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Climate Change Response at the Farm Level: A Review of Farmers' Awareness and Adaptation Strategies in Developing Countries

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ABSTRACT

The paper provides an overview of farmers' awareness and a typology of adaptation strategies undertaken in order to combat climate change at the farm-level in developing countries. The review suggests that the extent to which farmers are aware of climate change is uneven, and the link between perception and action, is often unclear.. Farmers adopt a range of strategies from financial responses, to agricultural changes, to religious and cultural strategies, to the use of local and wider support networks. However, whether these actions are adaptation or coping strategies is debatable. Response to climate change has both spatial and temporal dimensions. A host of socio-economic factors (e.g., lack of resources, gender or cultural identities) influence adaptation strategies. Finally, these adaptation strategies can be seen as nested within broadly defined livelihood strategies.

1. Introduction

> *But even as we seek to cut emissions, we must at the same time do far more to adapt to global warming and its effects. The impact of climate change will fall disproportionately on the world's poorest countries, ……. For them, adaptation is a matter of sheer survival. We must make it a higher priority to integrate the risks posed by climate change into strategies and programmes aimed at achieving the Millennium Development Goals* (Kofi Annan, 2006, un-paginated).

The concept of adaptation to climate change has become increasingly prominent within international and national climate policies over the past decade (Barnett 2007; Khan and Roberts 2013; Obama 2013; IPCC 2007). This is in part because of recognition of a failure to mitigate climate change through cutting carbon emissions (Khan & Roberts, 2013). Adaptations to likely climate impacts are therefore called for across society from national to local governments, to communities and citizens and throughout sectors including industry

and agriculture. A rich and diverse interdisciplinary literature has emerged over the past decade detailing the ways in which farmers in diverse settings across Asia, Africa and Central America are responding to the challenge of changing weather conditions, addressing a call by Crane et al. (2011) to examine farm-level agency in response to climate challenges within differentiated and complex socio-technical systems.

However, this literature raises important and largely unresolved issues about farm-level climate change adaptation. These include the difficult question of the conditions to which farmers may have to adapt, given a lack of certainty about the consequences of climate change in specific locations (Newsham & Thomas, 2011). Questions also remain about the extent to which farmers accept the phenomenon of climate change (a factor which significantly influences efforts to encourage adaptation) (Raymond & Robinson, 2013) and the extent to which they perceive it as a threat to their livelihoods (Anik & Khan, 2012; Tucker et al. 2010); the accuracy of farmers' perceptions of climate change (Ostwald & Chen, 2006); and to what extent any adaptations may be attributed to these perceptions or to autonomous short-term adaptation to weather change or other socio-economic factors (Raymond and Robinson, 2013). As several studies point out, many farmers, particularly in regions of Africa and Asia, have historically experienced harsh and variable climates (Brockhaus et al. 2013; Crane et al. 2011) and have developed a range of strategies allowing the continuation of farming. These mechanisms, often supported by rich networks of local knowledge (Mercer 2010; Khan and Roberts 2013), have largely evolved in response to the necessities of making a living in the face of a complex (and interconnected) array of political, economic, social and environmental challenges of which climate change is but one factor (Mertz et al. 2011). In fact, farmers in developing countries are continuously adapting to risk arising from uncertainty in constantly changing climate, weather events, and volatile or

imperfect markets. Responses to these short-term changes (e.g., weather) are generally regarded as risk mitigation strategies by farmers instead of recognising them as adaptation towards climate change. Also, adaptation strategy takes place in response to multiple factors rather than climate change alone, although extreme events and increasing variability motivates adaptation (Berrang-Ford et al., 2011). Furthermore, variability in the understanding of climate change has important implications on types of responses undertaken by farmers (Raymond and Spoehr, 2013). While many authors draw on these wider adaptations as evidence of the types of strategies which may be employed in response to climate variations or global change, the issue has led to a lively dialogue with the discipline of international development on the differences and synergies between climate adaptation measures and disaster risk reduction or livelihood strategies.

This article provides a comprehensive review of the recent literature on farm-level adaptations to climate change in developing countries, focusing on farmers' awareness and adaptation strategies undertaken. The strategies undertaken to conduct the review are as follows: (a) a literature search was conducted using web- and library-based search tools such as Google Scholar and Primo for articles published in world leading peer reviewed English language literature using the key words 'farmer, climate change, adaptation'; (b) articles published from 2009 onward are considered only to keep the review up to date; and (c) research conducted in developing economies are only considered without any particular preference to specific region because literature is dominated by research from developed regions and small number of countries from low-income regions while medium-income regions are underrepresented (Berrang-Ford et al., 2011). No attention was paid on variability in terminology, coverage, sample size, farm size category, topography and

methodology used in the literature because these are unlikely to affect broader conclusions derived from this exercise. .

The rest of the paper is structured as follows. Section 2 defines the concept of 'adaptation strategy'. Section 3 categorizes the main adaptations noted in the literature according to broad geographic location. Section 4 examines some of the barriers to adaptation. Section 5 discusses critiques of a narrow focus on technical climate-focused solutions in the context of an arguably more holistic approach provided from within international development.

2. Concept of adaptation strategy

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation as "…adjustment in natural or human systems in response to actual or expected climactic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (quoted in Deressa et al. 2009, p.248). Adaptation is therefore not limited to mitigating harmful effects but also includes taking up potential opportunities from changing climate patterns. The use of the term 'adaptation' has, however, been criticised for a tone which "burdens and blames the victim" and which focuses on climate hazards rather than wider underlying causes of poverty and environmental degradation (Ribot 2011, p.1160). Similarly, Khan and Roberts (2013) argued that international climate policy has focused on adaptations which are additional to the ongoing adjustments to changing environmental or societal pressures, meaning a focus on technical solutions, and a lack of attention to local knowledge and wider social or environmental causes of climate change (see also Burnham et al. 2013b).

2.1 Adaptation or coping strategies?

A further distinction referred to in the literature is that between 'adaptation' and 'coping' strategies. Tucker et al. (2010, p.28) use the latter to mean changes which are "easily

reversible" rather than longer term changes. Examples of coping strategies given are: reduction in weeding, trimming and fertilising and reducing hired labour (Tucker et al. 2010). However, these actions are sometimes treated as adaptations in other studies. Yegbemey et al. (2013), for instance, include changes to input levels as an adaptation; and Manandhar et al (2011) give increased weeding as an illustration of an adaptation strategy. For Osbahr et al. (2010, p.27) coping "is characterised by different household members responding to different shocks over a short period, and in different ways" and includes actions deemed adaptations by other authors such as temporary migration or selling assets. Further underlining the difficulty of separating these concepts, Morton (2007, p.19681) argues that often "what start as coping strategies in exceptional years can become adaptations for households or whole communities". Similarly, Brockhaus et al. (2013, p.95), argue that "the definition of adaptive strategies remains ambiguous" and not definitively differentiated from coping strategies. Furthermore, coping and adaptation strategies may conflict as in Northern Mali where adaptation strategies based on education were undermined by children's domestic work to cope with the labour shortages caused by migration – itself an adaptation, suggesting "a trade-off between coping with current problems and adapting in the long-term" (Brockhaus et al. 2013, p99).

3. Categorization of adaptation strategies

Adaptations to climate change cover a wide range of responses from use of prayers to changing crop types to migration. From an examination of 18 studies of adaptation towards climate change, 45 separate adaptation strategies were noted. These adaptation strategies can be grouped into: (a) financial adaptations (b) labour adaptations; (c) technology based

strategies; (d) land-based strategies; (e) cultural strategies; and (f) support from others[1] (Table 1). While there is some overlap between the technological solutions and land-based solutions, the categories are felt broadly to reflect the different types of strategies undertaken, and the details are discussed below.

3.1 Financial strategies

The most commonly mentioned strategy in this category is selling assets (4 responses), followed by reducing consumption and formal borrowing or investment (3 responses for each). Receipt of remittances and help from relatives might fall under this category, but we have reported them under 'support from others' because these are influenced by family, or community networks. A single mention of the 'use of savings' may reflect the dominance of studies from poorer communities in Asia and Africa where savings can be low. Only three studies mentioned reducing consumption. Trærup and Mertz (2011, p.479) noted that reduced consumption is "the most important coping strategy", in four of the six districts in rural Kagera in Northwest Tanzania, followed by casual labour, support from others, remittances, and the use of alternative crops and reduced investment.

3.2 Labour/family strategies

In terms of labour and family adaptations, the most prominent strategies were diversification out of farming (11 responses) and migration (local or international) (9 responses), followed by the uptake of wage employment (8 responses) and self-employment outside the agricultural sector (part-time or full time) (4 responses). As Below et al. (2010) argue, income from non-agricultural activities are multiple, varied and driven by a wide range of socio-economic factors as well as climate change; and the types of

[1] Some of this categorisation can be found in Below et al. (2010) and Hisali et al. (2011). Their review is focused either small-scale farmers in Africa and/or Uganda, whereas our review covers a wider range of economies.

diversification engaged in are often influenced by ethnicity, gender, or other forms of social or cultural differentiation, a finding reflected in several of the studies examined (e.g., Brockhaus et al. 2013; Jones & Boyd 2011; Nielson & Reenberg 2010).

3.3 Technology-based strategies

In this category, most common strategies were changing crop choices and adoption of new varieties (9 responses each) in addition to changing levels of inputs, water conservation, changed planting dates and sequencing, shifting to alternative types of farming and increased pest control. Climate changes have even facilitated the growing of new varieties and crop types including cucumber, bean, tomato, pumpkin and apples (Manandhar et al. 2011). Lasco et al. (2011, p.19) noted use of 'Scuba rice' by farmers in India and Bangladesh, which is more able to withstand flooding, although Mercer et al. (2012) cautioned against replacement of traditional maize varieties, which are adapted for Mexico's varied topography and growing conditions, by transgenic varieties. Anik and Khan (2012) also mention shifts to new types of crops/agriculture in the Haor area of Bangladesh, such as producing vegetables, duck-rearing and aquaculture. Other strategies include changing planting times, increased use of pesticides, different cultivation methods and soil techniques such as mulching (Anik & Khan 2012).

3.4 Land-based strategies

Of the land-based strategies, soil conservation was mentioned frequently (10 responses) alongside planting trees, the increased use of wild or forest products, changes in land management, and changes in land allocation for different crops. Chaudhury et al. (2011) describe the widespread planting by poorer Zambian farmers of fast-growing woody shrubs which fix nitrogen, and increase soil condition and stability. Paavola (2008) discusses the use of forest or wild products such as cutting wood for charcoal, and sourcing spices,

medicines and meat in Tanzania, while also questioning the sustainability of such strategies. However, a study based in northern Mali, described how this type of strategy was constrained by social mores (Brockhaus et al. 2013), highlighting the need for attention to difference, be that gender, ethnic, age or social status, in climate adaptation.

Another adaptation to rising water levels in some areas of south east Asia is the creation of floating gardens created through co-ordinated efforts at the community level (Lasco et al. 2011), emphasising the importance of community-based networks and collaboration in climate change adaptation action.

3.5 Cultural/religious strategies

Cultural or religious strategies form an important theme in several studies. Firstly, local or indigenous knowledge was frequently mentioned (8 responses). Local knowledge and practice regarding weather forecasting and planting calendars are seen as central to adaptation in areas of Nepal (Manandhar et al. 2011). The authors describe how many farmers in their lowland study site timed planting around rainfall predictions taken from the activities of house sparrows, ants and fireflies. In another site, farmers historically relied on agricultural advice from local religious leaders, who provide detailed timetables for planting (Manandhar et al. 2011).

Prayer is mentioned as a climate adaptation strategy in three studies. Religious and spiritual conceptions of climate change in Artur and Hilhorst's (2012) study in Mozambique exerted a considerable influence over interpretations of, and subsequent responses to, climate change. Cultural practices are also argued to play a part in adaptation in the Zambesi floodplain, as polygamy facilitates the maintenance by some farmers of more than one family unit, one on the floodplain and the other on higher ground (Artur & Hilhorst 2012), while in other studies the cultural or ethnic identities held and performed by

different groups created barriers to adoption of some livelihood diversification adaptations (Nielson & Reenberg 2010; Crane et al. 2011) as discussed further below.

3.6 Support from others

The final category is 'Support from others' which includes public services, local networks, remittances and help from relatives. While help from relatives and remittances were both mentioned frequently in the literature (8 and 6 responses respectively); help from Government and support from community or business networks were also prominent with 11 studies mentioning support from Government (including extension services), and 8 studies citing help from NGOs. Local and family networks were also important. For example, Below et al. (2010, p.14) argued that "Local networks have multiple functions in reducing vulnerability and enhancing adaptive capacity". As Jones and Boyd (2011, p.1269) argue in their study of adaptation in Western Nepal: "…universal to all caste strata, the principal and most significant source of aid and assistance in times of need relates to family and neighbour networks".

4. Discussion

4.1 Farmers' awareness of climate change

The extent to which farmers are aware of climate change, and the link between perception and action, is a debated issue in the literature. This is because variability in perception has important implication on actions undertaken, and those who accept human-induced climate change as a reality are significantly more likely to invest in mitigation measures (Raymond and Spoehr, 2013). Trærup and Mertz (2011, p480) compared rainfall data and householders' self-reported harvest shocks related to unfavourable weather conditions in Kagera in Northwest Tanzania and claimed "coherence between the number of shocks and anomalies in rainfall patterns", thereby, suggesting a link between local awareness and

actual climate variation. This is supported by Manandhar et al. (2011, p.341) who compared past 30 years of temperature and rainfall data for the study areas in Nepal with farmers' self-reported perceptions of changing climate, revealing a "close match" and establishing that "farmers in both study areas are aware of climate change" Others rely on farmers' self-reported evaluations of climate change and several studies show farmers, particularly in parts of Africa, noting significant negative changes in climate over past years (Nielson & Reenberg 2010; Mertz et al. 2011). Conversely, several studies also found that many farmers surveyed had no awareness of climate change. For instance, Anik and Khan (2012, p.884) claimed that only 41.7% of householders surveyed in their Bangladesh study site stated they had a "clear idea about climate change". Nonetheless, extreme climate events noted by villagers included drought, heavy rainfall and temperature change and these were believed to impact on declines in fish stocks, a decrease in water for irrigation, flooding, temperature variations, erosion and increased problems with disease and pests. Tucker et al (2010) studied smallholder coffee farmers' perceptions of climate change and changing coffee prices in Mexico, Guatemala and Honduras to establish that respondents had greater concern about coffee prices than climate change. This was attributed to historic experience of, and prior adaptation to, climatic variability and to the "generally diffuse and unpredictable impacts" of climate in the regions concerned (2010, p.27). However, farmers involved in the study did connect losses to climate and noted specific climate events leading to changes in productivity.

However, Ostwald and Chen's (2006) discussions with farmers in China regarding accounts of historical climate variations raised several further issues around the validity of perceptions of past experiences. Firstly, they noted that extreme events like flood or drought are more memorable than more normal weather patterns, which may lead to over-

reporting. Secondly, they argue, past variability means accurately mentally mapping fluctuations is difficult.

Further issues around the accuracy of climate change understandings are raised by Artur and Hilhorst who explain that within their study area in Mozambique "cosmological interpretations" of climate change as the will of God, of the ancestors, or as a result of witchcraft, were in evidence (2012, p.532). This suggests the importance of recognition of the influence of non-scientific discourses of climate change attribution, which may have varying impacts on the types of adaptation strategies pursued or rejected.

4.2 Spatial and temporal dimensions of climate change responses

The differentiated effects and responses to climate change over varying spaces and time-scales are noted by several authors. For example, Hisali et al. (2011, p. 1246) argue that because of the way climate change impacts vary across spatial contexts, the responses to climate change "tend to be context specific and localised". This suggests the importance of understanding adaptation within a particular national context, at the farm-level, regional as well as national policy levels. Furthermore, Raymond and Robinson (2013) have described how farmers (in Australia) are influenced by and respond differentially to information and influence on climate change and adaptation from different social institutions and actors within their communities and wider society. Mortimore (2010, p.135) argues that: "Small-scale private and community capacities are critical to success, both in the Sahel and in many other tropical drylands, where millions of decision makers interact with their eco-systems on a daily basis". Adaptation at the community level may also have negative impacts at the household level as wealthier families may have greater capacity to take on adaptations than poorer families, reinforcing existing inequalities (Osbahr et al. 2010). Bradshaw et al. (2004, p.123) warn that even at the farm-level, adaptations may be highly influenced by a

heterogeneous set of factors bearing on individual choices and actions such as “often very personal circumstances such as debt, family breakdown or the availability of off-farm income”.

Temporal differentiation is also noted within the literature. For instance, Lasco et al. (2011) note that some of the adaptation planning on climate change undertaken in developing countries has tended to concentrate on long-term and future scenarios which are often not of concern in the short-term for farmers and policy-makers; and Bharwani et al. (2005) note the way in which climate change influences are experienced across multiple and intersecting time frames.

4.3 Socio-economic factors influencing adaptation strategies

While awareness of climate change may vary within differing farming communities, higher levels of awareness may not necessarily translate into consequent take-up of adaptation strategies. For instance, Deressa et al. (2009, p.249) found over 50% of farmers in the Nile Basin, Ethiopia had observed changes in the climate over the past twenty years. However, 42% of those surveyed had made no adaptation due to “lack of information, lack of money, shortage of labour, shortage of land and poor potential for irrigation”. Similar constraints are noted by Frank et al. (2011) due to lack of resources or socio-economic limitations that may constrain adaptation even in the face of perceived risks. In other studies the cultural or ethnic identities held and performed by different groups created barriers to adoption of some livelihood diversification adaptations (Nielson & Reenberg 2010; Crane et al. 2011). Social barriers to adaptation are highlighted in two case studies in Western Nepal examining how “cognitive, normative and institutional determinants may influence adaptation and adaptive capacity at the local level” (Jones & Boyd, 2011, p.1262), including factors such as gender and caste, which could influence the migratory and employment options of some

groups such as Dalits. Similarly, socio-cognitive factors such as social identity have been found to be significant in determining how risks are translated into actions (Frank et al. 2011). In this case coffee farmers in Mexico stressed the influence on the acceptance of scientific climate change information of the perceived social identity of their informant, in relation to farmers' own socio-political identities (Frank et al. 2011). Further challenging any straightforward link between awareness and practice of adaptation strategies, Tucker et al. (2010) noted that household concern for a particular type of shock did not appear to lead to adaptive changes for coffee farmers in three Central American countries.

The above site-specific studies suggest a complex relationship between perception, social differentiation and norms, and whether and how these translate into action on climate adaptation. While adaptation strategies may vary in response to different types of climate events (Hisali et al. 2011), farm-level adaptations may also be differentiated along gender, ethnic, other socio-economic or cultural divisions. Yegbemey et al. (2013) found maize farmers' climate change adaptation strategies in northern Benin to be closely related to socio-economic and demographic variables and farmers' land rights. Crop diversification and farming calendar adjustments were the strategies most commonly adopted by male farmers, length of farmers' experience, extension contact and access to credit are positively related to the adoption of some strategies, but levels of education and household size did not have any affect (Yegbemey et al. 2013).

In contrast, Deressa et al. (2009, p.253), found that: "…when farmers have options for non-farm incomes, farmers can afford to plant tress [sic] on the limited available land, can afford the cost of irrigation, and can use less of the agronomic practices such as soil conservation and the use of different crop varieties". These findings suggest the importance

of attention to a complex set of context-specific social and demographic variables in understanding the adoption of specific types of actions in response to a changing climate.

Brockhaus et al. (2013) also found local-level strategies were commonly differentiated by gender, age and ethnicity in coping and adaptation to ecological change in Timbuktu, Northern Mali. Complex social and political dynamics in the area were noted including a rebellion by Tamacheq groups and subsequent instability and out-migration from the area. The authors found women favoured children's education as a diversification from livestock, whereas young men often used remittances from migrants to invest in livestock (Brockhaus et al. 2013). Such differentiation underscores the importance of close attention to context-specific social and demographic variables, a feature also noted by Jones and Boyd regarding adaptation strategies in Western Nepal (2011). They found that only men undertook temporary migration while women stayed to practice agriculture and that generally only Brahmin/Chhetri had the financial ability to look for work overseas, (Jones & Boyd, 2011).

Differences in both levels of perception and actions taken to address climate change were also found to differ across regional (Mertz et al. 2011) and national contexts (Tucker et al. 2010). For example, Tucker et al. (2010) found farmers in Guatemala expressing greater concern about climate than those in Mexico and Honduras. In terms of responses, few farmers in Mexico and Guatemala changed their crop mix, while in Honduras 73% of farmers had expanded their holdings, using fallow or forestry land and anticipation of future price rises. Differentiated responses were attributed to greater access to land and social networks, which facilitated credit in Honduras.

4.4 Adaptation to climate change or climate variability?

One unresolved issue is the extent to which the adaptations described are responses to normally occurring climate variations at the study site or to wider processes of global climate change. Berrang-Ford et al (2011) concludes that understanding of the magnitude of adaptation challenge is incomplete due to lack of understanding of if and how adaptation is taking place and majority of research reported assessment of vulnerability to climate change rather than actions undertaken in adaptation. Several studies emphasise many areas have historically experienced significant climate challenges and farmers have developed sophisticated portfolios of adaptive strategies (e.g., Below et al. 2010; Artur & Hilhorst 2012; Newsham & Thomas 2011). The highly complex and interrelated influences affecting adaptation make it challenging to discriminate between coping mechanisms in response to normal climate fluctuations and longer-term climate change adaptations (Below et al. 2010). Indeed, some studies focus on climate stress in areas with historically challenging climate, rather than attributing adaptation specifically to climate change. For example, Paavola (2008) and Nielson and Reenberg (2010) explore farmers' livelihood responses to climate variability and other stressors in a rural areas of Tanzania and Burkino Faso, respectively, where climate changes and impacts over past decades have been noted. And as Crane et al. (2011) argue, to farmers and herders in the Sahel facing harsh and uncertain climactic conditions, these distinctions are largely irrelevant. Nonetheless, as Below et al. (2010) explain, knowledge of existing adaptation practices in Africa is scant, creating a barrier to understanding and to formulating potential adaptations. Therefore information on past practices at the farm-level may inform future strategies in response to uncertain climate influences (Below et al. 2010). And as Newsham and Thomas (2011) argue through their case study of agroecological practices in Namibia, local knowledge which has been

developed to allow flexibility and resilience in the face of a historically challenging environmental conditions must form a central part in future adaptations to future climate challenges.

One approach to this challenge is to explore, like Tucker et al (2010, p.24), whether anomalous climate events prompt farmers to new types of adaptations: "If farmers perceive an event as highly anomalous, it may be sufficient to convince them that conditions are changing beyond the bounds of normal variation, and motivate adaptation strategies". Another is to suggest that in some contexts the line between past periods of extreme weather variability and projected climate change is insignificant. For instance, Mortimore (2010) argues that for those living in the drylands of the African Sahel over the past fifty years, the frequency of drought and variability of climate experienced was equal to or greater than the impacts predicted under climate change scenarios, rendering distinctions between past and future irrelevant and also underscoring the potential applicability of past solutions in the face of impending global change.

4.5 Climate adaptations or livelihood strategies?

The differentiation within the literature between adaptations driven by climate considerations and those influenced by other livelihood pressures is also not always clear. Mertz et al. (2011) have argued that despite a negative perception of climate variability and change, climate appears to be a relatively limited driver of change with other complex socio-economic and political factors largely informing land use change and livelihood diversification. It seems likely that many of these measures would possibly have been undertaken anyway for livelihood or other conservation reasons. In fact, "climate change is rarely the sole or primary motivator for adaptation actions" (Berrang-Ford et al., 2011: 25). For example, the study by Chaudhury et al. (2011) of adaptations in Zambia and Honduras

described the introduction and uptake of agro-forestry systems that increased yields in dry climates, irrespective of wider issues of global change. In the Asian context, Mandahar et al. (2011) note that an increasing population, and technological advancements as well as climate challenges have been drivers for the adoption of new rice varieties and new agricultural practices. Mortimore (2010) described the many innovative economic strategies used by householders in times of extreme hardship and drought in the Sahel. One such example is the use of local expertise in livestock breeding and the successful exploitation of new niche markets such as goats and sheep for *Eid festival* (Mortimore 2010). As Mortimore (2010, pp.138-40) notes: "these capacities, too, are not adaptations specifically to drought but address a broader goal of livelihood sustainability" and in this context are "inseparable from a developmental context". Differentiating between responses to climate change and those undertaken for other social, economic or environmental reasons is likely, therefore to be challenging. Furthermore, as Mortimore (2010, p.141) argues, it may also be counter-productive: "A global priority for rushing adaptation to the top of the agenda may encourage the rebranding (and duplication) of conventional development knowledge and the neglect of development studies that are immediately relevant to adaptation".

The above discussion suggests that the line between specifically climate-induced adaptation and changes made in response to a wider set of livelihood imperatives is difficult to discern and most studies have so far not set out to isolate climate-driven actions. Furthermore, as Mortimore (2010) and Below et al. (2010) argue, adaptations to wider influences and to past climate variations can help provide a better understanding of the repertoire of strategies for addressing future global climate change.

4.6 Climate change adaptation and international development

Over the past decade discussions have also centred on the difference between approaches to climate change adaptation and those which are already well established within international development. International development, it is argued, draws largely on local knowledge to help communities develop resilience against a wide range of challenges with complex and interrelated political, economic and environmental causes (Mercer 2010; Khan & Roberts, 2013). Mercer (2010) has argued for the embedding of climate change adaptation within existing disaster risk reduction (DRR) practices already established within local communities. She argues that climate change adaptation is narrower than DRR, looking only at climate factors and not attending to the root causes of livelihood problems. She argues that: "climate change has been used as a scapegoat, or in many cases a distraction, from other contributory underlying issues such as poverty, social deprivation, lack of resources and poor education" (Mercer 2010, p.252). A similar point is made by Khan and Roberts (2013, p.171) who argue that "technical solutions are often the focus in adaptation projects, when social, political, and cultural problems lie at the roots of vulnerability and should be addressed directly". In fact, both individual and social factors influence actions to adapt and the issues of values, ethics, risk, knowledge and culture exert societal limits to adaptation (Adger et al., 2009).

4.0 Conclusion

The review above provides a rich and contextually diverse overview of site specific adaptations to climate variation and to climate change. The strategies range from financial responses, to more obviously agricultural changes, to religious and cultural strategies, and to the use of local and wider support networks. While there is debate on whether some strategies should correctly be termed as adaptation or coping strategies, the complexity of

ways in which strategies are used in different settings means this distinction may not be useful. Furthermore, while it may be argued that many strategies described can also be seen as responses to livelihood or normal climate variations, this research provides valuable understanding of the potential adaptations to future climate change at the farm level in diverse agricultural contexts worldwide.

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Table 1. Typology of adaptation strategies

Financial Adaptations	Labour/family Adaptations	Technology based	Cultural/religious strategies	Land-based strategies	Support from others
• *Selling assets (4)* • *Reducing consumption (3)* • *Formal borrowing/ investment (3)* • *Mortgaging household assets (1)* • *Using savings (1)*	• *Diversification out of farming (11)* • *Migration (9)* • *Wage employment (8)* • *Work as self-employed (4)* • *Taking children out of school (2)* • *Sending children to live elsewhere*	• *Changing crop choices (9)* • *Use of different/ improved crop varieties (9)* • *Changing level of inputs (8)* • *Irrigation or water conservation (9)* • *Changing planting dates (8)* • *Switching to a different type of farming (e.g. to aquaculture) (5)* • *Pest management 4*	• *Indigenous/local knowledge (8)* • *Prayers (3)*	• *Soil conservation (10)* • *Planting trees (8)* • *Use of wild products (7)* • *Changes in land management (5)* • *Changes in land allocation for different crops (5)* • *Farming elsewhere (4)* • *Terracing (4)* • *Increased/decreased weeding (3)*	• *Help from Government local and national (includes extension services) (11)* • *Help from NGOs (8)* • *Help from relatives (8)* • *Knowledge sharing networks (7)* • *Collaboration with/help from community/ business networks (7)* • *Remittances (6)*

Financial Adaptations	Labour/family Adaptations	Technology based	Cultural/religious strategies	Land-based strategies	Support from others
	(2) • *Increasing agricultural labour (2)* • *Reducing hired labour (1)*	• *Double sowing/changing cropping sequence (4)* • *Change in Livestock type (3)* • *Improving technology (3)* • *Livestock waste management (1)*		• *Fire management (2)* • *Homestead gardening (2)* • *Not harvesting crops (1)*	

Note: These typologies appeared individually or in combination in the references provided in the reference list.

Numbers in parentheses are frequencies.