Comparative analysis of farmer's perceptions and adaptation to climate change on site-specific areas of Nepal, Myanmar, Thailand and Vietnam

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Título / Titre / Titolo

Análisis comparativo de las percepciones de los agricultores y la adaptación al cambio climático en áreas específicas de Nepal, Myanmar, Tailandia y Vietnam.

Analyse comparative des perceptions des agriculteurs et adaptation au changement climatique sur des zones spécifiques du Népal, Myanmar, Thaïlande et Vietnam.

Analisi comparativa delle percezioni degli agricoltori e adattamento ai cambiamenti climatici su dell' aree specifiche di Nepal, Myanmar, Tailandia e Vietnam

Abstract / Resumen / Résumé / Riassunto

During the 21st century extreme weather events are expected to increase in frequency and intensity, while having an impact in world's agricultural production. Farmers in rural and remote areas are among the most vulnerable socioeconomic groups as they are highly dependent on weather condition. South and Southeast Asia are considered regions of high vulnerability; in such areas, Nepal, Myanmar, Thailand and Vietnam deserve special mentioning. This study examines farmer's perceptions and adaptation to climate change in these countries' site-specific areas, as well as the bonds between agents especially interested in generating agronomic techniques and transferring them to the most vulnerable. Moreover, the main outcome of this work confirms that both climate change and adaptation are perceived differently depending on the country, and within each one. In effect, the combination of empirical information and recorded meteorological data is a key element in the decision-making process.

Durante el siglo XXI se espera que los eventos climáticos extremos aumenten en frecuencia e intensidad, a la vez que tienen un impacto en la producción agrícola mundial. Los agricultores de las zonas rurales y remotas se encuentran entre los grupos socioeconómicos más vulnerables, ya que dependen mucho del clima. Además, el sur y el sudeste de Asia se consideran regiones con mayor exposición y de los cuales merecen mención especial Nepal, Myanmar, Tailandia y Vietnam. Este artículo examina las percepciones y la adaptación del agricultor al cambio climático en áreas específicas de estos países, así como los vínculos entre los interesados en la transferencia y generación de técnicas agronómicas hacia los más vulnerables. Además, el resultado principal de este trabajo confirma que el cambio climático se percibe de manera diferente entre y dentro de los países, al igual que la adaptación. De hecho, la combinación de información empírica y datos meteorológicos registrados es, en consecuencia, un elemento clave en el proceso de toma de decisiones.

Au cours du XXIe siècle, les phénomènes météorologiques extrêmes devraient augmenter en fréquence et en intensité, tout en ayant un impact sur la production agricole mondiale. Les agriculteurs des zones rurales comptent parmi les groupes socio-économiques les plus vulnérables, car ils dépendent beaucoup du climat. En outre, l'Asie du Sud et du Sud-Est est considérée comme la région la plus exposée, dont le Népal, le Myanmar, la Thaïlande et le Vietnam méritent une mention spéciale. Cet article examine les perceptions et l'adaptation des agriculteurs au changement climatique dans des zones spécifiques de ces pays, ainsi que les liens entre ceux qui s'intéressent au transfert et à la génération de techniques agronomiques pour les plus vulnérables. En outre, le principal résultat de ce travail confirme que le changement climatique, ainsi que l'adaptation, sont perçus différemment entre et au sein des pays. En fait, la combinaison d'informations empiriques et de données météorologiques enregistrées est, par conséquent, un élément clé du processus décisionnel.

Nel corso del XXI secolo, si prevede che gli eventi meteorologici estremi aumenteranno di frequenza e intensità, e avranno un impatto sulla produzione agricola mondiale. Gli agricoltori delle zone rurali e remote sono tra i gruppi socio-economici più vulnerabili, poiché dipendono fortemente dal clima. L'Asia meridionale e sud-orientale sono considerate regioni con la maggiore esposizione; di esse il Nepal, la Birmania, la Thailandia e il Vietnam meritano una menzione speciale. Questo articolo esamina le percezioni e l'adattamento degli agricoltori ai cambiamenti climatici in specifiche aree di questi paesi, così come i legami tra coloro che sono interessati alla generazione di tecniche agronomiche e al loro trasferimento ai più vulnerabili. Inoltre, il risultato principale di questo lavoro conferma che tanto il cambiamento climatico quanto l'adattamento ad esso sono percepiti in modo diverso in paesi diversi, così come al loro interno. La combinazione di informazioni empiriche e dati meteorologici registrati è, di conseguenza, un elemento chiave nel processo decisionale.

Keywords / Palabras clave / Mots-clé / Parole chiave

Climate change, world's agricultural production, Nepal, Birmania, Thailandia, Vietnam.

Cambio climático, producción agrícolo mundial, Nepal, Birmania, Thailandia, Vietnam.

Changement climatique, production agricole mondiale, Nepal, Birmania, Thailande, Vietnam.

Cambiamento climatico, produzione agricola mondiale, Nepal, Birmania, Thailandia, Vietnam.

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Myanmar, Nepal, Vietnam and Thailand are respectively ranked 148, 145, 116 and 93, out of 188 countries, in the Human Development Index (UNDP, 2015). In spite of having insignificant contribution to global greenhouse gas emissions Myanmar has been placed, for the period 1995-2014, as the second world's most affected country by climate hazards, Vietnam seventh, Thailand ninth while Nepal seventeenth (Kreft *et al.,* 2016). Moreover, climate related impacts are broad and differ between countries, where one particular weather event can have distinct effects from one region to another. For instance, temperature rise in Nepal has made 12 districts out of 75 highly vulnerable to glacial lake outburst flood (GLOF); whereas in Vietnam this has resulted in sea level rise and flooding of low-lying areas of the Mekong Delta (UNFCCC, 2015c; UNFCCC, 2016).

In this manner, it is important to understand how climate affects the most vulnerable, i.e. small scale subsistent farmers; particularly in sites where agriculture accounts for most of the workforce and is responsible on assuring local/national food security. As a result, behavioural responses under changing climatic conditions must be thoroughly understood; hence, if farmers are conducting self-adaptation or are provided with the means to adjust to changing climatic conditions.

Moreover, this study replicates one of the main pieces of research conducted in agro-climatology. Indeed, Maddison's work is considered a tipping point within the scientific literature. It is also the first research carrying out a comparative analysis on farmer's perceptions and adaptation to climate related impacts in 11 African countries (Maddison, 2007). What is more, up till now, plausible investigations about farmer's perceptions on climate variability are still intra-regional and site-specific, with no commensurate investigations between the Sahel region and the so-called Third Pole and Southeast Asian countries. In this way, Le Dang *et al.* (2014) assert that farmer's perceptions on climate variability as well as non-effective adaptation are found to be additional barriers exacerbating farmer's susceptibility.

Consequently, farmer's exposure and vulnerability, along with insufficient literature on perceived climate change, autonomous/strategic adaptation and lack of bonds between stakeholders are the main reasons triggering the present research. In regards to this paper's structure, the first part is a literature review examining climate change projections in each of these countries, besides the institutional framework on agricultural adaptation. Secondly, the main research findings from fieldwork activities are then analysed and finally discussed within the third section.

Literature Review

First of all, it is important to highlight noticeable discrepancies between scientists when defining climate related concepts, i.e. vulnerability and adaptation. Lack of understanding among researchers as well as ambiguous and imprecise language used at the United Nations Framework Conventions on Climate Change (UNFCCC) are somehow concerning (Smit and Pilifosova, 2001; Yohe and Tol 2002; Adger *et al.*, 2005; Füssel, 2009). In fact, these have certainly impoverished the actual climate conceptual framework. As a result, in order to avoid further misleading interpretations this paper will refer to those defined by the Intergovernmental Panel on Climate Change (IPCC) in 2007 (see definition Box 1).

Additionally, gaps within the climate change and agricultural adaptation discourse are constantly reflected in the scientific literature. For instance, Biggs *et al.* (2013) point out the lack of investigations concerning climate change adaptation in developing countries. In this line, Barlett *et al.* (2010) go further by implying that climate change impacts are not well-understood, while adaptation is still non-existent in theory or practice. Moreover, Manandhar *et al.* (2011) study indigenous knowledge on climate change, while concluding that those living in remote areas are frequently being neglected. On top of all that, indigenous knowledge can provide policymakers and researchers with useful information for effective adaptation. Others assert the

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dearth of research on understanding the role of climate as a stimulus for technological innovation, along with the benefits of using farmer's perceptions for the study of past climate (Thomas *et al.,* 2007; Mertz *et al.,* 2009; Chhetri and Easterling, 2010). Finally, insufficient literature on climate related aspects in countries presently undergoing a democratic political transition undoubtedly hinders the implementation of National Adaptation Programs of Action (NAPA).

Finally, the next section examines the existing literature on observed and predicted changes in climate, its impacts on agriculture as well as on the efforts made from public/private institutions on increasing resilience amongst farmers.

Vulnerability: the degree to which a system is susceptible to, and unable to cope, with adverse effects of climate change, including climate variability and extremes.

Adaptation: the adjustment in natural and human systems in respects to actual or expected climatic stimuli or their effects.

Adaptive capacity: the ability of a system to adjust to climate change to moderate potential damages, take advantage of opportunities and cope with the consequences.

Autonomous adaptation: those responses implemented by individuals without intervention of national governments or international agreements.

Strategic adaptation: refers to policies or strategies at national level that proactively responds to the effects of climate change.

Box 1. Climate change related concepts. IPCC definitions (IPCC, 2007)

Climate change and agricultural adaptation: Nepal

Temperature rise in Nepal is far more concerning than in other regions of the world, as temperatures have augmented by 0.6 ºC per decade between 1970 and 2010. This value, 0.6 ºC, is two to eight times greater than mean global warming in the past 100 years (ICIMOD, 2014). Temperature variation has not been homogenous throughout the country, having experienced a greater temperature increase in mountainous regions than in low-lying areas of the Terai (Xu *et al*., 2007). In regards to mean rainfall, it has decreased by 3.7 mm per month per decade between 1970 and 2010. However historical rainfall changes do not follow a clear pattern along the country. For instance, annual precipitations in the area of interest (see Figure 1) have astonishing increased by 774 mm in the period 1965-2005 (Regmi *et al.,* 2007). Further research for the area of study has shown that increasing rainfall trends in the first decades have been outweighed by last decade decreasing rates (Timilsina, 2015). Additionally, glacier retreat in Nepal is extraordinary with a 29 % depletion of its ice reserve, while the ice surface area has decreased by 24 % between 1997 and 2010. This has resulted in the augmentation of glacial lakes by 11 %, consequently elevating GLOF risk and the exposure of those living in water catchment areas (ICIMOD, 2014).

Observed climate records are disturbing, but climate scenarios are even more alarming as temperatures are expected to increase by 1.3-3.8 ºC, while annual precipitation is estimated to decrease by 10 to 20 % in 2060 (UNFCCC, 2016). Economic assessments evaluating the impact of climate change on the country's GDP have elevated its costs to approximately 1.5-2 % per year. In such a way those living in remote areas and often lacking infrastructure besides access to technologies and knowledge are definitely the most exposed to social exclusion and vulnerable to climatic threats. Along with the previous statement, Gentle and Maraseni (2012) assert that marginalization of the poorer is often associated with climate change impacts.

Nepal's agricultural sector accounts for 34 % of the GDP and 66 % of the workforce (FAO, 2014a). The main crops are rice, maize and wheat, often found in low-lying areas of the Terai and mid-hill regions (MoAD, 2014). Nevertheless, Nepal has the worlds' highest rice varieties, Chandannath 1 and 3, found at 3000 metres in the district of Jumla (Sapkota *et al.,*

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2010). Moreover, in the last decades food production has significantly increased but undernourishment rates continue to be high, as 7.8 % of the population and 29 % of the children under 5 are underweight (FAO, 2014a). Meanwhile, food security is called into question as larger parts of the country are already facing the impacts of climate change. For instance, during 2005/06 the delay of the monsoon onset in eastern Terai led to a reduction of 12.5 % of national crop production, while in the winter drought of 2008/09 barley and wheat crops significantly dropped, leaving approximately 2 million people food insecure (Malla, 2008; Barlet *et al.,* 2010). This figure has then been revised upward to 3.4 million people by Oxfam in 2009.

As a consequence of the previous natural hazards, adaptation of the most vulnerable was seen as an immediate need, thus motivating the promulgation of the NAPA in 2010. In this plan, out of 75 districts 29 have been considered highly vulnerable to landslides, 22 to droughts, 12 to GLOF and 9 to flooding (UNFCCC, 2016). Since then, further research has examined the role of Nepal's institutions on adapting its people to climate change. For example, Chhetri *et al.* (2012) affirm that within the last decade bonds between stakeholders are even tighter thanks to the creation of National, Regional and Local Agricultural Research Centres and Services (NARC, LARC and RARS) as well as Community Based Organizations (CBO). Recent and afterward publications overthrow Chhetri *et al.* (2012) statements. Including Barlett *et al.* (2010) who insist that the institutional framework in Nepal is still weak with very few bonds between actors, consequently resulting in the non-effective adaptation of the most susceptible. Later on, Karki and Gurung (2012) pointed out the poor communication and cooperation among institutions, highlighting that between the Ministry of Forestry and Environment. Additionally, *Biggs et al.* (2013) have considered the present adaptation plan as broad and not site-specific. As a result, further research must be conducted in order to validate, in-situ, the extent of governmental support to adapt farmers to climate change.

Climate change and agricultural adaptation: Myanmar

Myanmar is placed as the second world's most affected country to extreme weather events; particularly in 2008, Cyclone Nargis was the worst ever recorded natural hazard in the country's history with an estimated toll of 130,000 casualties (McPhaden *et al.,* 2009; Fritz *et al.,* 2009; Kreft *et al.,* 2016). Even though most of the climatic literature has been produced since Cyclone Nargis, there is still a profound scientific gap with very few studies examining observed and projected climate data (Sen-Roy and Kaur, 2000; Htway and Matsumoto, 2011; Htut *et al.,* 2014). In fact, there are hardly any investigations that somehow analyse the impacts of climate change in agriculture (Rao *et al.,* 2013; Shrestha *et al.,* 2014; Swe *et al.*, 2015). As a consequence of scarce meteorological observations, proxy records currently are the main source of information to study Myanmar's past climate (D'Arrigo *et al.,* 2011).

Available information at NAPA's last report shows respectively a mean temperature and rainfall increase of up to 0.08 ºC and 29 mm per decade for the period 1951-2010 (UNFCCC, 2012). However, proximate weather stations to that of the area of study (see Figure 2) indicate a rainfall increase of 13 mm per decade in Mandalay, while in Taunggyi the decrease is of 5 mm per decade since 1951 (UNFCCC, 2012). On the other hand, since 1951 temperatures have risen by 0.2 ºC and 0.16 ºC per decade, respectively in Mandalay and Taunggyi (UNFCCC, 2012). With regard to climate projections, temperatures are predicted to increase by 2.8 to 3.5 ºC for the period 2051-2099. Moreover, rainfall is expected to increase throughout the country, though greater in western and coastal areas.

Myanmar's agriculture accounts for 33 % of the GDP and represents 61 % of the workforce (FAO, 2014b). Although food production has tripled in the last 25 years food insecurity rates remain high, with up to 23 % of the children under 5 underweight (FAO, 2014b). Nonetheless, changing climatic conditions and upsurge of extreme weather events will jeopardise governmental efforts on alleviating food insecurity. This is

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the reason why NAPA has placed resilience in agricultural systems at first priority level with strategies focused on: agronomic management, sustainable water use and climate-resilient farming systems. Despite the political will, money flow towards adaptive strategies in the agricultural sector is still insignificant, being actual national contribution of just 6 million US$ (UNFCCC, 2012; UNFCCC, 2015a). In fact, international aid has become crucial for disaster risk reduction and climate change adaptation. For instance, the UNDP has released a sum of over 20 million US$ for the period 2013-2015, being by far the greatest input ever done on climate change adaptation in Myanmar (UNDP, 2016)

To conclude, it is important to highlight recent efforts to fill research gaps concerning agricultural adaptation and climate change in Myanmar. For example, *Swe et al.* (2015) conclude that the driest zones of the country are experiencing temperature rise, while rainfall is becoming more erratic. Furthermore, they acknowledge that conventional agricultural strategies are being used to store water more efficiently. This demonstrates that farmers perceive changes in climate and are consequently undergoing autonomous adaptation. In spite of previous efforts, the country deserves greater scientific attention so as to provide policymakers with the sufficient climatic information. By doing so, policymakers will then be responsible of implementing the most suitable adaptation strategies.

Climate change and agricultural adaptation: Thailand

According to Thailand's Meteorology Department (TMD) temperatures have risen by 1 ºC for the period 1981-2007, while projections indicate a temperature increase of 1.2 to 1.9 ºC by 2050 (TMD, 2008). In fact, the TMD acknowledges that inter-annual rainfall variability is nowadays greater and scarcer since 1951. Additionally, the nation's exposure to flooding, drought, sea level rise and landslide is highly concerning and seen as an imminent threat. For instance, McGranahan *et al.* (2007) estimate that over 26 % of Thai people live in low-lying areas, below 10 metres, especially in Bangkok. Other major cities like Chiang Mai are considerably exposed to flash-floods, as it is within the flood prone area of the river Ping (Lebel *et al.* 2011). The high exposure and vulnerability of Thai people has been reflected during La Niña 2011 event, when major floods affected large parts of the country (Thai-water, 2011).

In regards to Thai's agricultural sector, it employs 40 % of the population and represents 12 % of the GDP (NSO, 2013; FAO, 2014c). In fact, Thailand is one of the world's largest food exporters, playing an important role on assuring food security within the region (ADB, 2013). In regards to the literature, it is merely focused on climate change impacts on rice production, with very few studies examining other type of crops (Buddhaboon *et al.,* 2005; Felkner *et al.,* 2010; Babel *et al.,* 2011). Moreover, Attavanich (2013) asseverates that crop yield projections remain uncertain thus hampering policy formulation. For example, CERES and DSSAT model predictions highly differ between each other, and are only along on the fact that northern parts of the country are at higher risk of flooding (OEPP, 2011).

Also, Thailand begins to address climate change adaptation in 1993, when the National Committee on Climate Change was created. Subsequently, it continues to do so with the submissions of the first and second national communications to the UNFCCC, respectively in 2000 and 2011. With respect to agriculture, adaptation plans have sought to develop drought resistant varieties, improve agronomic practices and encourage crop diversification strategies (MSTE, 2000). In fact, governmental efforts to adapt Thai people to climate change is still disproportionate in comparison to the little attention given by scientists, with very few studies examining agricultural adaptation, vulnerability and exposure. For instance, Manandhar *et al.* (2015) research is unique, being the only piece of research that focuses on people's perceptions on climate change. However does not revise the ways Thai farmers are adapting to it. On the contrary, Oxfam's (2015) report pays closer attention to farmer's adaptation to climate change. In their project, Oxfam assesses community-based adaptation, notably to increase farmer's resilience, scale up climate change adaptation and food

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security strategies as well as to strengthen bonds among actors involved. Finally, governmental sustained efforts are often pointed out at the UNFCCC (2015b) communication reports. Nevertheless these are recommended to come along with further independent research to evaluate and validate implemented strategic adaptation measures.

Climate change and agricultural adaptation: Vietnam

During the last 50 years Vietnam has experienced a temperature rise of 0.5 ºC, however in southernmost parts temperatures have slightly decreased (MONRE, 2012). For the same baseline, rainfall trends indicate an increase of 20 % for central and southern parts of the country, while in northern parts it has depleted by 20 % (MONRE, 2012). Furthermore, IPCC B2 scenario estimates that in 2100 temperatures will have increase by 2 to 3 ºC, whereas rainfall is projected to augment from 2 to 7 % (IPCC, 2007). Similarly, sea level rise is highly concerning as low-lying areas of the Mekong Delta, Saigon and Red river are the most densely populated areas of the country, such as Hanoi and Ho Chi Min city. For instance, if sea level rises 1 meter (observed rate between 1993 and 2010 was 2.9 mm per year) 39 % of the Mekong Delta, 20 % of Ho Chi Min City and 10 % of Red river will be flooded. This will consequently affect 11 % of the population, 7 % of the agricultural land while having an impact of 10 % on the country's GDP (Dasgupta *et al.,* 2009; MONRE, 2012). Hence, the country's economy is considerably threatened, as agriculture contributes to 18 % of the GDP as well as providing jobs for 47 % of the population (FAO, 2014d).

In regards to the literature, Le Dang *et al.* (2014) are among the very few researchers examining farmer's perceptions on climate variability in Vietnam. In addition, vulnerability and adaptation is within the scope of research of Adger (1999, 2000, 2003 and 2012). Nevertheless, not only his work is broad but also does not consider different forms of agricultural adaptation. Furthermore, agricultural adaptation in Vietnam has been addressed by the UNDP (2007) and UNEP (2009), where impacts of climate change on agriculture are quantified and small community based projects are examined. For instance, capacity building on water management techniques, higher yielding temperature resistant and short duration seeds, extensive small-scale irrigation and women support through micro-credits are among the short and long-term agricultural adaptation practices assessed. In respects to coastal zones and salt-water intrusion, the government has identified three strategic options: protection measures (elevating embankments), adaptation (reform infrastructures and people's habits) and withdrawal (resettling population). These efforts differ between coastal and inland parts of the country depending upon the risks, exposure and vulnerability of the population.

To conclude, it is somehow concerning the fact that the Vietnamese government has already affirmed its limitations to finance adaptation to only one-third of the actual needs, being of approximately 3 to 5 % of the GDP by 2030 (UNFCCC, 2015c). As a consequence, private investment and international cooperation becomes imperative and of vital importance. Alongside, the role of researchers is to promote policymakers with scientific as well as empirical data that promotes effective adaptation. Moreover, Vien (2011) suggests that farmers should not depend on external support, yet adopt self-adaptation to cope with forthcoming environmental threats.

Methods

Fieldwork data collection has been carried out between March and June 2016, and is based on 66 surveys and 13 semi-structured interviews. Surveys and interviews have been respectively conducted with farmers and social leaders belonging to agricultural associations, research centres, NGO's, public and private institutions. Each survey contains 18 questions as well as an additional section that includes village's name, type of crop, altitude, further researchers' observations and indigenous knowledge. Surveys have been designed to obtain data on three main aspects: agriculture (questions 1-4), farmer's perceptions on

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climate change (questions 5-15), likewise public/private support on adapting farmers to climate change (questions 16-18). Moreover, spontaneous focal group discussions have occurred, providing the research with further information on climate related issues. In regards to semi-structured interviews, they have aimed to better understand the role of key stakeholders on adapting farmers to climate change. For this reason, interviews have been designed to evaluate if effective adaptation is actually happening, therefore increasing resilience among the most susceptible.

Data collection has been done using a simple random sampling technique where any individual had the same chances of been selected. Nonetheless, the country's area of study has been chosen according to the following criteria: ability to find a translator, appropriate road access, high exposure and vulnerability to natural hazards. In fact, further investigations are encouraged to examine farmer's perception and adaptation elsewhere, as private/public support could differ within the country. Additionally, language has been found to be a barrier between the actors involved on the research, for example, researcher-translator-farmer. To avoid misunderstanding and biased outcomes, translators have been familiarized with the survey and research methods. Finally, perceived climate trends could have been disrupted by specific extreme weather events, thus altering farmers overall perception of climate variability. Such known uncertainties have been overcome by reviewing the literature on past climate anomalies.

Area of study: Nepal

The area of study is located on the southern face of the Annapurna Mountain, Kaski district, between the hill and mountain ecological zones. Climate records in the RARS-Lumle weather station, at 1500 metres, show a mean annual precipitation of 3517 mm, while mean temperatures of 16.6 ºC (Climate-Data, 2016). The elevation profile of the study area varies between 850-2300 metres, Pokhara and Sinowa village, respectively. Despite altitude changes the following crops have been observed: rice, maize, wheat, pulses and vegetables.

Area of study: Myanmar

Bagan and Nyaung-Shwe, at 67 metres and 883 metres, are respectively located in Mandalay region and in Shan state. Mean annual rainfall in Bagan is of 621 mm, while mean temperatures of 26.9 ºC. Furthermore, in Nyaung-Shwe rainfall is of 1584 mm, while mean temperatures of 21.4 ºC (Climate-Data, 2016). Contrasted climatic conditions result in different crops, while Bagan mainly has sesame, peanut and pigeon pea, Nyaung-Shwe with better weather conditions favours the growth of rice, sugarcane and vegetables.

Area of study: Thailand

Pai and Chiang Mai are located in Mae Hong Son and Chiang Mai provinces, northern Thailand. At an altitude of 510 metres Pai has a mean annual rainfall of 1131 mm, while mean temperatures of 24.9 ºC. Moreover, Chiang Mai, at 313 metres, has an annual rainfall of 1184 mm, while mean temperatures of 25.6 ºC (Climate-Data, 2016). Crops in both areas are similar being rice, corn, soybeans, bananas and vegetables the main ones. Monocultures of garlic as well as coffee plantations have been observed in villages proximate to Pai.

Area of study: Vietnam

Bên Tre and Con Cuông are respectively situated within the Mekong Delta, Bên Tre and Nghe An provinces. The altitude of Bên Tre is 5 metres, with mean annual rainfall of 1441 mm, while mean temperatures of 27.3 ºC. On the contrary, the closest weather station to Con Cuông, Vinh, is at an altitude of 9 metres, with mean annual rainfall of 1735 mm, while mean temperatures of 24.6 ºC (Climate-Data, 2016). Observed crops varied drastically from the southernmost parts of the country, with large coconut plantations, to northern parts where rice, corn and vegetables are amongst the most common crops.

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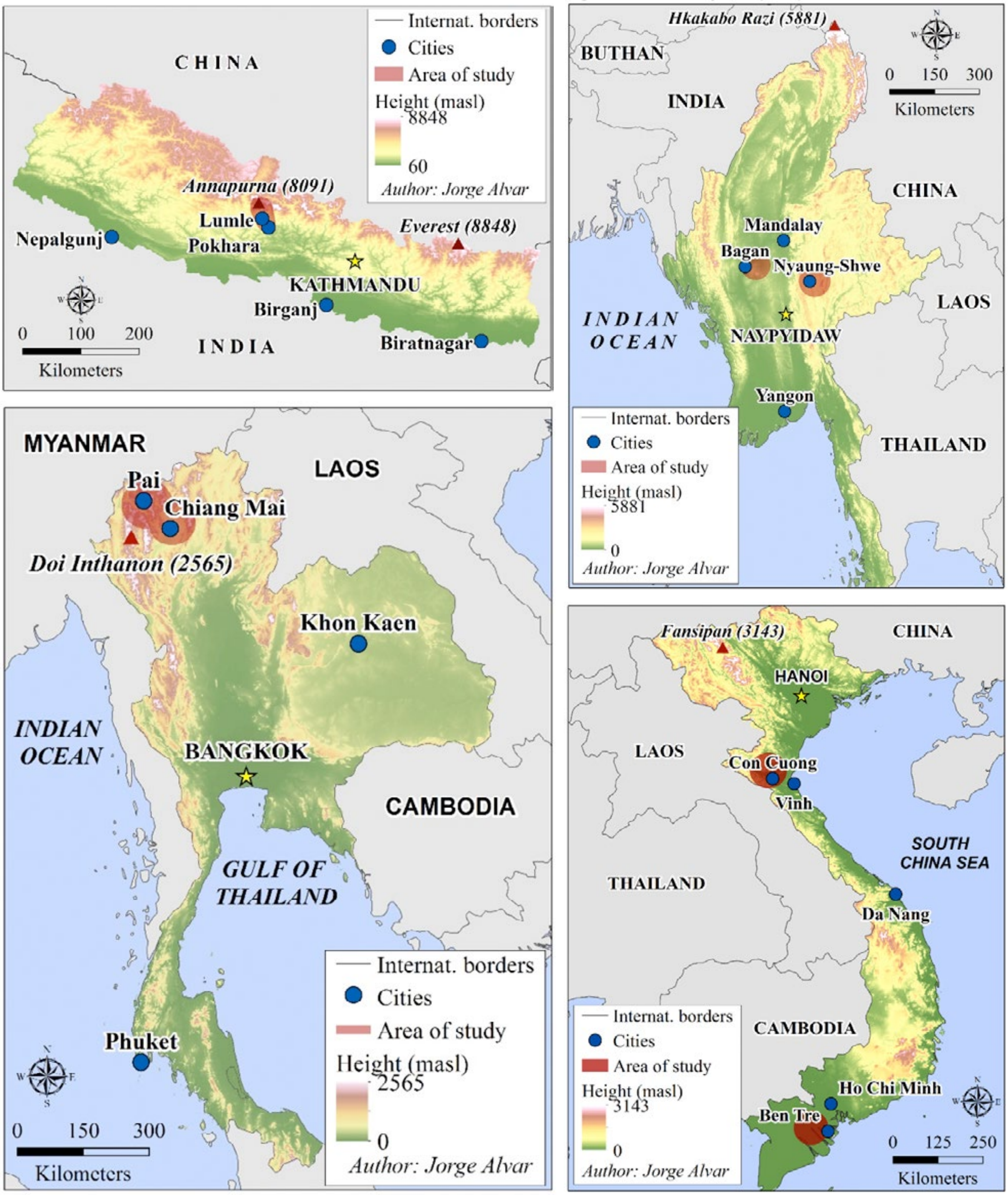

Figures 1 to 4. Area of study: Nepal, Myanmar, Thailand and Vietnam

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Research findings

Farmer's perceptions on climate change: surveys

Questions 1 to 4 aim to get further information on the respondents' educational level, temporal relationship with agriculture, land property and crop size. Emerging results indicate that literacy rates are of 67 % for all the farmer's surveyed, Myanmar being the country with higher values, 81 %, and Vietnam with the lowest, 38 %. Overall, 55 % of the respondents have been engaged in agricultural activities for longer than 30 years, while most of them are landowners of small-scale subsistent farms. Finally, 80 % of the survey respondents have crops smaller than 5 hectares, while 27 % less than 1 hectare.

Temperature and rainfall are key indicators of climate change, thus deserving greater attention. For this reason, answers regarding the latter, questions 5, 6 and 10 to 14, are summarized in Figure 5. Moreover, questions 5 and 6 shows that most farmers perceive changes in temperature, being 90 % those who consider present temperatures as warmer. In fact all respondents in Myanmar and Vietnam have pointed out a temperature rise, while this value drops down to 70 % for Nepalese farmers. In regards to rainfall, results from questions 10-12 indicate that most of the farmers agree upon changes in precipitation, as 82 % perceive it as less frequent and 50 % as less intense. Nevertheless, 87 % and 61 % of Burmese and Vietnamese farmers respectively acknowledge that rainfall is nowadays more intense. In addition, natural hazards such as floods and droughts are examined in questions 13 and 14. Impacts of flooding differ between regions, while Nepalese and Burmese farmers predominantly recognize that floods have, at some point, seriously affected their crops, most of the Thai farmers affirm the opposite. On the other side, the majority of farmers in all sites share common response on droughts, perceiving present dry periods as more intense.

Furthermore, impacts of temperature and rainfall changes in crop yield and crop-growing calendars are examined in questions 7 to 9. In spite of the fact that farmers discern changes in temperatures and rainfall these have not yet had a major impact on sowing/harvesting dates, as over 60 % stick to traditional crop-growing calendars. Except 7 respondents in Nepal and Myanmar affirming that growing is delayed, while 8 farmers in Thailand and Vietnam assert the opposite. In respects to shifts in crop yield, half of the farmers asseverate that current production levels are lower than in the past, being significant the number of farmers that assert so in Nepal, 67 %.

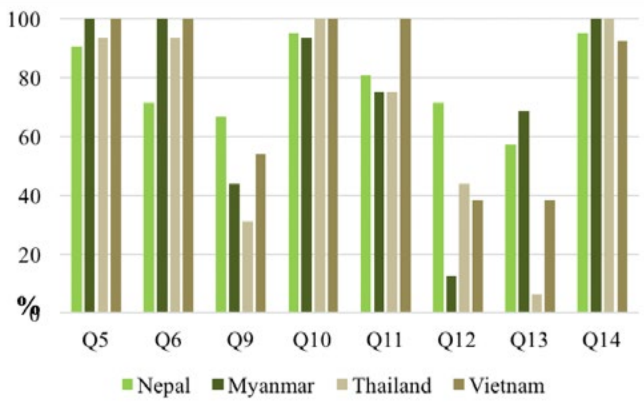

Figure 5. Survey results on climate change indicators

Q5. Temperature has changed · Q6. Present temperatures are warmer Q9. Crop yield is lower · Q10. Rainfall has changed · Q11. Present rainfall is less frequent · Q12. Present rainfall is more intense · Q13. Droughts have severely affected crops · Q14. Present droughts are more intense

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Survey nº 7 (Lumle village, Nepal): I perceive that present maximum temperatures are higher, while minimum temperatures are lower. Rainfall is becoming more extreme, around this time last year a close-by weather station registered up to 357 mm of water, in just 3 hours!

Survey nº 34 (close to Nyaung-Shwe, Myanmar): 10 years ago maximum temperatures were of 28-29 ºC, but now they can rise up to 35 ºC.

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Survey nº 46 (Pudia village, Chiang Mai, Thailand): I have never seen this dam so dry before. I remember that 17 years ago was also dry, but not as dry as now!

Survey nº 59 (close to Bên Tre, Vietnam): Water is getting saltier, less rain is available and crop yield has depleted

Box 2. Farmer's rationale on changes on temperature and rainfall trends (source: farmer's surveys)

Social leader's and farmer's perceptions on climate change adaptation: interviews vs. surveys

Climate change adaptation strategies in agriculture are broad and strongly differ between countries. Exposure to climate risks and vulnerability are often triggers for effective adaptation and preventive strategies. However, this is not the case in developing countries, where economic resources, lack of political willing and bonds between stakeholders, poor technological innovation and access to rural areas are among the countless factors hampering effective adaptation. For this reason, the succeeding section brings to light observed evidences on public/private efforts, and where social leaders as well as farmers perceptions are compared and contrasted.

In Nepal, head of units 5 to 7 of Village Development Committee (VDC) in Lumle, Regional Director of the Agricultural Research Station (RARS) for the Kaski district and Program Coordinator at the International Centre for Integrated Mountain Development (ICIMOD) in Kathmandu have been interviewed. The following adaptation strategies have been distinguished: poly-house technology, crop diversification, capacity building, water harvesting, crop-growing calendars, risk reduction schemes, hybrid seeds and promotion of organic fertilizers. In particular, poly-house technology is an example of large-scale adaptation strategy, where 50,000 and 10,000 farmers have respectively benefited in Nepal and Kaski district. Moreover, at a local level, the community of Lumle is adopting self-adaptation strategies for water harvesting. In this case, in 2016 this community began the construction of a 70 m^3 water tank, replacing the one that was swept away during the 2015 summer flash-floods killing over 30 people.

In regards to the latter part of the surveys, 33 % of the respondents in Nepal affirm to know the causes of climate change, 86 % have not yet received any public/private support to adapt to climate change and 56 % do not actively participate in any agricultural association. So, those receiving support has been mainly through credits and climate resilient seeds. Additional fieldwork observations have given information on self-adaptation through water harvesting mechanisms and drip-irrigation systems, as well as on other agricultural practices such as surface applied manure, commonly used as a fertilizer. To conclude, results emerging from surveys and interviews show disturbing inconsistencies. In many cases what is affirm by social leaders is then denied by farmers, at least within the area of study.

In Myanmar, social leaders of both public/private institutions have all been interviewed in the city of Nyaung-Shwe and are the following: Private Agency Collaborating Together (PACT), Environmental Education Centre, Paddy Rice Association, Ministry of Environmental Conservation and Forestry, Ministry of Agriculture and Agricultural Bank. During the interviews a broad number of adaptation and risk reduction measures have been identified. In respects to those coming from the private sector, capacity building (workshops on climate related issues and sustainable agriculture), technology transfer (higher yield and climate resilient seeds) and microfinance have repeatedly been pointed out. On the other side, the succeeding public initiatives have been identified: rise environmental awareness (with the community and at schools), capacity building (agronomic techniques and water use efficiency), subsidies (climate resilient seeds) and early warning systems (TV channel and flyers with agricultural recommendations during ENSO events).

Moreover, findings emerging from surveys indicate that very few Burmese farmers know the causes of climate change, while little actively participate in agricultural associations. Up to 75 % of the farmers have re-

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ceived public/private support predominantly through microcredits, higher yield and climate resilient seeds; besides, in some cases, machinery, capacity building and early warning. This support has been found to be greater in nearby villages to Bagan. In fact, all respondents affirm to have been provided with microcredits from the Agricultural Bank to buy better seeds. Fieldwork observations show that farmers generally used manure as an organic fertilizer, while wealthier farmers had water tanks, pumps and drip-irrigation systems.

In Thailand, two community social leaders in Muang Soi and Payan, Pai, as well as the chief and manager of the irrigation and water transfer departments have respectively been interviewed at the Ministry of Agriculture and Cooperatives in Mae Tang, Chiang Mai. Results show that government is committed on deploying agricultural adaptation strategies at different levels. For example, microcredits (One Million Baht Village Fund), subsidies (water tanks), cloud seeding (Royal Rainmaking Project), Maefaek-Maengad Somboonchon Irrigation project, capacity building, early warning systems (TV channel, rain gauges with colour code label to alert the community and large speakers to prevent disasters) as well as better seeds. In fact, the most extended strategy within the area of study is microcredits, where each village is assigned with 1 million Baht (±28,000 US$) at an interest of 4 %. What is more, the social leader and committee manager for microcredits in Payan-Pai admits to have recently distributed 6000 to 12000 Baht (± 170-340 US$) to each of the 84 beneficiaries within the village.

Furthermore, surveys results for Thailand also show that even though most of the farmers do not participate in agricultural associations they still receive some kind of support to adapt, 81 % asseverate so. In this case, the majority of respondents have been provided with microcredits and technology, in which machinery, water tanks and irrigation systems are included. Other observed adaptation and climate change risk reduction strategies have been: capacity building, climate resilient seeds and early warning systems. Finally, and despite of governmental efforts to adapt and diminish climate risks in agriculture these are sometimes insufficient, triggering self-adaptation to alleviate water stresses. For instance, farmers in villages close to Pai are illegally piping the river source to water their crops, thus resulting in conflicts among farmers.

In Vietnam, language considerably limited data collection and only one social leader in the village of Con Cuông has been interviewed. Survey outcomes show that, among the countries studied, Vietnam is the one where farmers are more aware of the causes and impacts of climate change, up to 40 % acknowledge the phenomenon. This is probably because all respondents affirm to actively participate in agricultural associations and its periodical meetings. In respects to climate change adaptation, the government is committed and considers capacity building as the most effective way to create resilience; not only by training farmers, but also by spreading knowledge among social leaders. In fact, half of the farmers surveyed recognize having received environmental training in workshops at the agricultural associations. Nonetheless, a greater degree of governmental support has been observed in northern parts of the country.

Subsequently, survey respondents point out the key role of social leaders on transferring them with environmental and agronomic information, for instance by notifying them with the most appropriate planting dates and suitable seeds. Other widespread measures are to provide farmers with higher yield American seeds and to provide the poorer with land. The latter measure has been observed in two cases. In this situation, the farmer is fully responsible to work the land, while benefiting of the whole yield. Notwithstanding of these social practices, farmers generally consider them as insufficient for effective adaptation. For instance, farmers in the Mekong Delta are aware of and concern about sea level rise and salt-water intrusion, having already experienced depletion on coconut yields. To avoid further damages, farmers have decided to self-adapt by pumping fresh underground water.

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Surveys 12 to 14 and 17 to 20 (villages close to Ghandruk, Nepal): I know the VDC in Ghandruk exists, but do not actively participate in meetings nor receive support for agriculture. **Some acknowledge that the VDC mainly helps those working in tourism, as these are located along the Annapurna Base Camp Trek.*

Survey nº 26 (Minnanthu village, Bagan, Myanmar): Climate change is already affecting me and I do not consider current governmental support to be sufficient to adapt to observed changes.

Survey nº 48 (Nong Mua village, Chiang Mai, Thailand): Microcredits are not enough to pay all needs. I receive 1000 Baht (± 28 US$) for 10 ray (1.16 hectares), but is still insufficient to water my crops.

Survey nº 57 (villages close to Bên Tre, Vietnam): Credits interests are at 1 %, while the quantity received depends on crop size. Not only the government focuses on training farmers but also gives recommendations regarding sea level rise. However, I have decided to self-adapt by buying two water tanks as well as to start pumping my own water

Survey nº 60 (Con Cuông village, Vietnam): Two years ago the government provide me with American seeds, being more productive than Vietnamese. In addition, every three months I receive training from local authorities on agricultural techniques and environmental issues.

Box 3. Farmer's rationale on autonomous and strategic climate change adaptation (source: farmer's surveys)

Discussion

The conceptual framework and fieldwork results indicate that indigenous knowledge on climate patterns are not always in harmony with weather stations' records, particularly in regards to long-term observations. For instance, 82 % Nepalese respondents assert that actual rainfall is less frequent. Nonetheless, Regmi *et al.* (2009) use RARS-Lumle weather station records, very close to that of the area surveyed, to affirm the opposite. In this case, they reveal a rainfall increase of 774 mm or 22 % for the period 1965-2005 in RARS-Lumle. In fact, Regmi *et al.* (2009) do not point out that rainfall has slightly decrease in the last decade, thus shaping overall farmers perceptions being, in many cases, of short-term duration. Similar inconsistencies, between perceived and registered climate data are found in Central Dry regions of Myanmar. In this case, 8 out of 11 farmers indicate that rainfall is less frequent in the present. However, recorded and published data at the UNFCCC (2012) report reveals that at least three weather stations in the region have registered a rainfall increase for the period 1951-2007. Moreover, other differences between observations and recorded data are found in the Mekong Delta, Vietnam. In such case, climate records show that temperatures have rising in some parts of the Mekong Delta, while in other parts it has decreased over the past 50 years (MONRE, 2012). On the other side, all survey-respondents affirm that temperatures are certainly increasing. Finally, this research's results are in harmony with those of Le Dang *et al.* (2014), affirming that farmers in the Mekong Delta are experiencing an extraordinary temperature rise.

Despite of the previously highlighted discrepancies between the different research methods, it is relevant to say that in many other cases indigenous knowledge and climate records do match. For instance, temperature rise is perceived along the four countries of study, with up to 94% of the respondents acknowledging that present temperatures are warmer. In all the areas of study, except the Mekong Delta, climate records indicate a significant temperature increase, being Nepal the country experiencing the greatest temperature rise. In addition, 97% of the overall respondents acknowledge that droughts are intensified in the present and that the monsoon onset is more unpredictable. Greater rainfall variability within the area of study is pointed out in the IPCC (2013) report; however, models indicate that global warming will result in more intense but less frequent rainfalls. This fact was corroborated by farmer's in Nepal, where 81% and 71% of respondents consider pre-

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sent rainfall less frequent but more intense, i.e. during the flash-flood of summer 2015 Lumle weather station recorded 288mm in 24hours (RARS, 2016).

Both empirical and scientific research methods need to be carefully treated and interpreted. The first one can be disrupted and shaped by specific extreme weather events therefore changing the overall perception of a phenomenon; whereas the second one can provide wrong data due to inaccurate calibration, measurement or change in location, among other reasons. Countries with poor recorded data highly rely on indigenous knowledge and other proxy methods to reconstruct the country's past climate. Finally, it is important to state that site-specific indigenous knowledge on local climate can be highly beneficial for both scientists and policy-makers, as they are affected by it on their daily basis.

Moreover, autonomous and strategic climate change adaptation in agriculture has been observed in all areas of study. Nevertheless, as stated by Smit and Wandel (2006) adaptive capacity is context-specific and varies among countries, communities, social groups and over time. For instance, recent natural hazards, Cyclone Nargis in Myanmar and flash-floods in Lumle, have confirmed that Burmese and Nepalese farmers are more susceptible to those in Thailand. Higher exposure of the population as well as fragile economic systems, remote livelihoods, lack of infrastructures and political willing are the main reasons that exacerbate farmer's vulnerability.

Furthermore, the degree of support with strategic adaptation measures was greater in Thailand than in Myanmar, Vietnam and Nepal, at least among the areas of study. The first one has implemented a package of strategies both at local and regional scale, i.e. irrigation and cloud seeding projects, which are increasing resilience amongst farmers but that are also preparing them against disasters, i.e. community inter-connected early warning systems. Thai farmer's do recognized this support but demand greater governmental efforts. The strategic adaptation pathway in Vietnam is quite vague with very little attention given to its major threat, sea level rise. Private support is insignificant whereas public, through capacity building, better seeds and land lending, is visible mainly in northern parts. Further research must be conducted in Vietnam and needs to be shared with policymakers. The implementation of effective coastal adaptation strategies cannot be delayed just because of the fact that the sea level rise is a slow natural process.

In the case of Myanmar, and even though it has a fragile political stability and low HDI value, its regional and local authorities both from the public and private sector are committed to increase resilience and reduce risks; for instance, through a set of actions during ENSO events. However, the commitment at a national level is still questioned, as it is one of the most vulnerable but only designates 6 million US$ to agricultural adaptation. Poor public funding brings to light the dependency of this country on external aid so as to assure food security when facing natural hazards.

Finally, the area of study in Nepal shows ineffective adaptation to climate change, disaster preparedness and poor bonds between stakeholders. It is incomprehensible that the community of Lumle, two kilometres far away from the RARS, aid recipient of SafBin, European Union and Caritas Nepal project on "Building resilience to climate change through adaptive small farming systems in rainfed areas of Nepal" and host of multiple national/international investigations (Bhusal, 2009; Regmi *et al.* 2009; Timilsina, 2015; Pandey, 2016) is still facing the abominable consequences of climate change with over 30 casualties in July 2015. Weak bonds between stakeholders have been identified at all scales, not only from fieldwork results but also within the scientific literature (Barlett *et al.*, 2010; Karki and Gurung, 2012). For instance, RARS authorities did not alert social leaders in Lumle of extraordinary rainfalls. In this line, the Oxfam (2009) report recognizes that coordination between line agencies and other non-governmental institutions is still a challenge.

Ultimately, fieldwork results indicate that autonomous adaptation is triggered by external stresses and therefore fosters adjustments at any cost. This is the case of Burmese farmers in Central Dry Regions, currently self-adapting to dryer conditions with water-pumps, even if

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they indebt themselves with high interest credits. Self-adaptation was observed in Thailand where, regardless the supports from the government, farmers have decided to extract water from the river source to irrigate their crops. It can be consider as autonomous adaptation but it is not the most appropriate measure as conflicts emerged. Other observed traditional strategies for effective farming and that are broadly known are: fertilising with manure, seed-sharing, nutrient conservation and water management techniques such as ponds and terraces.

Conclusion

The lack of public awareness, capacity building, technology transfer and poor political willing are often barriers for effective disaster preparedness and adaptation; however, bonds, communication and cooperation, between stakeholder's across-scales is often consider as the most important one. As a result, research centres, NGO's, private agencies, governmental institutions and farmers play an important role on augmenting adaptive capacity and reducing vulnerability of local people.

Unfortunately, adaptation to climate change is often triggered by extreme weather events raising concern of the public once the disaster has happened. Even though palliative strategies seem to be more common as natural hazards worsen, they should not dominate the political discourse and give legitimacy to policymakers to act once the disaster has happened. Instead, NAPA should be legally binding in order to promote the management and prevention of climate risks and elevate adaptive capacity of the most vulnerable.

To conclude, this work has brought to light gaps within the climate scientific literature and on the adaptation policy framework. Indigenous knowledge and social leader's insights have been compared to better understand local perceptions on changing climate and the agricultural adaptation discourse. Finally, this research has aimed to fill, to some extent, the scientific gap by providing both scientists and policymakers with an external evaluation of farmer's perceptions and climate change adaptation in agriculture in Nepal, Myanmar, Thailand and Vietnam.

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