics of households and communities, especially education level, skills, access to forest products, public services and infrastructure (e.g. access to market, water supply system) considerably influence their choice of coping strategies.

It should be noted that, adaptive capacity is a complex multidimensional phenomenon (Below et al., 2012) which is determined by a range of socio-economic, institutional and technological factors (Figure 1). For the households and communities affected by climate change, their adaptive capacity is influenced by internal and external factors. These factors may facilitate or hinder the development and application of coping strategies and adaptation.

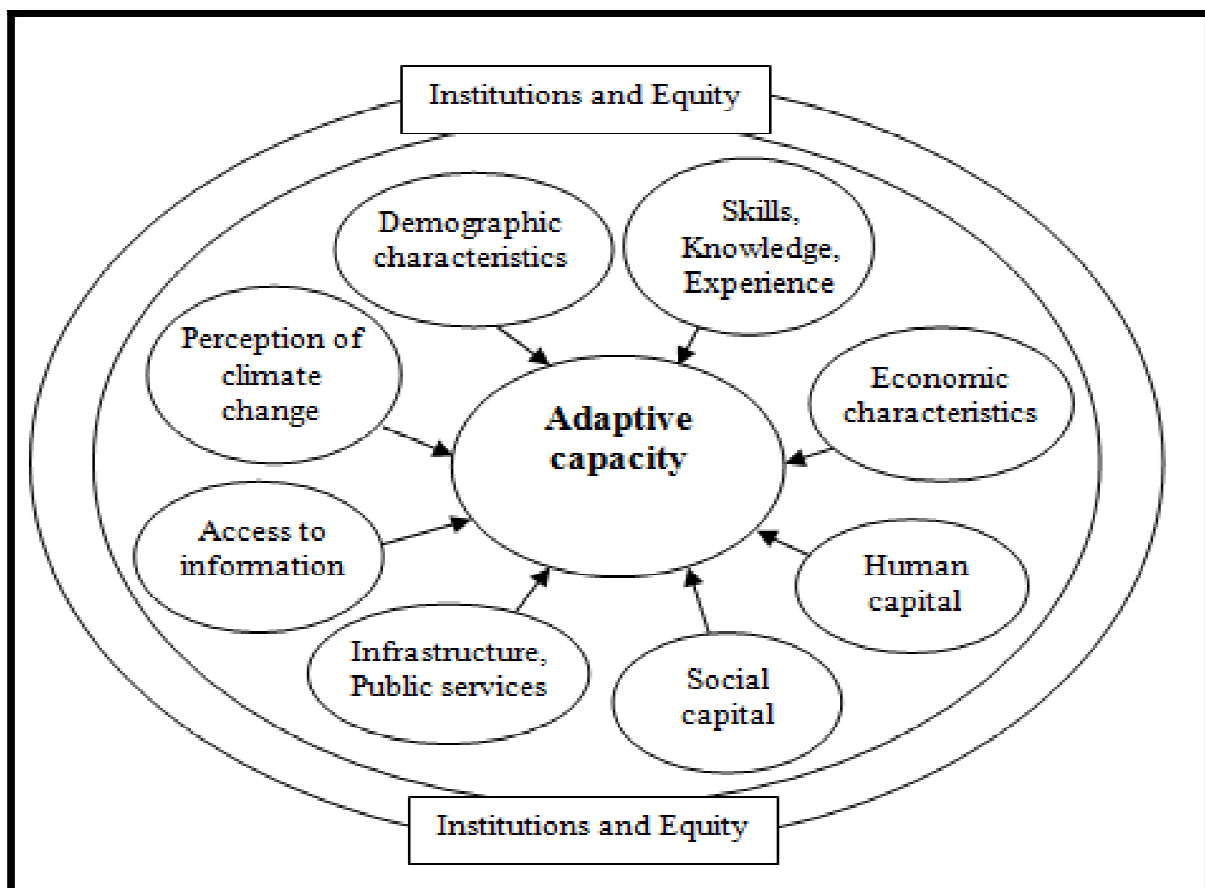


Figure 1: Determinants of Farmers' Adaptive Capacity to Climate Change

3. Adaptive Strategies to Climate Change

Empirical studies in many developing countries have shown that farmers select and apply different strategies to cope with and to adapt to climate change, depending on their adaptive capacity which is determined by individual and community property and specific local context. These strategies are also influenced by policies, institutional structures and public services. Some strategies are strongly contingent on technological conditions and required more resources than others (Adger et al., 2003). Such major strategies could be summarized in Figure 2.

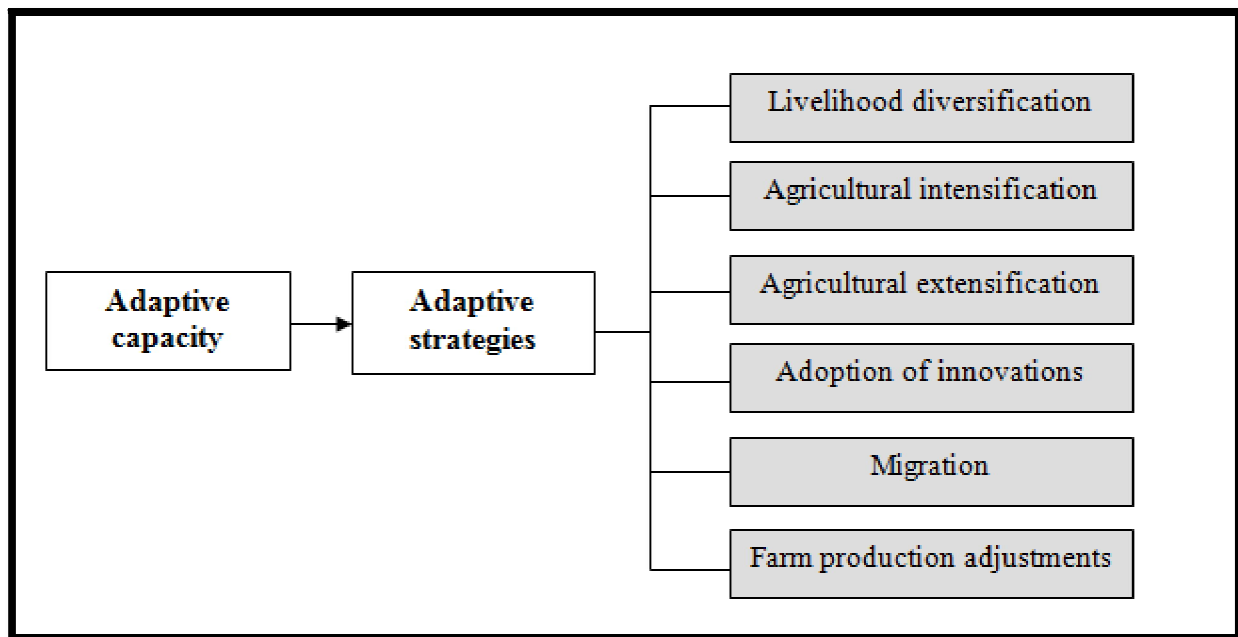


Figure 2: Farmers' Adaptive Strategies to Climate Change

3.1. Income Diversification, Livelihood Diversification

Individuals and farm households may diversify their livelihoods and income and incorporate non-farm components as a way to reduce vulnerability to climate change than agriculture (Marcus and Ajaya, 2004). Paavola (2008) used secondary data provided by the government, combined with primary data collected through a survey to explore different strategies applied by farmers to respond to climate variability and other stressors in Morogoro, Tanzania. The study showed that livelihood diversification in term of increasing non-farming activities was the main coping strategy of farmers to reduce their exposure to climatic-related risks. The role of agriculture in farmers' livelihoods declined while contribution from non-farm activities to household income constantly increased. Based on case studies conducted in regions affected by drought and flood in India and Nepal, Marcus and Ajaya (2004) also found that non-farm income diversification was the major strategy employed by the farmers to maintain their livelihoods and avoid income disruption during flood and drought. Farmers diversified their income by establishing a business, migrating outside the country or city to find a job or participating in regional labor markets. Maintaining the income would help the farmers to maintain consumption and invest in farm and non-farm activities. In some cases, the farmers had to sell or pawn their productive assets and find off-farm work to maintain their income when the agricultural production dramatically declined during or after extreme flood and drought events (Marcus and Ajaya, 2004).

Because agriculture is inherently vulnerable to climate change, farmers usually diversify their livelihoods away from agriculture as a measure to go through difficult times when the climate extreme events occur (Marcus and Ajaya, 2004). As a result, ability to diversify income plays a decisive role in maintaining the agricultural livelihood systems. However, it should be noted that non-farm income is not a constantly secure source as the farmers are often disadvantaged in terms of education levels, expertise, skills and social status when competing for jobs with other urban people. In addition, ability to diversify income also depends on specific livelihood characteristics. Farmers with better livelihood assets would generally have more opportunities to diversify their income while vulnerable groups such as rural women, poor or ethnic minority people whose access to land, employment, markets and public services is limited face difficulty applying this strategy (Paavola, 2008). Nhemachena and Hassan (2007) stated that farmers with access to technology have better chances of taking up adaptation options and they often diversify their livelihoods by extending non-farm activities, although the farmers who have invested more in farming would find that this transformation is much more expensive (Nhemachena and Hassan, 2007).

3.2. Agricultural Intensification and Agricultural Extensification

Agricultural intensification or agricultural extensification can be applied by farmers as a strategy to cope with climate extreme events as observed in Morogoro, Tanzania (Paavola, 2008) or in northern Benin, West Africa (Yegbemey et al., 2014). Farmers apply agricultural intensification in order to improve agricultural productivity, usually by increasing their exploitation of resources. Agricultural intensification refers to farming activities such as using more labor or other inputs (fertilizers, pesticides, agricultural equipment) per unit of land or reducing the length of fallow periods due to population pressure and a surplus of labor, to achieve greater productivity. Meanwhile, the farmers can also take another option to maintain their farm output by extensification of agricultural production. Extensification implies the expansion of production by allocating inputs over a larger cultivated area and is viable only where unused land is abundant (Aune and Bationo,

2008). Lack of access to finance is also an obstacle for applying this strategy as farmers need finance for the purchase of inputs. In addition, because farmers traditionally extended their crop production by clearing forest, an obvious consequence of applying this strategy is deforestation which was observed in Uluguru Mountains (Burgess et al., 2002). To summarize, adaptive strategies such as agricultural intensification or extensification can help farmers to cope with, resist and recover from the impacts of climate hazards but they can also simultaneously aggravate farmers' vulnerability to climate change due to their adverse impacts on environment such as soil erosion, soil exhaustion, deforestation and changes in water flows (Paavola, 2008).

3.3. Adoption of Innovations

The literature on climate change adaptation in developing countries shows that adoption of technological innovations (e.g. using new crop varieties, new irrigation technologies) is also used by farmers as a response to climatic and other stressors. To cope with changes in long-term temperature and precipitation, farmers in southern Africa applied different farming techniques such as new irrigation and water conservation techniques, new crop varieties or new cultivating techniques (Nhemachena and Hassan, 2007) which were also used by farmers in Nepal (Gentle and Maraseni, 2012). Nhemachena and Hassan (2007) also mentioned that access to technology, finance and markets and private property enable farmers to employ new farming technologies. Besides, technologies are often highlighted as an important base for using and ensuring effectiveness of other adaptation measures.

3.4. Migration

In the absence of livelihood options in the region, farmers may migrate elsewhere to find work supporting their livelihoods. Migration is a coping and adaptive mechanism of humans as a response to shocks. This coping strategy plays an important role in maintaining livelihoods in the face of climate variability in developing countries (Adger et al., 2003). The study of Gentle and Maraseni (2012) on coping strategies of farmers in Nepal showed that poor farmers turned to seasonal migration to India for work as another income source due to lack of income opportunities during climate hazards such as drought and erratic rainfall. Although seasonal migration to India was not a new coping strategy, there was an increase in number of farmers migrating to India accompanied by children and women. Rural-urban migration was observed as an important strategy to maintain livelihoods employed by farmers in other developing countries (Adger et al., 2003). In the case in Rajasthan region of India, both male and female members of the family migrated to find work and food both within and outside the region during the drought (Marcus and Ajaya, 2004). Migration could be short-term or long-term, depending on the presence of income sources as well as specific livelihood characteristics. Low-income farmers were among the most vulnerable to climate hazards due to their lack of opportunities for income diversification, therefore they had a strong tendency to migrate. Moreover, short-term migration and seasonal migration was popular than long-term migration, and migration within the region is popular than migration out of the region. In some cases, migration was the last option when the farmers decided to sell out their assets and move to another place.

3.5. Farm Production Adjustments

Adjustments in farm activities such as crop and livestock diversification or changes in farm and crop management are exercised by farmers and expected to help them cope with climate variability. Yegbemey et al. (2014) found that climate change induced adjustments in agricultural calendar of farmers in northern Benin, West Africa where agriculture in general and maize farming in particular rely on rainfall for water. With limited support from agricultural extension services, most of the farmers designed their agricultural calendar based on personal experience. Farmers in Southern Africa also adjusted their crop management in response to changes in long-term temperature and precipitation; besides, they switched to new crop varieties that required less water and used improved irrigation water use practices (Nhemachena and Hassan, 2007). However, these adjustments heavily rely on farmers' resources. Farmers with larger area of agricultural land tended to invest more on their farms (e.g. irrigation system) for adaptation. Adimo et al. (2012) identified five groups of adaptive strategies applied by farmers in East African region to cope with climate variability, comprising of: (i) improved water use through sinking shallow wells, water harvesting, irrigation, etc.; (ii) use of adapted crop varieties and practices (e.g. drought resistant crops); (iii) environmental protection through re-forestation or encouraging tree nurseries; (iv) soil and water conservation practices (e.g. soil fertility improvement, crop rotation); (v) dissemination of information about climate change. It should be noted that these coping and adaptation strategies help to reduce farmers' vulnerability to climate change and maintain their income and consumption levels, however, they could lead to socio-economic problems and have adverse impacts on environment. Depletion and degradation of natural resource will affect its role as a safety net for human societies and increase their vulnerability during periods of stress (Paavola, 2008). Therefore, many studies concluded that it is necessary to have a comprehensive solution to cope with climate change and variability, in which issues related to environment, health, education and well-being need to be involved.

4. Conclusion and Policy Recommendation

Farmers in developing countries apply different strategies to cope with and to adapt to climate change such as livelihood diversification, agricultural intensification and extensification, migration or agricultural adjustments. The selection

of strategies depends on farmers' adaptive capacity which is defined by multiple factors like their perception of climate change, socio-economic characteristics and resources, as well as related institutional structure and equity. Adaptation policies need to be designed as a fundamental part of the country's development policies and activities and measures of adaptation to climate change need to be integrated in all related sectors. First of all, improving awareness and knowledge of farmers on climate change is needed to make them understand that they need to proactively cope with impacts of climate extreme events. However, this requires supports from the government and local authorities in terms of providing them essential resources and favorable conditions. Adaptation measures to enhance adaptive capacity and reduce vulnerability to climate change for farmers by making investments on both physical and intangible resource are needed. Several aspects to be invested include infrastructure, systems of irrigation and energy, extension services, technologies, information system, financial system, education and early warning systems against weather and climate-related shocks. Besides, there is a need for research and dissemination of knowledge and appropriate technologies for farmers. Ensuring access to cheap technologies for farmers can significantly increase their ability to adapt to climate change and variability. To improve farmers' adaptive capacity and mitigate impacts of climate change, adaptation policies should focus on both ex-ante and ex-post coping strategies. In order for these policies to be effective, appropriate attention should be paid to forecasting and warning systems because if these systems do not work effectively, the inaccurate forecasts would lead to waste of resources and adverse impacts.

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