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The Impacts of Climate Change on Agriculture and Water Resources in Cambodia: From Local Communities' Perspectives

Nong Monin

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Abbreviations

CDRI	Cambodia Development Resource Institute
Covid-19	Coronavirus
DRR	disaster risk reduction
FGD	focus group discussion
KAP	knowledge, attitudes and practices
MRC	Mekong River Commission
NCDD	National Committee for Sub-National Democratic Development
NCDD-S	National Committee for Sub-National Democratic Development Secretariat
NGO	nongovernmental organisation
RGC	Royal Government of Cambodia
V&A	vulnerability and adaptation

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Executive Summary

In 2019, 61 percent of the population living in rural areas, 76 percent of whom rely on agriculture as the main source of income and livelihood, sustainable rural and agricultural development is paramount to the Cambodian economy. National Strategic Development Plan 2019–2023 forms the basis of the national approach for strengthening the agriculture sector to generate jobs, ensure food and nutrition security, expand agricultural exports, reduce poverty, improve rural livelihoods and revive rural areas towards achieving sustainable and inclusive development and climate change resilience.

The shock of the Covid-19 pandemic has coincided with other shocks and trends such as the risk of economic crisis and financial collapse, the US-China trade war, disruption of supply chains, and impact on the poor due to lack of alternative or additional livelihood opportunities and income and the absence of social safety nets. The Covid-19 outbreak has shed new light on agriculture as a relatively more resilient sector and the imperative of ensuring food security (World Bank 2020).

Agriculture and water are among the high priority sectors for achieving the targets of the Cambodia Sustainable Development Goals, Cambodia Climate Change Strategic Plan 2014–2023 and Cambodia's Nationally Determined Contributions (intended reductions in greenhouse gas emissions) under the UN Framework Convention on Climate Change. The impacts of climate change on these two sectors vary depending on location and the levels of exposure and sensitivity and adaptive capacity.

The study set out to identify groups of people who are vulnerable (both site and context-specific) to climate change, and their capacity and practices for responding to and coping with climate hazards such as flood, drought and windstorm across the four agro-ecological zones. The study looks at how climate change affects the agriculture and water sectors and the livelihoods dependent on them, highlights cost-effective and technically appropriate climate change responses, and suggests best practices to suit different local settings in Cambodia.

Among all climate hazards, the study found that prolonged droughts from 2013 to the present (2020) caused the most severe impacts. Across all four agro-ecological zones, the rural communities dependent on agriculture have high levels of vulnerability and those dependent on water resources have medium levels of vulnerability. Agriculture and water resources in the Tonle Sap, Mekong floodplain and coastal areas were found to be moderately vulnerable to floods. Agriculture in the Tonle Sap, Mekong floodplain and coastal areas is moderately vulnerable to windstorms and water resources in all communities are less vulnerable (flash flood damage locally). Local community adaptive capacity levels for both agriculture and water resources are assessed at low and medium.

High vulnerability to drought can be attributed to local communities' low adaptive capacities, influenced by such factors as poverty (most rural residents are still living just above the poverty line), poor infrastructure, lack of social safety nets (lack of resilience), low understanding of the causes and effects of climate change, and inadequate hazard predictions and warnings even though droughts are becoming increasingly frequent.

How local households and communities deal with climate risks mainly depends on their level of reliance on natural resources and traditional ad hoc (i.e., unplanned adaptation actions), which will not be enough to mitigate climate change. Information is not provided in an easy-to-understand format suitable for people with low literacy skills or without technological means.

The study proposes three measures for strengthening local community resilience to climate change:

1. Improve access to financial and technical supports (to be responsive and sustainable) so that local communities can enhance their capacity to adapt and cope with extreme events.
2. Distribute climate change responses in irrigated and climate-resilient agriculture among local people and authorities geographically (most vulnerable locations) and fairly (based on actual needs without political consideration or bias).
3. Engage stakeholders from different levels of government, from central to subnational administration including commune, village and community authorities, in a highly integrated approach to build climate resilience through local community actions.

1. Introduction

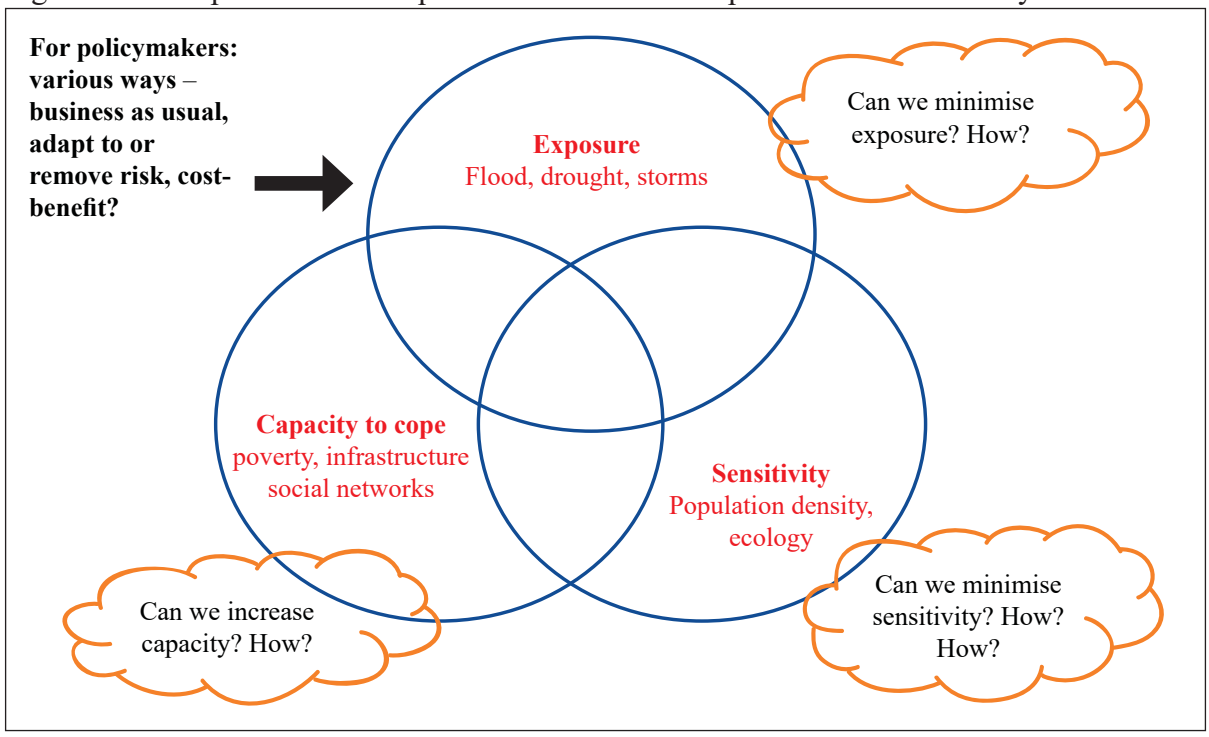
1.1 Background

Agriculture contributed 29 percent of the country's GDP in 2018; but, at 1.6 percent, annual growth was modest compared to 12.3 percent for industry and 6.5 percent for services (RGC 2019). The main constraints on agricultural growth are insufficient capacity to adapt to climate change and manage disaster risks, low productivity, poor quality agricultural inputs, and inadequate technical support (MAFF 2020). Cambodian agriculture is predominantly rainfed and characterised by low inputs, soils with moderate or low fertility levels, low to moderate yields and low productivity, making it weather-dependent and susceptible to climate-related risks.

National Strategic Development Plan 2019–23 focuses on strengthening the irrigated agriculture sector to generate jobs, ensure food security and reduce poverty by transforming agriculture into a modern, competitive, inclusive, climate-resilient and sustainable sector (RGC 2019; MAFF 2020). Agriculture and water remain the highest-priority sectors that the government pays strong attention to for dealing with climate change, promoting agri-business and improving rural livelihoods. Climate change adaptation and mitigation are articulated in national strategies and plans such as Cambodia Climate Change Strategic Plan 2014–2023, National Adaptation Plan Process, Cambodia Sustainable Development Goals, and Cambodia's Nationally Determined Contributions under the United Nations Framework Convention on Climate Change.

The impacts of climate change affect different regions of the country in different ways depending on the level of exposure, sensitivity and adaptive capacity to stresses (Figure 1).

Figure 1: Conceptual relationship between different components of vulnerability



Source: MOE, ADB and Hatfield Consultants 2013

Latterly, national adaptation strategies have shifted focus to prioritise local and community-based adaptation planning because rural people are on the frontline of climate change impacts and variability yet have limited coping and adaptation mechanisms and responses. Moreover,

climate change vulnerability is site and context-specific – it varies depending on local geography, types of livelihood strategy and over time (Sam and Pech 2015). Despite slight progress reported in the second national knowledge, attitudes and practices (KAP) survey on climate change by the Ministry of Environment (MOE 2016), adaptive capacity in Cambodia remains moderately low. This is largely due to citizens' poor understanding of climate change, limited response options, and weak resilience to natural disasters and climate change (National Climate Change Committee 2013). Local adaptive capacities to respond to and recover from (resiliency) extreme events including flood, drought, disease and storms are low due to limited access to early warnings, lack of preparedness (poverty and social support), inadequate climate-resilient facilities and infrastructure, and limited opportunities for alternative or additional livelihood and income sources. Well-informed and enhanced adaptive capacity at community and household levels translate into increased local resilience to cope with and recover from exposure to natural hazards in a timely manner (Sam et al. 2015).

Cambodia is among the countries that have contributed the least to causing climate change, yet is one of the most vulnerable to climate change impacts, especially drought. The UNESCAP report *Ready for the Dry Years: Building Resilience to Drought in South-East Asia* warns that "in the near future, even with less severe El Niños, the drought area will have extended to Cambodia and the southern part of Thailand" (UNESCAP 2020, 12) and "in the far future, the conditions will be even more severe. Almost every part of Cambodia and Thailand will have moderate to extreme drought" (UNESCAP 2020, 34).

Cambodia's Second National Communication reported that "under future climate conditions (2025 and 2050), most of Cambodia's agricultural areas will be exposed to higher drought risks. The growing period for most agricultural areas will be less than five months (between two and three months). Efforts to increase the planting index of more than 1.0 may be impossible without the development of irrigation facilities" (GSSD 2015, xv). Many institutions have assessed climate change and water resources. It is predicted that rising sea levels will inundate low-lying areas of the coastal zone (GSSD 2015),[1] and the level and duration of the Tonle Sap flood pulse will change in addition to the changes caused by dam development and operation in the Mekong Basin (MRC 2010).

Change in the flood pulse (caused by both dam and water diversion and long-term climate change) will inevitably cause significant losses in capture fisheries, degrade soil fertility due to dam sediment trapping, exacerbate water shortages caused by dam regulation and droughts, inflame upstream-downstream water conflicts, and heighten barriers to water-efficiency including reliance on traditional practices and rainfed agricultural systems because of limited irrigation coverage, inadequate rural road networks and lack of rural banking services. The combined effects of overfishing, human-induced and natural climate change, hydrological change and fertility-cycle disruption in the Mekong River and Tonle Sap Lake could ultimately destroy fish habitats, deplete fish stocks and lead to fish species collapse (Baran et al. 2007; Ros, Chhim and Nang 2011; MOWRAM et al. 2013).

1 The projected rise in sea levels will affect coastal ecosystems through saltwater intrusion, inundation, flood and storm surges, wetland losses, erosion, and rising water tables. An area of about 25,000 ha would be permanently submerged by a sea level rise of 1 metre, and 38,000 ha by a sea level rise of 2 metres (GSSD 2015).

1.2 Objectives

The main objectives of the study are to identify site- and time-specific responses and practices to cope with local vulnerability to climate change across agriculture and water resources in selected communities across Cambodia's four agro-ecological zones, and the factors that either facilitate or hinder climate change and disaster risk reduction mainstreaming and implementation. To that end, the study addresses two research questions:

- To what extent does climate change affect the agriculture and water sectors in rural Cambodia from the perspective of site- and context-specific vulnerability?
- What are the most cost-effective and technically appropriate responses to climate change impacts across agriculture and water sectors in different local settings in rural Cambodia?

2. Literature review

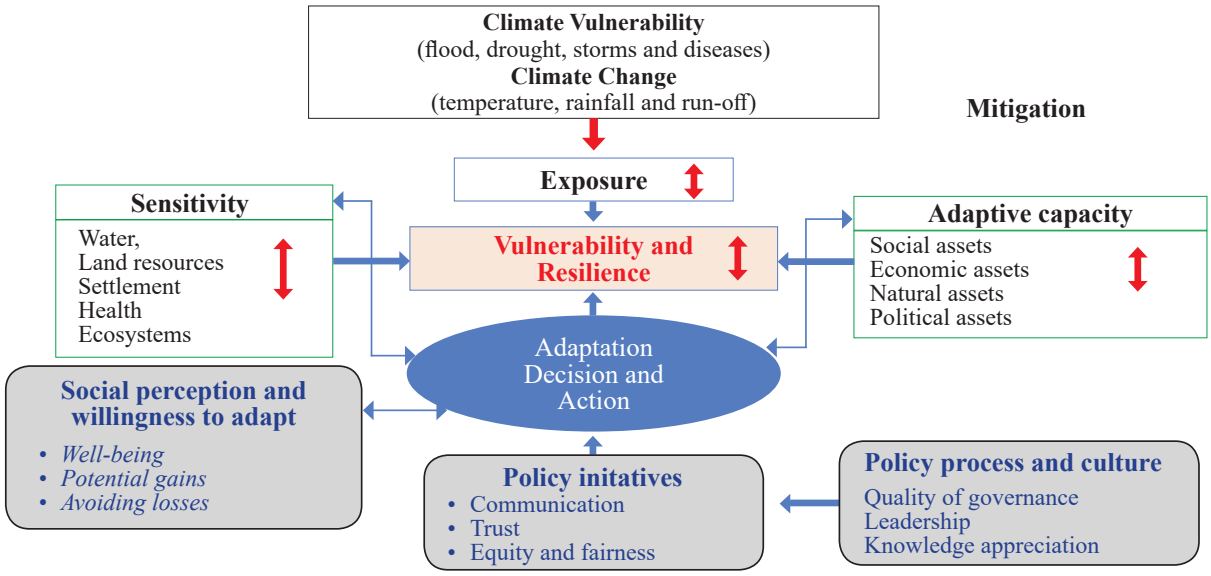
2.1 The conceptual framework for climate vulnerability assessment and adaptation

Climate vulnerability is closely linked to livelihoods and access to key assets, especially those needed for production and recovery from climate-driven disasters (MOE et al. 2013). Moreover, site- and context-specific vulnerability and adaptation (V&A) assessment is a key aspect of anchoring climate change impact assessments to development planning for specific sectors and localities (MOE et al. 2013; Barnett 2008).

Climate change impacts constitute additional stress on livelihood systems in terms of the interactions between climate hazards and system characteristics, that is, the degree to which a system is exposed, its sensitivity and its adaptive capacity. The level of vulnerability of a system determines the extent to which it is adversely affected by extreme events and disasters (MOE et al. 2013; IPPC 2001).

The current study builds on a previous V&A assessment in Cambodia's Tonle Sap Basin conducted by CDRI (Kim et al. 2014) using the above mentioned approach. The authors argue that vulnerability should be perceived in terms of vulnerability to both current climate hazards and future climate change, as presented in Figure 2.

Figure 2: Conceptual framework for climate change vulnerability and adaptation



Source: Kim et al. 2014

2.2 Climate change vulnerability and gender

The 52nd session of the Commission on the Status of Women drew attention to the fact that climate change is not a gender-neutral phenomenon, that women are more vulnerable to climate change than men. Women and girls bear the brunt of the risks and the consequences of climate change and climate-related natural disasters. Further, gender inequalities, discriminatory social and cultural norms and gender biases impede women's full economic, political and social participation. The Commission called on governments to pay greater attention to gender equality and women's empowerment, to mainstream gender awareness into all aspects of national environmental policies, and to provide adequate technical and financial supports "to ensure women's full and equal participation in decision-making at all levels on environmental issues, particularly on strategies related to the impact of climate change on the lives of women and girls." (United Nations 2008, para.11).

The household-level V&A assessment by Mendoza et al. (2014) in Cambodia, the Philippines and Vietnam identified three key aspects underlying women's greater vulnerability to climate change: limited skills, few opportunities, and care responsibilities. In Cambodia, climate change is increasingly recognised as both an environmental issue and a social issue as it disproportionately affects vulnerable groups such as women, persons with disabilities, ethnic minorities and indigenous people (MOWA 2013, 2020). Because vulnerable groups face a higher risk of living in poverty, and because of traditional gender social roles, women are likely to be affected more severely than men. It is therefore imperative that V&A measures consider and address the multi-faceted elements of vulnerability and gender inequality otherwise women will continue to disproportionately suffer the consequences of climate change.

2.3 Loss and damage from climate hazards

Analysis by the National Committee for Disaster Management indicates that, in an average year, 1,000 to 2,000 houses are destroyed by climate-related disasters. Over the past 20 years, natural disasters have destroyed around 20,000 residential houses, 26 km of urban and rural roads and 1,853 ha of crops, and killed 2,507 people (Figure 4). The World Bank (2012 cited in MEF and GSSD 2019) estimates that Cambodia's average annual losses from natural disasters amount to USD74.2 million, or 0.7 percent of GDP, of which floods account for USD41.6 million or 55 percent of the total, droughts USD28.5 million or 28.5 percent, storms 4 percent, and other hazards 3 percent.

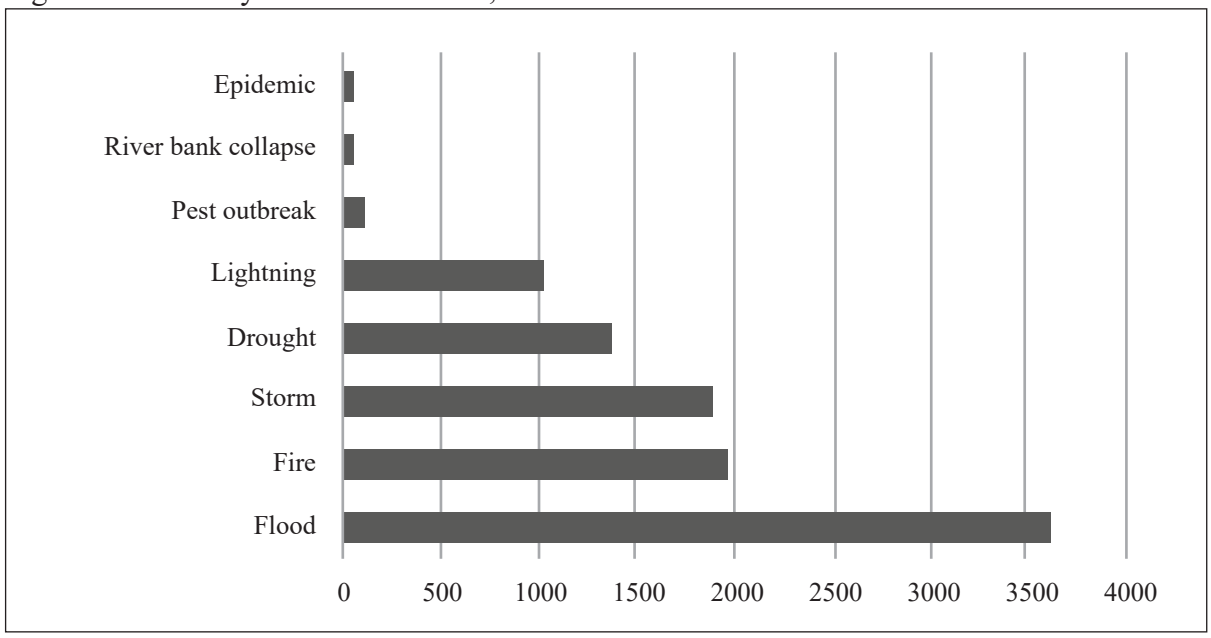
Major floods occurred in 2000, 2006, 2011 and 2013. Cambodia's Second National Communication to the UNFCCC (MOE 2015 cited in MEF and GSDD 2018, 74) states that flood damage amounted to USD157 million in 2000, USD30 million in 2001 and USD12 million in 2002. Flood damage analysis by the Mekong River Commission estimated that the average damage to infrastructure in three districts between 2000 and 2007 was USD2.5/person/year, implying a national total of USD35 million or 2.5 percent of GDP (MRC 2010 cited in MEF and GSDD 2018, 74).

The 2011 flood affected 350,000 households and damaged 267,000 ha of transplanted rice. Several rural roads and bridges were destroyed at an estimated loss of USD630 million (Leng 2014).

The Post Flood Early Recovery Needs Assessment Report for the 2013 flood estimated the total cost of the floods to be USD356 million (USD203 million for loss and USD153 million for damage). Agricultural losses amounted to USD152 million. Damage to water and irrigation amounted to USD52 million and damage to roads USD80 million (RGC 2014 cited in MEF

and GSSD 2019, 74). The 2013 flood affected 377,345 households and 31,314 households were urged to escape to safe places (Leng 2014).

Figure 3: Events by datacards/records, 1996–2020

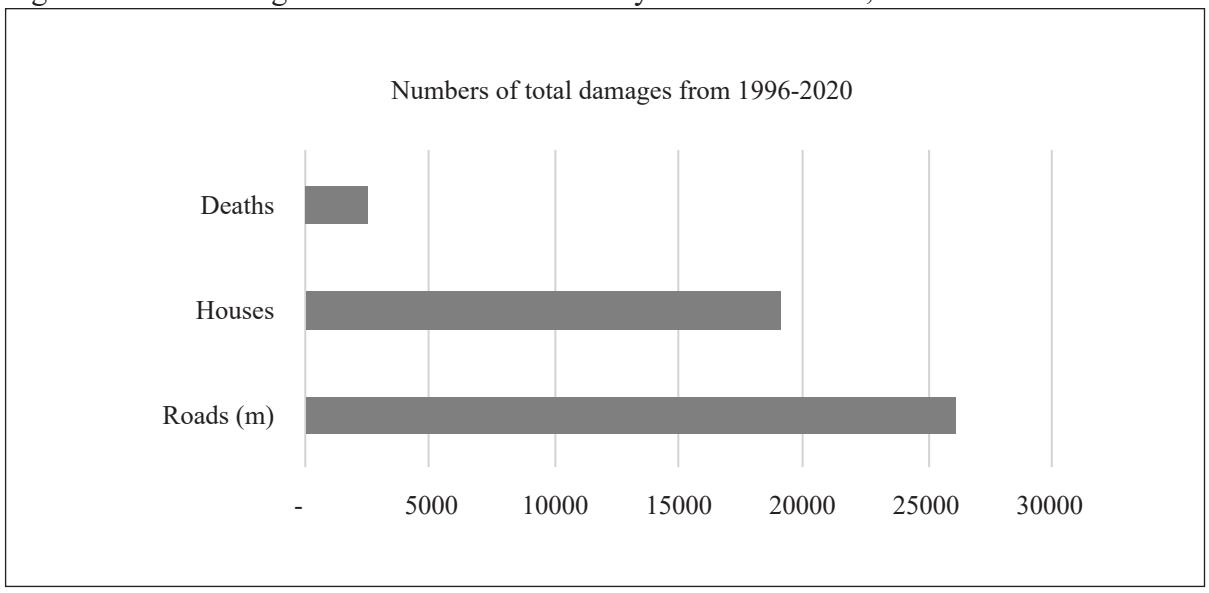


Source: NCDM 2020

Drought occurs when seasonal rainfall is late or ends early. Sometimes seasonal drought extends into the rainy season. In 2009, drought destroyed 2,621 ha of the total 57,965 ha of rice crops. Then in 2010 drought destroyed 14,103 ha of transplanted rice, 3,429 ha of rice seedlings and 5,415 ha of subsidiary crops. In 2012, drought damaged 3,151 ha of the total 14,190 ha of rice fields (CFE-DMHA 2017).

Storms always occur in the rainy season and are more severe in September and October. In 2009, 180,000 households were affected and 43 people killed when Typhoon Ketsana hit Cambodia (Leng 2014).

Figure 4: Total damage to infrastructure caused by natural disasters, 1996–20



Source: NCDM 2020

2.4 Climate change – impacts and vulnerabilities

The vulnerability assessment by the Ministry of Environment in 2014 indicated that 279 communes (17.2 percent of the total) were "highly" vulnerable and 515 (31.5 percent) were "quite" vulnerable to multiple climate change hazards (GSSD 2017). Overall, 186 in every 1,000 households were affected by climate hazards in 2014. The Mid Term Review of Cambodia Climate Change Strategic Plan 2014–2023 classified communes as highly vulnerable or quite vulnerable to storms, and households and communities as highly vulnerable to droughts and floods (Garcia, Tech and Gurung 2019).

Our appraisal of the literature concurs that local communities are highly vulnerable to climate change because they have high levels of exposure and sensitivity and low levels of adaptive capacity. The exposure level in communities is high because floods, droughts and storms are becoming more intense and more frequent and their destructive magnitude has increased. These events severely affect rice fields, other crops and household landholdings. Similarly, the level of sensitivity is high because people depend on natural resource-based income sources including farming, fishing, and collecting and selling timber and non-timber forest products, all of which are climate-sensitive. The second biggest contributing factor in increasing sensitivity is the area of land affected by disasters, followed by the area of crops affected (Sam et al. 2015).

Vulnerable households in the Tonle Sap region are affected by river floods and flash floods which disrupt livelihoods and incomes. Floods can harm crops but can also increase fish productivity. Storms are becoming more frequent in the region as well. In 2011, for instance, Typhoon Ketsana destroyed rice fields, other crops, houses and infrastructure in Pursat province. The increase in the frequency of drought has negative impacts on agriculture, forestry and ecosystem services, substantially affecting local economies and livelihoods. Some weeds thrive in drought conditions and harbour crop pests and diseases, and fish catches generally decline during drought. The Minister of Agriculture, Forestry and Fisheries reported in 2020 that due to historical drought freshwater fish catches had decreased by 13 to 30 percent compared to 2019 and the cost of fish had more than doubled.[2] The Mekong River Commission's regional fish abundance and diversity monitoring in the Tonle Sap Lake show that household fish catches in Kampong Chhnang province decreased by about 35 percent in 2019 compared to the average for the previous eight years (2011–2018). Compared with the wettest year in 2013, the total fish catch has decreased by about 50 percent. There is a correlation between fish catch and water flow, coupled with the timing and duration of seasonal flows along the Mekong mainstream (MRC 2020). Climate change coupled with the mushrooming of hydropower dams on the Mekong and Tonle Sap affects the water level of the Tonle Sap Lake, resulting in reduced fluctuations and lake shallowing (Nang 2013).

2.5 Local adaptive capacity

Local understanding of climate change and its impacts on agriculture has progressed, but local knowledge on climate change adaptation remains poor. In a follow-up knowledge, attitudes and practices (KAP) survey on climate change (MOE 2016), almost 40 percent of 1,000 respondents did not know how to respond to climate variability and change. Those who did know were mainly engaged in agriculture and faced limited financial and technical resources (Sam et al. 2015). Climate change adaptation and disaster risk reduction are interlinked as climate change will exacerbate and intensify natural disasters. NGOs are working with the government to mainstream disaster risk reduction and climate change adaptation into local development and

2 www.freshnewsasia.com/index.php/en/localnews/181138-2020-12-22-14-54-27.html.

disaster management planning. However, financial, technical and social challenges hinder the scope and implementation of plans (Sam 2015).

A previous study by CDRI on climate change and water governance in Cambodia (Sam and Pech 2015) found that rural people with limited adaptive capacity are most vulnerable to climate change impacts and have limited ways of responding to change, despite concerted efforts to disseminate climate change adaptation initiatives nationwide. Sam and Pech (2015) emphasise the vital role of formal and informal institutions in building local resilience to climate change. Disaster risk management and reduction and climate change are cross-cutting issues and have gained much attention from various national and international institutions. However, based on a report on disaster management in local areas of Cambodia, it seems that due to limited institutional, financial and technical supports, disaster management in Cambodia is largely ineffective (Sam 2015).

2.6 Key vulnerabilities, key risks and risk reduction

The government has put in place various planned and "no regret" adaptation measures to cope with climate change impacts. Those measures include the rehabilitation and construction of new irrigation infrastructures such as pumping stations, canals, flood protection barriers and water control gates.

Moreover, the government has expanded the irrigated area, developed technology for improved land and water use, explored alternative water sources and improved operational and institutional performance. There has been much interest and investment in the irrigation sector since the mid-2000s, with over USD1.3 billion (80 percent development partners, 20 percent government) going into the rehabilitation of existing irrigation schemes and the construction of several large irrigation schemes and reservoirs. Further funds of at least USD2.5 billion will be invested in irrigation and water resources development by 2033 (ADB and MOWRAM 2018)

Despite recent investments, 1,926 of the total of 2,500 irrigation schemes need to be fully rehabilitated, water delivery is inefficient and water does not reach all farm plots in the schemes, and some systems have failed due to design errors, improper drainage systems, and soil sealing (ADB and MOWRAM 2018). The National Irrigation and Water Resources Management Investment Program 2019–33 has embarked on an ambitious six-year program to 1) address water security for agriculture, and water supply; 2) complete fully functional irrigation schemes; 3) ensure sustainable irrigation water management; and 4) create an enabling environment – law and policy. It envisages restoring 1.0 million ha for wet season crops – 22 percent of the total arable land area (4.5 million ha) and 0.5 million ha for dry season crops. The program faces many constraints, however. The Ministry of Water Resources and Meteorology (MOWRAM) and its provincial departments are under-resourced and overstretched and therefore unable to properly support sustainable water resource and irrigation management under the 2007 Water Law. The 25 provincial departments need several hundred qualified staff and resources for managing both sustainable irrigation development and water resource management (e.g., monitoring, reporting and planning) (ADB and MOWRAM 2018).

Table 1: Summary of hazards, vulnerabilities, risks and risk reduction initiatives

Hazard	Vulnerability	Risk	Risk reduction
Extreme precipitation and inland flooding	- Large numbers of people exposed in urban and rural areas to flood events, particularly in low-income informal settlements - Poorly maintained and inadequate urban and rural drainage infrastructure - Limited ability to cope and adapt due to marginalisation, high poverty rate, and culturally imposed gender roles - Inadequate attention from government to disaster risk reduction	- Death, injury and disruption of human security, especially among children, the elderly, and disabled persons	- Large-scale disaster risk reduction projects/programs - Preparedness for emergency response and recovery
Drought and rainfall variability	- Poor populations in urban and rural areas susceptible to food insecurity, especially farmers who are net food buyers and people in low-income agrarian economies - Limited ability to cope among the elderly and female-headed households - Existing water shortages (and irregular supplies) and constraints on increasing supplies - Lack of adaptive capacity and resilience in the water sector including rural and urban governance regimes	- Risk of harm and loss of life due to the reversal of progress in reducing malnutrition - Insufficient water supply for people and industry, yielding severe harm and economic impacts - Loss of agricultural productivity and/or income of rural people - Destruction of livelihoods, particularly for those depending on water-intensive agriculture - Risk of food insecurity	- Recent major disaster risk reduction projects/programs - Action plans for preparedness, response and recovery
Sea level rise, coastal flooding including windstorms and storm surges	- Vulnerability index of agriculture, water, fisheries and forestry - High exposure of local people, economic activities and infrastructure in low-lying coastal areas - Urban population unprotected due to substandard housing and inadequate insurance - Marginalised rural population with multi-dimensional poverty and limited alternative livelihoods - Insufficient local governmental attention to disaster risk reduction	- Potential impacts (exposure and sensitivity) index of agriculture, water, fisheries and forestry - Death, injury and disruption to livelihoods, food supplies and safe drinking water - Loss of common-pool resources, sense of place and identity, especially among the most vulnerable groups in rural coastal areas	- Governmental attention at the subnational level to disaster risk reduction - Both structural and non-structural preparedness is necessary to plan and provide all hardware to reduce the toll of natural disasters - Short-term emergency actions to save lives, deal with the immediate effects and start recovery in disaster-affected communities

Source: Author's compilation from literature review and policy documents

3. Research methodology

3.1 Research design and data collection

The study used a mixed-methods approach combining qualitative and quantitative methods and data. The data was collected from five sources: fieldwork observations, key informant interviews (KIIs), focus group discussions (FGDs), household surveys and a desk review. The data emphasises the parameters of vulnerability, the severity of climate hazards and adaptive capacity to floods, droughts and windstorms relating to agriculture and water resources.

The study focused on four provinces for which recent data was available, one in each of the four agro-ecological zones: Battambang in the Tonle Sap floodplain, Kampot in the coastal zone, Preah Vihear in the plateau and mountain region, and Prey Veng in the Mekong floodplain. Forty villages in 10 communes were selected as study sites in consultation with district-level and provincial authorities and civil society representatives.

In March 2019, the research team conducted 16 FGDs (four in each province) involving 133 (98 female and 35 male) local people in total and eight KIIs (two in each province) with local authorities (see annexe 2: list of FGDs and KIs). Primary data and information obtained through fieldwork observations provided insights into how local communities and farmers are coping with changing and erratic weather patterns and extreme weather events.

Secondary data was gathered from a comprehensive desk review of climate change adaptation literature, national policy and strategy documents and plans. We collected data on water resources, agriculture, fisheries and forestry, as well as on agricultural development efforts and their implications for food security and poverty alleviation. Moreover, the study used available household survey data of the two-year participatory research project with support from the United Nations Democracy Fund to assess local awareness of climate change and their capacity to respond to climate change impacts (CDRI and UNDEF 2019). The survey to 400 (263 female and 137 male) was collected in May 2019 and household heads or principle adult[3] decision-makers were randomly selected. The survey questionnaire collected information on respondents' basic demographic characteristics (gender, age, level of education, training attended, and main occupation), perceptions of the issues affecting their village, knowledge about climate change (causes and effects), attitudes towards climate change and proactive adaptation to climate change. This information was used to identify parameters and variables for the analysis.

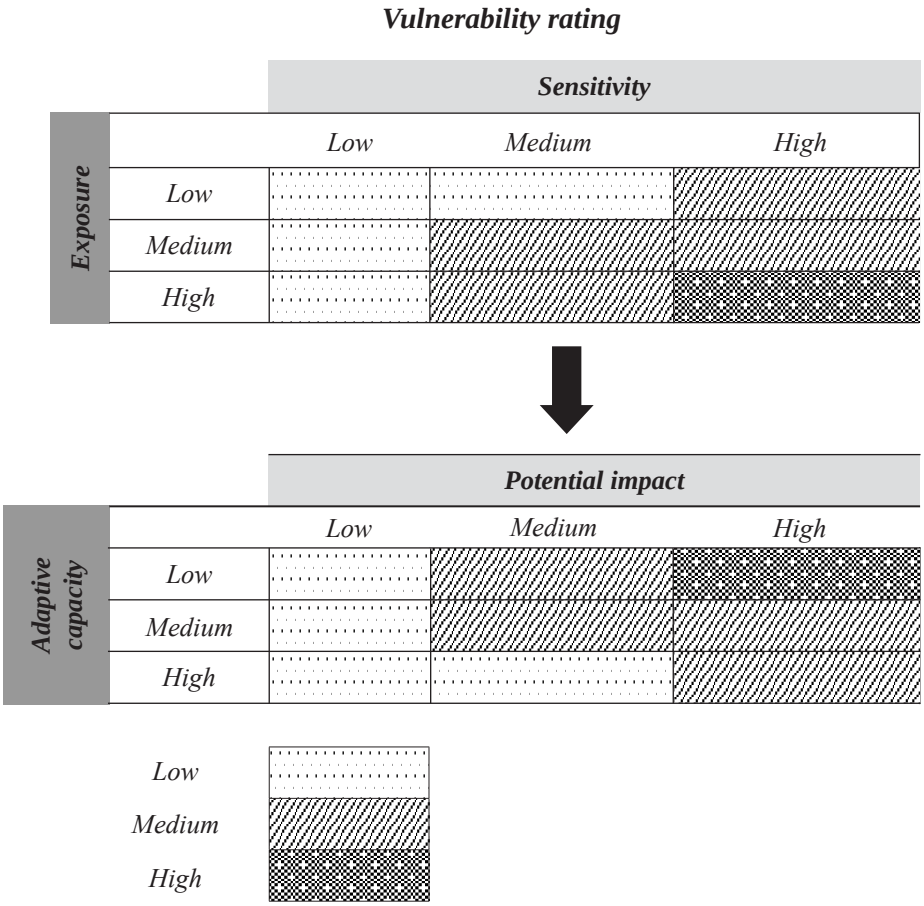
The study used a vulnerability index[4] to assess the severity of impacts from climate change (see, for example, climate change vulnerability index calculations in Yusuf and Francisco 2009 and Comer et al. 2019). Vulnerabilities are characterised by three score levels: low, medium and high (Figure 5). These were derived from relative measures of potential impacts, calculated as a combination of exposure to climate change and sensitivity, and adaptive capacity. The indicator values were then normalised on a scale of 0.0 to 1.0, where 0.01 to 0.39 = low, 0.40 to 0.59 = medium, and 0.6 to 1.0 = high overall vulnerability.[5]

3 Adult is defined as age 16 years and above.

4 "The Climate Change Vulnerability Index evaluates the vulnerability of human populations to extreme climate events and changes in climate over the next 30 years. It combines exposure to climate extremes and change with the current human sensitivity to those climate stressors and the capacity of the country to adapt to the impacts of climate change" (www.maplecroft.com/risk-indices/climate-change-vulnerability-index/).

5 See details of index calculation guide in Annex 1.

Figure 5: Vulnerability calculation and rating



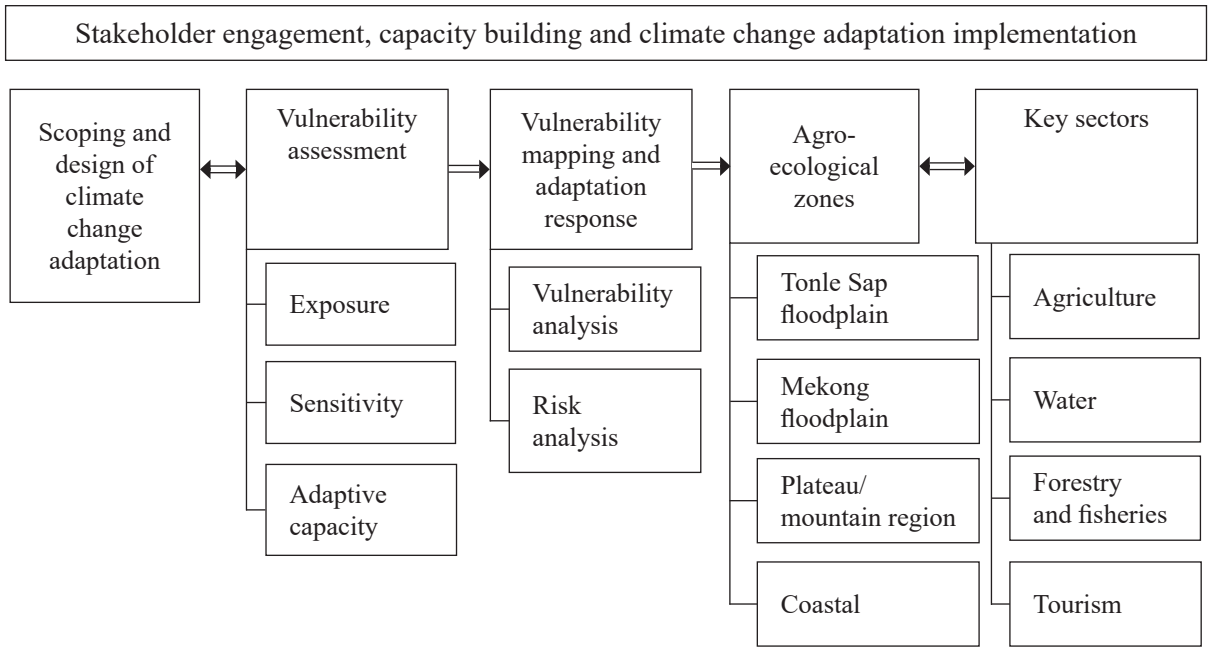
3.2 Scope and limitation of the study

The study focuses on agriculture and water resources as they are two of the most vulnerable sectors in Cambodia. The study sites were selected in four provinces, one from each agro-ecological zone – Tonle Sap floodplain, Mekong floodplain, plateau and mountain region, and coastal area, which have different climate change vulnerabilities, namely floods, droughts and windstorms.

3.3 Research framework

The research framework, shown in Figure 6, links climate change adaptation and disaster risk reduction in a joint vulnerability and risk assessment. The impact of climate change level is modulated by the exposure and sensitivity of the systems to climate variabilities and change. Risk is the probability that identified hazards that could cause harm will occur. Vulnerability is a function of exposure to climate change, inherent sensitivity to climate change, and capacity to tolerate or adapt to change (Australian Greenhouse Office 2005).

Figure 6: Research framework

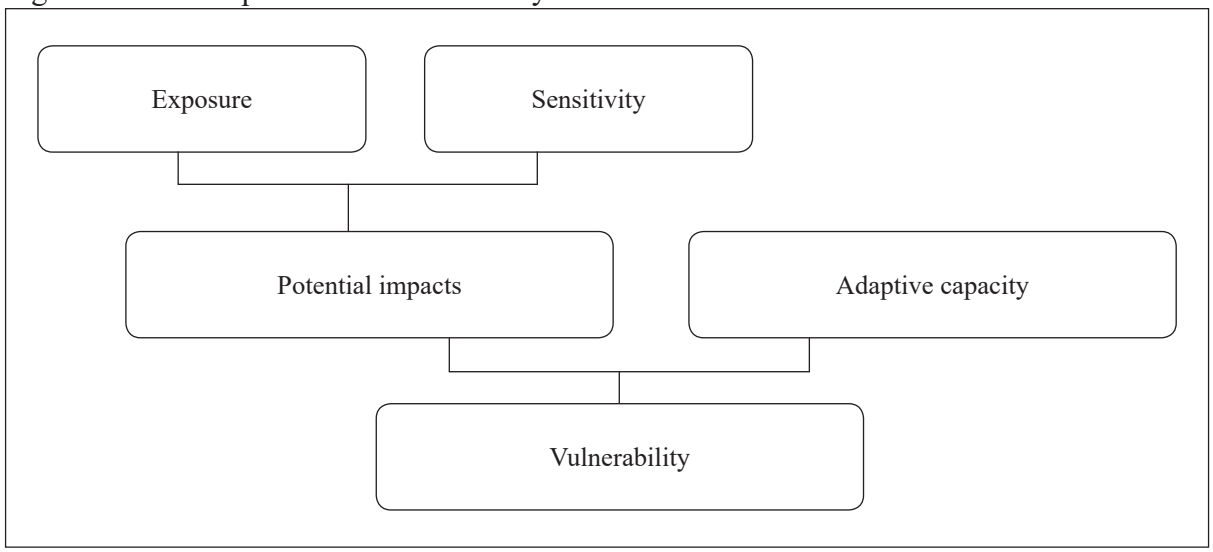


Sources: Adapted from Australian Greenhouse Office 2005; NCSD 2013; GSSD 2017

The vulnerability and livelihood frameworks were proposed to improve understanding of the linkages between poverty, livelihood issues and vulnerability. Site-specific and context-specific V&A assessment is a key step for anchoring the assessments of climate change impacts to present and future development planning for specific sectors – agriculture and water resources and selected localities.

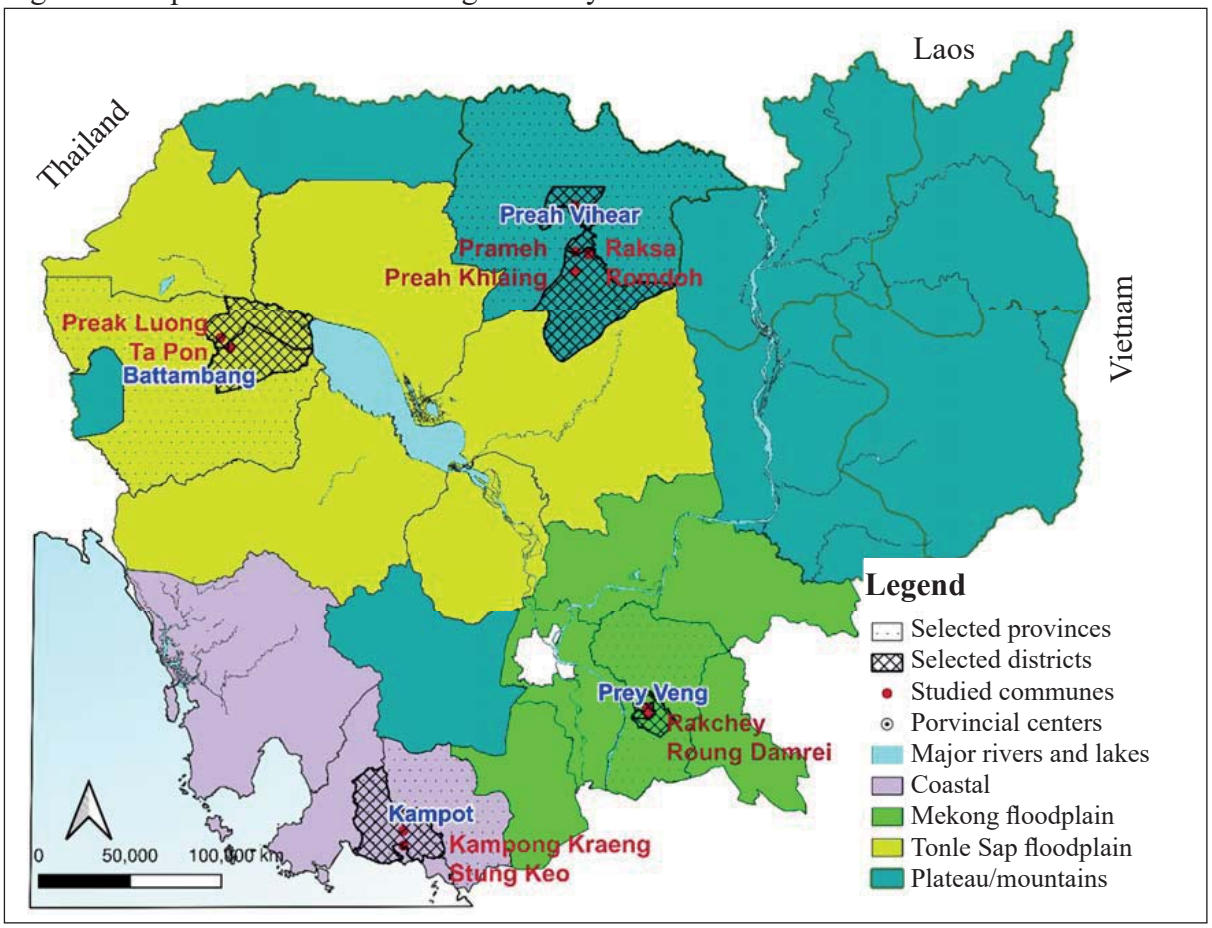
Importantly, our framework integrates gender dimensions. Unless gender inequalities are identified and addressed, women and girls will continue to shoulder a disproportionate burden of climate change impacts.

Figure 7: The components of vulnerability



Source: Australian Greenhouse Office 2005

Figure 8: Map of Cambodia showing the study sites



Source: Author, 2019

4. The findings

4.1 Characteristics of survey respondents – age, education and occupation

Of the 400 survey respondents, 263 (65.8 percent) are women. The 16 FGDs involved 133 participants, 98 (73.7 percent) of whom are women.

Respondents were classified into four age categories, as shown in Table 2. The average age of respondents is 46.3 years. Most of the respondents fall into either the 40–54 or the 55+ age group, accounting for 64 percent of the total sample, and those in the 25–39 and 16–24 age groups account for 30.8 percent and 5.3 percent, respectively.[6]

Table 2: Age profile of survey respondents (percent)

Respondents	16–24	25–39	40–54	55+	Average
Battambang (n=100)	3.0	27.0	38.0	32.0	47.6
Kampot (n=100)	5.0	36.0	35.0	24.0	44.3
Preah Vihear (n=100)	8.0	41.0	25.0	26.0	42.7
Prey Veng (n=100)	5.0	19.0	30.0	46.0	50.6
Total (n=400)	5.3	30.8	32.0	32.0	46.3

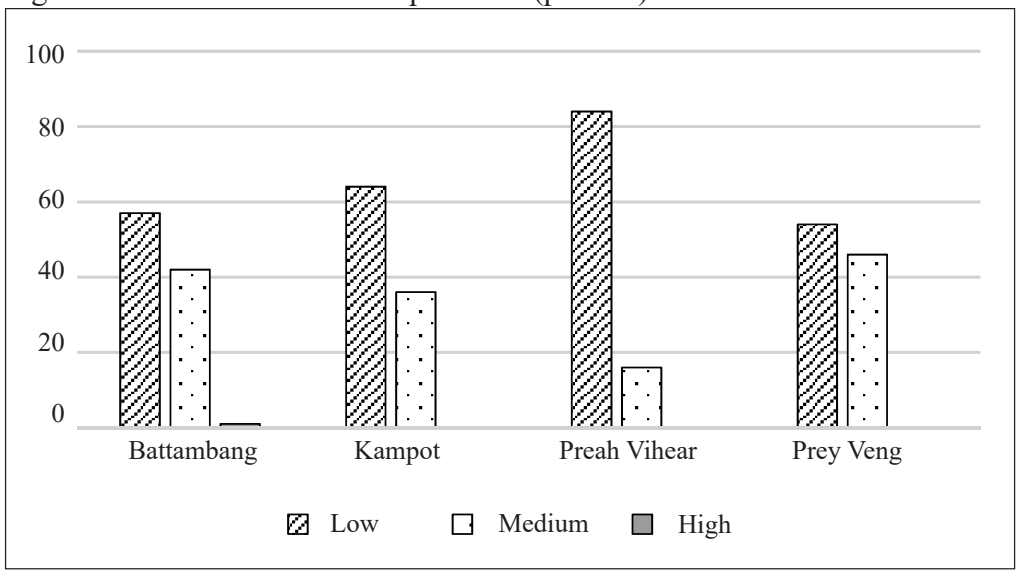
Source: Survey, May 2019
Note: Pearson chi-square test is statistically significant at 1 percent, $\chi 2 = (24.00)$.

6 The Pearson chi-square test (χ^2) attempts to test the statistical difference among two or more categorical variables that occur by chance (Pearson 1900).

The education level of respondents was classified using three broad standardised categories:[7] low (no education, primary), medium (lower secondary, upper secondary, basic vocational training), and high (university education, specialised vocational training) as Figure 9 shows, none of the respondents in Kampot, Preah Vihear and Prey Veng provinces and only 1 percent of those in Battambang province have a high level of education. In all four provinces, respondents with a low level of education outnumber those with a medium level. The biggest disparity in education level occurs in Preah Vihear province where only 16 percent of respondents have a medium level of education.

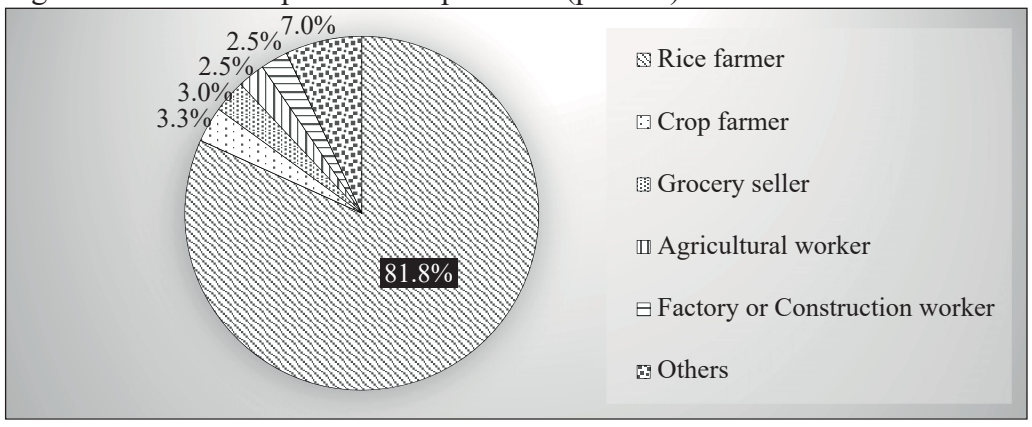
The main occupations of respondents are shown in Figure 10. The majority (81.8 percent) of them are rice farmers. The rest are engaged in other occupations (7.0 percent), crop farmers (3.3 percent), grocery sellers (3.0 percent), agricultural workers (2.5 percent), factory workers or construction workers (2.5 percent).

Figure 9: Education level of respondents (percent)



Source: Survey, May 2019
Note: Pearson chi-square test is statistically significant at 1 percent, $\chi 2 = (26.64)$

Figure 10: Main occupation of respondents (percent)



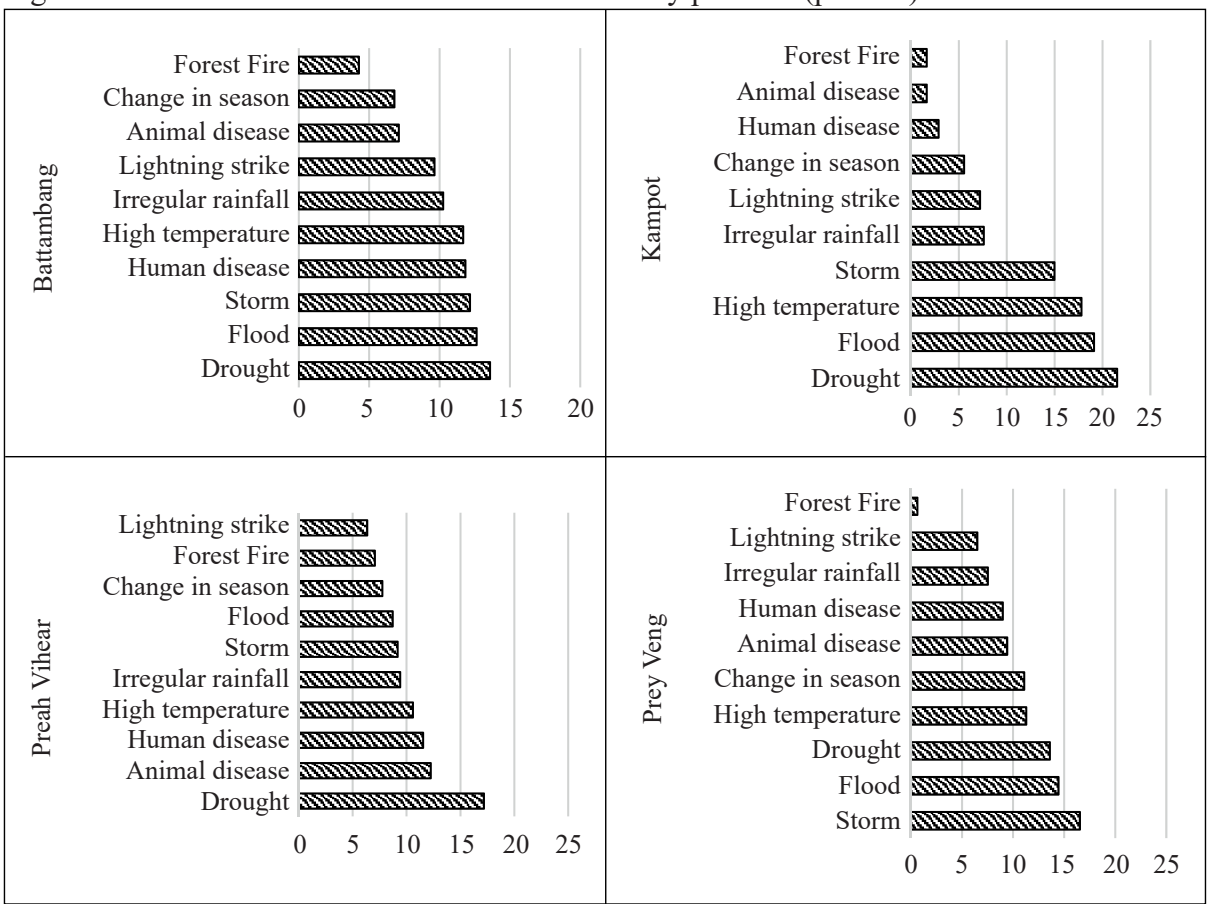
Source: Survey, May 2019
Note: Pearson chi-square test is statistically significant at 1 percent, $\chi 2 = (63.35)$.

7 The education levels are based on the International Standard Classification of Education (OECD 1999). Only completed education and training were considered. Incomplete training and education were coded to the next lower level.

4.2 Exposure to climate hazards

Respondents' experience with extreme weather events indicates that the four provinces are affected differently by similar natural disasters (Figure 11). Drought frequency is highest in Kampot and drought is the most frequently occurring natural disaster in Kampot, Battambang and Preah Vihear, whereas in Prey Veng storms are the most frequent hazard. Floods are the second most common extreme event in Battambang and Kampot, followed by storms in Battambang and higher temperatures in Kampot. The second and third most common climate hazards in Prey Veng are floods and droughts and in Preah Vihear animal disease and human disease.

Figure 11: Disaster occurrence from 2010 to 2019 by province (percent)



Source: Survey, May 2019

4.3 The impacts of climate change on agricultural water management

4.3.1 Climate hazards and agriculture

The results of the climate change vulnerability index calculation for the effects of flooding indicate that agriculture is highly vulnerable in Prey Veng and Kampot, moderately vulnerable in Battambang and less vulnerable in Preah Vihear. Agriculture in all four provinces is highly vulnerable to drought and slightly vulnerable to storm damage (Figure 12).

In Battambang province, FGDs with local people in Ta Pon and Preak Luong communes revealed that the climate hazards they most often encounter are droughts, floods and windstorms. In Preak Luong, a series of worsening droughts in 2010, 2011, 2014 and 2016 has had many detrimental impacts on commune facilities and people's lives including lack of water for domestic use and

irrigation, crop damage, lack of seeds, human disease, animal disease, indebtedness, domestic violence, migration, and school dropout.

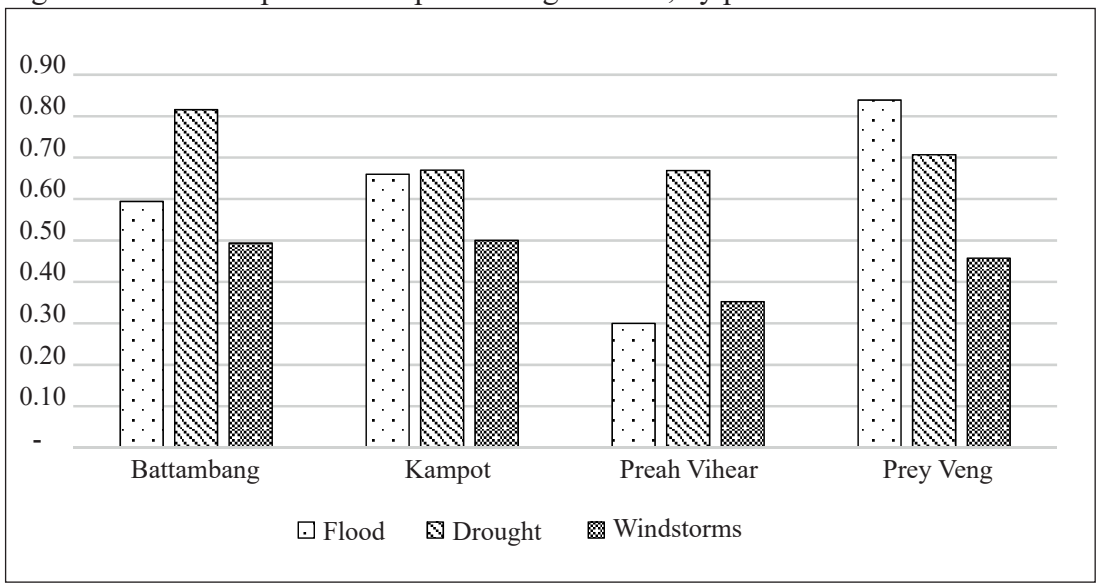
In Kampot province, residents in Kampong Kraeng and Stung Keo communes are affected by flooding every year. Floods cause much upheaval to people's daily lives, damage fruit, rice and other crops, affect human and animal health and may lead to loss of life, and damage houses and critical infrastructure. Local people relayed their experiences of the 2015, 2016 and 2017 floods in Kampong Kraeng, where floodwaters rose to 3 metres, destroyed rice, banana, pomelo, papaya and pineapple crops, and lasted for up to a week.

In Preah Vihear province, located in the plateau and mountain region, the risk of drought is high but the risk of flooding and storms is relatively low. The main crops destroyed by drought are rice, cassava, mung bean, maize and vegetables.

Windstorms, floods and droughts are the most frequently occurring climate hazards in Roung Damrei and Rakchey communes, Prey Veng province. Located on the Mekong floodplain, both communes are affected by river floods and flash floods caused by heavy rains during the wet season. They have also experienced extreme droughts in the past decade. The rapid change in seasonal timing, including sudden temperature increases, has negative impacts on local livelihoods, human and animal health, and crops.

> …previously, I considered this time of the year to be the rainy season, but now I wouldn't be able to tell the difference between the rainy and the dry season. When it rains, heat is released from the soil, affecting both humans and animals, and it brings not only heat and disease but also pests to my plants… I haven't harvested anything yet in this changing weather… I don't know how my rice crop will fare this year as I've only just started our rice farming…
>
> Interview with a local person in Roung Damrei commune, Prey Veng province, March 2019

Figure 12: Index of potential impacts on agriculture, by province



Source: Author's calculation
Note: Scale range: 0.01 to 0.39 = low; 0.40 to 0.59 = medium; 0.6 to 1.0 = high.

4.3.2 Climate hazards and water resources

The impact of floods on water resources is high in Battambang, medium in Prey Veng and low in Kampot and Preah Vihear, as shown in Figure 13. The impact of drought on water resources is high in Battambang and Preah Vihear and medium in Kampot and Prey Veng. Storm severity is low for all provinces.

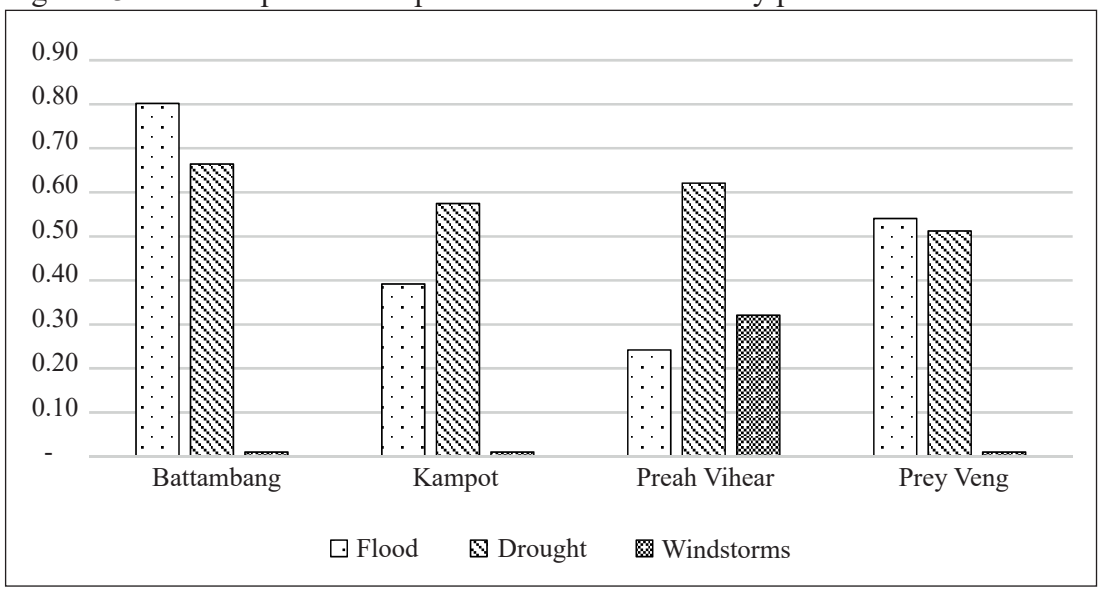
Water resources in Battambang province are severely affected by floods during the rainy season. In Preak Loung and Ta Pon communes, floods destroyed irrigation canals and structures and resulted in the loss of all reservoir water during the flood recession period. Moreover, floodwater inundated village wells and ponds, contaminating the main sources of water for drinking and household use. Although there is less rainfall in the wet season, Ta Pon commune has experienced prolonged flooding lasting one to two months. The severe floods in 2000, 2001 and 2012 destroyed village roads and crops and lack of clean water and latrines led to health and sanitation problems.

> …the weather in this commune is constantly fluctuating, with either too much or too little rain. Heavy or increased rainfall means the village will be flooded. However, when the water level starts to decrease, it will become extremely dry. This makes our lives difficult as we sometimes don't have enough water for our daily needs let alone farming…
>
> Interview with Ta Pon commune councillor, Battambang province, March 2019

Water resources in Preah Vihear communities are highly affected by drought. For instance, at the time of the study, the rains were one to two months late, there was a shortage of water for daily use and little water in the wells. The water in Preah Khlaing and Romdoh communes was dirty and had turned black. In Raksa and Prameh communes, farmers had no water to transplant their paddy, the canal and ponds (both natural and man-made) had dried out, and there was not enough water for domestic use.

> …when I was young, say between 10 and 20 years old, it was different. Back then, we would already have had some rain in April or May and could start growing rice. However, this year, no rain. If it rains just a little, I can't do anything and must wait. And I don't know when I'll have enough water…
>
> Interview with a local person, Preah Khlaing commune, Preah Vihear province, March 2019

Figure 13: Index of potential impacts on water resources by province



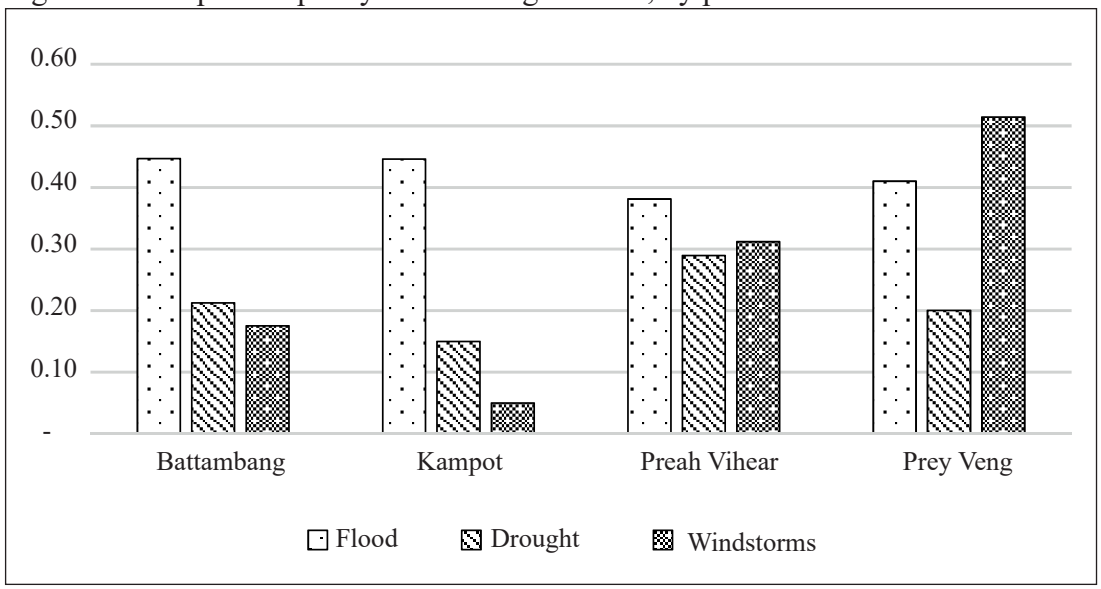
Source: Author's calculation
Note: 0.01 to 0.39 = low; 0.40 to 0.59 = medium and 0.6 to 1.0 = high.

4.4 Adaptive capacity

4.4.1 Adaptive capacity for the agriculture sector

Overall, as Figure 14 illustrates, local people in all four provinces have a medium adaptive capacity to cope with the risk of flooding to their farming and low adaptive capacity to drought and windstorms. The exceptions are in Prey Veng where locals have more experience and adaptive capacity to windstorms is medium, in Preah Vihear where the adaptive capacity to floods is low, and in Kampot where the adaptive capacity to windstorms is very low.

Figure 14: Adaptive capacity index for agriculture, by province

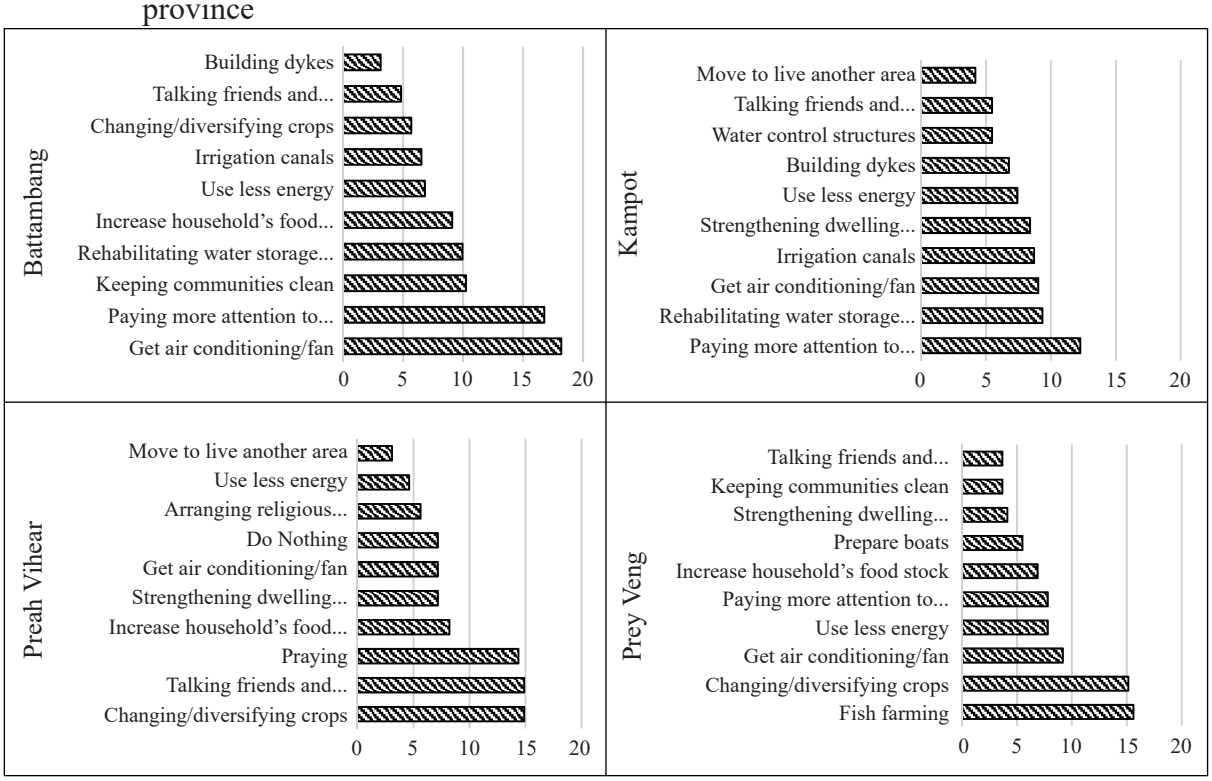


Source: Author's calculation
Note: 0.01 to 0.39 = low; 0.40 to 0.59 = medium; 0.6 to 1.0 = high.

To cope with the current stresses, the survey respondents reported using autonomous or ad hoc adaptive measures such as using an electric fan and spraying water on the roof to cope with hot weather, paying more attention to weather forecasts even though the accuracy is questionable, and diversifying and changing cropping systems albeit randomly.

Survey respondents were asked to select the three most preferred solutions for coping with climate change. In Battambang, getting air conditioning or an electric fan was the most popular solution accounting for 18.2 percent of responses, followed by paying more attention to weather forecasts (16.8 percent), keeping the community clean (10.2 percent), rehabilitating water storage structures (9.9 percent), and stocking up on food (9.1 percent). In Kampot, respondents prioritised paying more attention to weather forecasts (12.3 percent) and rehabilitating water storage structures (9.4 percent) above getting air conditioning or an electric fan (9.0 percent), followed by digging irrigation canals (8.7 percent), building stronger houses (8.4 percent) and reducing energy use (7.4 percent). In Preah Vihear province, respondents favoured changing/diversifying crops (14.9 percent), talking to friends and neighbours (14.9 percent) and praying to God/Buddha (14.4 percent). In Prey Veng, engaging in fish farming accounted for 15.6 percent of responses and changing/diversifying crops for 15.1 percent (Figure 15).

Figure 15: Respondents' top three solutions for coping with climate hazards (percent), by province

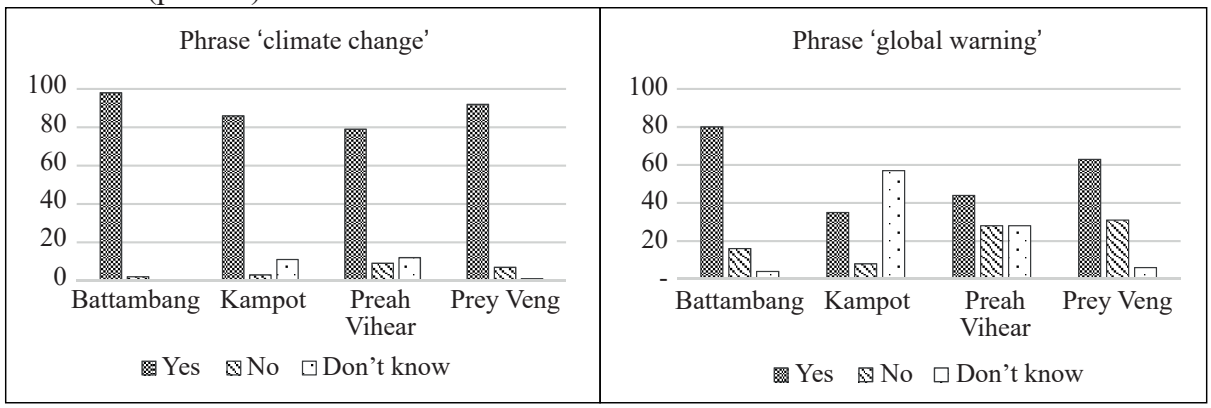


Source: Survey, May 2019

4.4.2 Awareness of climate change/global warming

The survey results shown in Figure 16 indicate that the majority of respondents in all four provinces were familiar with the term "climate change" but far less familiar with the term "global warming". Overall, almost 20.0 percent of respondents had not heard of global warming and 23.8 percent said: "don't know". In Kampot, 35.0 percent of respondents had heard of global warming, 8.0 percent had not heard the term and 57.0 percent said "don't know".

Figure 16: Respondents who have heard the phrases 'climate change' and 'global warming' (percent)



Source: Survey, May 2019
Note: For climate change, Pearson chi-square test is statistically significant at 1 percent, χ^2= (28.81); for global warming, Pearson chi-square test is statistically significant at 1 percent, χ^2= (115.30).

> …for ordinary people and the local authorities in Cambodia, the climate change problem seems like a new concept … sometimes even the word 'adaptation' was unknown among the local people although they could easily understand when talking about natural disasters….
>
> Interview with a representative of NCDD, March 2019

4.4.3 Adaptive capacity for the water sector

Local adaptive capacity in the four provinces to the impacts of climate change on water resources is low to medium (Figure 17). Local adaptive capacity to floods and droughts is medium but adaptive capacity to windstorms is very low except in Preah Vihear.

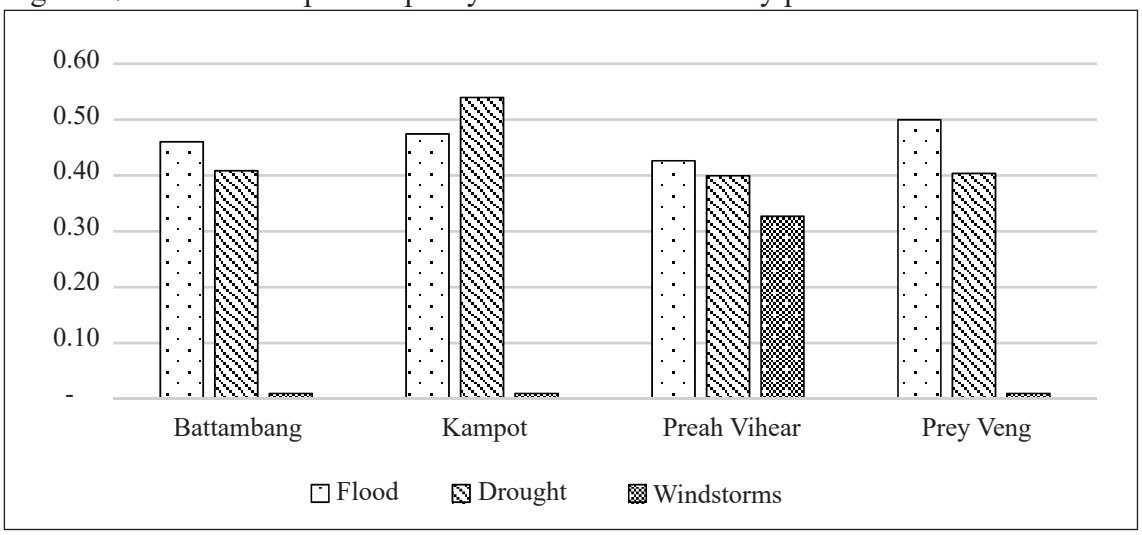
Buying clean water or boiling water for drinking, collecting and storing rainwater for domestic use during floods, pumping water from the stream, using well water or groundwater, and digging more wells during drought are the common practices of local communities in Battambang.

Local communities in Kampot face major problems related to water, especially during the dry season, namely water scarcity and brackish (salty taste) water that is unpalatable for drinking and unsuitable for farming. About 60 percent of dug wells in villages have water and some villagers share water with their neighbours but some have to buy water from villagers nearby.

In Preah Vihear province, villagers in Raksa and Prameh communes reported pumping water from ponds and canals or asking their neighbours for water for household use during the dry season. Some had to use murky well water, letting it sit until it cleared, and others bought expensive bottled water. They received some support from the commune authority and an NGO provided 10 kg of rice seed to drought-affected families.

> It's quite difficult for us to do rice farming because there is no rain or nearby water source. We don't even have enough water for household use as we only have a little in our well. We're now waiting for the rains to come so that we can start cultivating short duration rice.
>
> FGD in Prameh commune, Preah Vihear, March 2019

Figure 17: Index of adaptive capacity for water resources by province



Source: Author's calculation
Note: 0.01 to 0.39 = low; 0.40 to 0.59 = medium; 0.6 to 1.0 = high.

4.5 Vulnerability assessment of agriculture and water resources

The results of the vulnerability assessment of agriculture and water resources are summarised in Table 3.

The vulnerability of agriculture to drought in all four provinces is high. The sector's vulnerability to floods and windstorms in Battambang, Kampot and Prey Veng is medium and in Preah Vihear it is low.

Although the potential impacts of drought on water resources in Battambang and Preah Vihear are high, water resources are only moderately affected due to the moderate adaptive capacity of the sector. The level of the effect by floods is medium for communities in Battambang and low for all communities in the other three provinces.

The vulnerability of agriculture to windstorms is medium in Battambang, Kampot and Prey Veng but low in Preah Vihear. The level of community adaptive capacity to windstorms is low, except in Prey Veng where it is medium. Windstorms have only a slight effect on water resources in all provinces. However, community adaptive capacity to cope with windstorms is low in all provinces.

Table 3: Vulnerability assessment of agriculture and water resources

Sector	**Battambang**			**Prah Vihear**			**Kampot**			**Prey Veng**		
hazards	Floods	Drought	Storms	Floods	Drought	Storms	Floods	Drought	Storms	Floods	Drought	Storms
Agriculture												
Potential impacts	M	H	M	L	H	L	H	H	M	H	H	M
Adaptation	M	L	L	L	L	L	M	L	L	M	L	M
Vulnerability index	**M**	**H**	**M**	**L**	**H**	**L**	**M**	**H**	**M**	**M**	**H**	**M**
Water resources												
Potential impacts	H	H	L	L	H	L	L	M	L	M	M	L
Adaptation	M	M	L	M	M	L	M	M	L	M	M	L
Vulnerability index	**M**	**M**	**L**	**L**	**M**	**L**	**L**	**M**	**L**	**M**	**M**	**L**

L = Low; M = Medium; H = High

Source: Author's calculation

5. Discussion

The household survey data provided primary information on vulnerability, knowledge and the demographic effects of extreme weather and climatic events in the studied communes, where climate hazards (flooding, droughts and windstorms) pose risks to agricultural production and freshwater supplies. The study assessed the drought impacts experienced by respondents in the 2018/19 drought, which had severe impacts on agriculture in all four provinces. Local adaptive capacity in the study areas is markedly low; thus the agricultural sector is highly vulnerable to drought.

The impacts of climate change on agriculture and water resources are severe because the sectors are inherently sensitive to climate conditions and are among those most vulnerable to drought- and flood-related hazards. Underpinning this is the poor condition and vulnerability of Cambodia's landscape. Climate hazards can therefore be expected to impact agriculture, reducing resource productivity and causing loss and damage equivalent to 17 percent of national GDP by 2050 (MEF and GSDD 2018). In this sense, temperature increases are associated with decreases in labour productivity especially in the agricultural sector, and natural shocks hamper rice production in Cambodia's traditional production system, which is characterised by limited technology and poor input application (Ros, Chhim and Nang 2011).

Unevenly distributed and erratic rainfall patterns can delay cropping practices, as happened in Preah Vihear province where tillage and sowing were impeded by prolonged drought from November 2018 to May 2019. The rainy season usually starts in April or May but there was very little rain and the weather was unusually hot, making sowing and planting rice almost impossible. What rain there was fell in a few areas only, but not in the villages. Although local people could rely on wells for drinking water and water for domestic use, there was no water for agriculture.

Local people in Battambang province commonly face drought, flood and high temperatures, which can badly affect human health and wellbeing and animal welfare. As a consequence, people may need to spend more money on medical care. These climate hazards make farming harder, especially rice production, and can ruin farmers. Without rain, crops perish and farmers will not be able to continue farming. More extreme variations in weather mean either too much or too little rain.

In Kampot province, high temperatures and flash floods are the challenges facing the study communes. These have huge impacts on local farmers in terms of crop damage and low yields. It is difficult to live with increasingly unpredictable weather as farmers must ride out a storm one day and then brace themselves for flooding the next. Flash flooding has caused severe damage in some villages, ruining bridges and durian farms, eroding roads and contaminating drinking water sources.

In Preah Vihear, local communities were facing extreme drought. Their rice plants had been scorched by continued exposure to high temperatures and there was not enough water available to ensure healthy crops because the water source was far away. Recurrent droughts had also damaged cassava plants, delayed farming practices and hindered the growth of short-duration (3-month) crops in the study communes. Most farmers can usually sow and start transplanting rice in April, but at the time of the study (in May 2019) they had not been able to sow any rice. The drought had hampered other crops as well. Even mung beans and grass, which can normally cope with dry conditions, had withered. There was not much left to harvest, but local people had already spent a substantial amount on hiring workers to plough the land twice or

more. Moreover, higher temperatures can reduce rice yields, resulting in less profit for farmers. Extremely hot weather can also harm pig and poultry production. Pigs especially are prone to heat stress and heatstroke.

In Prey Veng province, local people were very concerned about the changing weather. The rains were supposed to have arrived by the time of the study, but they did not have enough water to plant rice. It normally pours with rain in the rainy season but in 2019 only a few areas had enough rain to grow rice. Farmers live in fear of a long dry spell of weather in the wet season. Drought means their lives will get tougher. As long as they can grow crops, they will be able to generate some income for their families and survive. However, rainfall patterns in the study communes are becoming more unpredictable. A dark sky is no longer a guarantee that it will rain, not these days. Respondents compared their current situation of still waiting for the rice to germinate with that a year ago when short-duration rice had already started growing. They used to be able to grow two rice crops a year, but now they can grow only one because they do not have access to enough water. If they were unable to grow crops regularly, their living standards would be severely affected as they would not have enough money to support the family. In November 2018, there was even a heavy rainstorm, which destroyed house roofs and several trees.

Mendoza et al. (2014) found that low adaptive capacity is the key risk underlying vulnerability to climate change at both household and commune level in Cambodia. Their assessment ranked adaptive capacity in Cambodia's four agro-ecological zones as low to medium. Not all local people are fully aware of the causes and effects of climate change. Moreover, local people build resilience in their own way and act on their own initiative to adapt to change rather than acquire new knowledge and information from outside (Nong, Chhaing and Sorn 2018). For instance, because of the lack of rain, people in Raksa commune of Preah Vihear have often resorted to doing paid work to sustain their livelihoods. Others usually collect and sell wood and grass flowers. Grass flowers fetch 40,000 riels/kg but they are not abundant, so they can only collect 0.5 kg to 1 kg a day.

The national curriculum barely mentions climate change. This poses another challenge for Cambodia when it comes to promoting the institutional capacity to mitigate the impact of climate change (Dany, Bowen and Miller 2015). Because the level of education in the study areas remains low, local people are not able to read and write well, and their ability to obtain proper climate-related information is correspondently slow. Furthermore, the main source of news villagers obtain is from television, radio, neighbours and family members. However, weather and climatic information are concentrated at the national level and very little flows to locals through local authorities such as commune chiefs and village heads. Although the majority of respondents had heard of the term climate change, few of them have discussed climate change issues/impacts or paid more attention to the weather forecast.

The majority of rural people take autonomous action to adapt rather than select planned adaptation options. Common practices include living their lives and running their livelihoods in the usual way, growing the same crops they normally grow or getting an electric fan or air-conditioner to keep cool in hot weather (Nong, Chhaing and Sorn 2018). Yet, vulnerability mapping in Ratanakiri and Stung Streng provinces indicates that climate stresses are disrupting traditional agricultural production, increasing the need for livelihood diversification and reducing water resources and food availability (IOM 2009, 2010). For example, according to our FGD participants in Battambang province, using an electric fan and splashing water over the roof were considered practical options for coping with hot weather. Besides, their family

members usually migrate to work elsewhere. Those with teenage children tended to migrate to Thailand, while those with small children usually migrated to towns on the Cambodian-Thai border such as Somlot, Phnom Prek, Kom Reang and Sampovloun, where they could get agricultural jobs.

Despite lack of financial support, resources and local knowledge, local people, with the support of local NGOs and development partners, had participated in village or commune projects such as pond restoration and infrastructure (road and irrigation) development. In addition, climate change awareness campaigns had been carried out in the study communes in Preah Vihear. There is still a big gap between awareness and action, however. Some villagers had attended workshops on how to build ponds and canals but had not dug a canal or a pond themselves or seen anyone else do so, even though existing ponds do not hold sufficient water for irrigation.

Rural people mostly relied on local knowledge and obtained some "outside" knowledge and information about climate change via social media, and a few had attended informal training organised by local NGOs (Nong, Chhaing and Sorn 2018; Nang et al. 2014). As a consequence, local people in Preah Vihear and Battambang provinces have learned a little about climate change. One solution they have adopted is to take refuge in the shade in very hot weather. They have been taught how to build irrigation structures such as community ponds to store water. However, they cannot apply the techniques they have learned because their landholdings are small (1 ha on average) and used for farming only. Similarly, they ought to choose rice varieties that can withstand climate changes by replacing late maturing rice varieties with early maturing ones. However, they are reluctant to do so because they do not know how to select and find the right seed varieties. The extension services they receive are not comprehensive or always practical. For example, although some communities have been shown how to store water by digging irrigation ponds and channels, no one has done that because they do not want to sacrifice any of their small piece of land for the benefits of irrigation. Others have heard about the need for more irrigation channels but have done nothing about it.

There were small grants available for village-level climate resilience initiatives facilitated by a local NGO. At first, there was interest in investing the money in planting vegetation. But then it was decided to invest the money in a savings group, which was deemed a more sustainable option. Group members can borrow money to invest in their livelihoods or pay for emergency household expenses such as food or medicine and priority duties such as loan repayments and education fees.

6. Conclusion and recommendations

The study set out to identify how climate change affects agriculture and water resources across Cambodia's four agro-ecological zones and how local people in selected communities respond to and cope with climatic hazards, specifically floods, droughts and windstorms. To that end, the study has analysed the effects of climate change on those key sectors, highlighted affordable and technically appropriate responses to climate change and suggested best adaptation practices for different local settings in Cambodia.

Overall, agriculture has a high level of vulnerability and water resources a medium level of vulnerability to drought. Both sectors in the Tonle Sap, Mekong floodplain and coastal regions have medium levels and in the plateau/mountain region low levels of vulnerability to floods. Agriculture in the Tonle Sap, coastal and Mekong floodplain communities is moderately vulnerable to climate change impacts and in the plateau/mountain zone slightly vulnerable to windstorms, whereas water resources in all regions have the relatively low vulnerability to

this hazard. The adaptive capacity levels of agriculture and water resources across the study communities are low to medium.

Agriculture is extremely vulnerable to drought in all regions. This is because the sector is inherently very sensitive to water scarcity, which more often than not occurs where the capacity to deal with drought is low. The sector's vulnerability to floods and windstorms is medium in the Tonle Sap, Mekong floodplain and coastal zones but low in the plateau and mountain area. Adaptive capacity to cope with floods in this sector is low in the plateau and mountain area but medium in the other three zones. Although the adaptive capacity to cope with floods in the coastal zone is medium, the area suffers extreme flooding, especially flash floods, resulting in vulnerabilities of medium severity. Agriculture in the plateau and mountain area is less vulnerable to floods and storms because of low exposure to those hazards. However, windstorms pose a moderate risk in the other three regions.

Water resources are moderately vulnerable to drought but only at slight risk to windstorms in all selected communities. In the Tonle Sap, Mekong floodplain and coastal zones, water resources are moderately vulnerable and, in the plateau/mountain area slightly vulnerable to floods. Adaptive capacities to flood and drought for water resources are ranked medium in all regions. Although windstorms pose a low risk to water resources in all zones, adaptive capacities to this hazard are low.

High vulnerability is the outcome of high impacts and lack of resilience due to low adaptive capacity. Low adaptive capacity means local communities have a low understanding of the causes and effects of climate change even though they recognise climate stresses exist. Local people deal with climate risks based on traditional resilience afforded by natural resources, which is not necessarily robust enough to keep abreast of rapid change. Rural people with poor reading and writing skills do not have enough access to information-sharing channels. The range of planned adaptation options available to local people is not user-friendly and the linkages to internal and external sources of finance, resources and knowledge sharing are insufficient. The new knowledge and guidance for local resilience imparted through informal training activities seem beyond the capacity of local people to apply in practice.

The following recommendations for strengthening the resilience of local communities to the impacts of climate change on agriculture and water resources merit consideration.

1. Improving access to technical and financial resources for vulnerable groups will enhance their capacity to adapt and cope with extreme events. Climate-resilient infrastructure development and community capacity building is required to ensure water availability and control floodwater as well as to resolve water conflicts. Support for local institutions that promote adaptation, whether in the form of information sharing or mutual support such as rice banks and savings groups, would help vulnerable groups cope with climate extremes. Hastening decentralisation and deconcentration reform would elevate local voices and enable local people to take initiatives to secure their livelihoods.

2. Climate change adaptation in agriculture should benefit all local communities fairly, without discrimination, and be based on proper vulnerability and adaptation assessment to avoid sub-optimal or maladaptation to climate change. Responses and coping strategies should be applicable and sustainable and build access to social and economic facilities including markets and other critical assets. Government agencies and NGOs working in agriculture and irrigation/water resources need to work together to expand extension coverage, water supply and irrigation services and improve access-related equality. Local communities

can also contribute to climate change adaptation through sharing information, labour and innovation. Investments in local infrastructure will be needed so that communities can have better access to sufficient water, transport goods to markets readily, and have access to good quality inputs.

3. Building climate resilience through local community action requires a highly integrated approach to engaging stakeholders at different levels of government, from central and subnational administration to local authorities at the commune, village and community level. At every level, there must be a clear understanding of disaster risk management and the situations local people face and the capacity building needed to do what is required to monitor and reduce residual risk, increase adaptive capacity and devise a comprehensive disaster risk management framework that integrates climate change adaptation for the country.

4. The government has invested a lot of effort into preparing a strategic plan for climate change mitigation and adaptation. But the successful implementation of climate change responses depends on its ability to achieve policy integration through 1) coordination among ministries and line departments, particularly the Ministry of Environment, Ministry of Water Resources and Meteorology, Ministry of Agriculture, Forestry and Fisheries, Ministry of Rural Development and the National Committee for Sub-National Democratic Development Secretariat, and other agencies responsible for climate change adaptation planning and strategy, 2) coherent information and data collection and sharing and 3) harmonisation of understanding and actions. This would bring all ministries and departments up to speed and create a pool of expertise (experts and trainers) as a national technical resource to support subnational authorities in their implementation of local climate change projects and promotion of adaptive agricultural practices through building local capacities to implement vulnerability reduction assessments, plan for adaptation to climate change, and access and mobilise climate-related funding and information.

5. People who are marginalised – women, the elderly, the poor, people with disabilities, children, ethnic minorities – are especially vulnerable to the impacts of climate change. Serious and more systemic efforts should be made to ensure the participation of those vulnerable groups by raising awareness of the situations they face and creating relationships between local authorities (including the village, commune, district and provincial administration) and central government as the necessary basis to ensure inclusive mitigation and adaptation actions.

References

ADB, and MOWRAM. 2018. "Draft National Irrigation and Water Resources Management Investment Program 2019-2033." Phnom Penh, Cambodia: Asian Development Bank.

Australian Greenhouse Office, G. 2005. "Climate Change Risk and Vulnerability." *The Australian Greenhouse Office, Department of the Environment and Heritage.*

Bansok, R. O. S., Chhim Chhun, and Nang Phirun. 2011. *Agricultural Development and Climate Change: The Case of Cambodia.* CDRI.

Baran, Eric, S. Sophort, Yumiko Kura, Blake Ratner, WorldFish Center, and Cambodia Committee. 2007. *Infrastructure and Tonle Sap Fisheries : How to Balance Infrastructure Development and Fisheries Livelihoods? The Challenge Facing Decision-Makers in Cambodia.*

Barnett, Jon. 2008. "The Effect of Aid on Capacity to Adapt to Climate Change: Insights from Niue." *Political Science - POLIT SCI 60* (June): 31–45. doi:10.1177/003231870806000104.

CDRI, and UNDEF. 2019. "Empowering Women for Climate Resilience in Cambodia." Cambodia Development Research Institute and United Nations Democracy Fund. https://www.un.org/democracyfund/news/empowering-women-climate-resilience-cambodia.

CFE-DMHA. 2017. "Disaster Management Reference Handbook Cambodia." Center for Excellence in Disaster Management & Humanitarian Assistance. https://reliefweb.int/report/cambodia/disaster-management-reference-handbook-cambodia-2017.

Comer, Patrick J., Jon C. Hak, Marion S. Reid, Stephanie L. Auer, Keith A. Schulz, Healy H. Hamilton, Regan L. Smyth, and Matthew M. Kling. 2019. "Habitat Climate Change Vulnerability Index Applied to Major Vegetation Types of the Western Interior United States." *Land 8* (7). Multidisciplinary Digital Publishing Institute: 108.

Dany, Va, Kathryn J. Bowen, and Fiona Miller. 2015. "Assessing the Institutional Capacity to Adapt to Climate Change: A Case Study in the Cambodian Health and Water Sectors." *Climate Policy* 15 (3). Taylor & Francis: 388–409. doi:10.1080/14693062.2014.937385.

F.R.S, Karl Pearson. 1900. "X. On the Criterion That a given System of Deviations from the Probable in the Case of a Correlated System of Variables Is Such That It Can Be Reasonably Supposed to Have Arisen from Random Sampling." *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* 50 (302). Taylor & Francis: 157–75. doi:10.1080/14786440009463897.

Garcia, Jon, Chey Tech, and Dibya Gurung. 2019. "Mid Term Review of Cambodia Climate Change Strategic Plan 2014 - 2023." Phnom Penh, Cambodia: Le Groupe-conseil baastel ltée.

GSSD. 2015. "Cambodia's Second National Communication under the United Nations Framework Convention on Climate Change." General Secretariat of National Council for Sustainable Development/Ministry of Environment, Kingdom of Cambodia.

———. 2017. "National Adaptation Plan Process in Cambodia." General Secretariat of National Council for Sustainable Development/Ministry of Environment, Kingdom of Cambodia.

IOM. 2009. "Mapping Vulnerability to Natural Hazards in Ratanakiri." International Organization for Migration.

———. 2010. "Analyzing the Impact of Remittances from Cambodian Migrant Workers in Thailand on Local Communities in Cambodia." International Organization for Migration. https://us.data.toolbar.yahoo.com/bh/v3/epa/?.sc=&.tc=&.intl=us&.cv=3.2.11.20150226051211&url=https%3A//www.google.co.jp/%3Fgfe_rd%3Dcr%26ei%3D_z44U8O-M6yT8QeW7ID4AQ&error=2152398878.

IPPC. 2001. “Climate Change 2001: Impacts, Adaptation and Vulnerability.” Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar3/wg2/.

Kim, Sour, Phalla Chem, Sovannarith So, Somatra Kim, and Sokhem Pech. 2014. “Methods and Tools Applied for Climate Change Vulnerability and Adaptation Assessment in Cambodia’s Tonle Sap Basin.” Phnom Penh, Cambodia: Cambodia Development Resource Institute (CDRI).

Leng, Heng An. 2014. “Country Report of Cambodia’s Disaster Management.” National Committee for Disaster Management.

MAFF. 2020. “Draft Agricultural Sector Master Plan 2030 – Transforming Cambodian Agriculture into a Modern, Competitive, Inclusive, Climate Resilient and Sustainable Sector.” Phnom Penh, Cambodia: Ministry of Agriculture, Forestry and Fisheries.

MEF, and GSDD. 2018. “Addressing Climate Change Impacts on Economic Growth in Cambodia - Google Search.”

Mendoza, Maria Emilinda T, and Kim B Arias. 2014. “Assessing Vulnerability to Climate Change Impacts in Cambodia, the Philippines and Vietnam: An Analysis at the Commune and Household Level” 17 (2): 14.

MOE. 2016. “A Second Study on Understanding of Public Perception of Climate Change in Cambodia: Knowledge, Attitudes and Practices.” Phnom Penh: Ministry of Environment.

MOE, and Hatfield Consultants. 2013. “Synthesis Report on Vulnerability and Adaptation Assessment for Key Sectors Including Strategic and Operational Recommendations.” Ministry of Environment.

MOWA. 2013. “Neary Ratanak IV Five Year Strategic Plan for Gender Equality and Women’s Empowerment 2014-2018.” Phnom Penh, Cambodia: Ministry of Women’s Affairs.

———. 2020. “Eary Ratanak IV Five Year Strategic Plan for Gender Equality and Women’s Empowerment 2019-2023.” Phnom Penh, Cambodia: Ministry of Women’s Affairs.

MOWRAM, TSA, SNEC, HC, and CEPA. 2013. “Report on Conflict Analysis and Power Relations in Pursat Catchment: Fostering Evidence-Based IWRM in Stung Pursat Catchment (Tonle Sap Great Lake).” Ministry of Water Resources and Meteorology, Tonle Sap Authority, Supreme National Economic Council, Hatfield Consultants, Culture and Environment Preservation Association,.

MRC. 2010. “Technical Note 10 Assessment of Basin-Wide Development Scenarios: Impacts on the Tonle Sap Ecosystem.” Mekong River Commission.

———. 2020. “Situation Report on Hydrological Conditions in the Lower Mekong River Basin in January-July 2020.” Vientiane, Lao PDR: Mekong River Commission Secretariat.

Nang, Phirun. 2013. *Climate Change Adaptation and Livelihoods in Inclusive Growth: A Review of Climate Change Impacts and Adaptive Capacity in Cambodia.* CDRI Working Paper Series, no. 82. Phnom Penh: Cambodia Development Research Institute.

Nang, Phirun, Sreymom Sam, Pichdara Lonn, and Chhuong Ouch. 2014. *Adaptation Capacity of Rural People in the Main Agro-Ecological Zones in Cambodia. Cambodia,* A CDRI Publication. Available at: https://www.cdri.org.kh.

NCDM. 2020. “Cambodia Disaster Damage & Loss Information System (CamDi).” *Sendi Framework for Disaster Risk Reduction.* http://camdi.ncdm.gov.kh/DesInventar/profiletab.jsp?countrycode=kh2&continue=y.

NCSD. 2013. “Cambodia Climate Change Strategic Plan 2014-2023.” National Climate Change Committee.

Nong, Monin, Marong Chhaing, and Pisey Sorn. 2018. "Women's Adaptive Capacity in Climate in Cambodia's Four Agroecological Zones." Cambodia Development Review. Phnom Penh, Cambodia: Cambodia Development Resource Institute (CDRI).

OECD. 1999. "Classifying Educational Programmes - Manual for ISCED-97 Implementation in OECD Countires."

Ros, Bansok, Chhun Chhim, and Phirun Nang. 2011. *Agricultural Development and Climate Change: The Case of Cambodia.* CDRI.

Royal Government of Cambodia. 2019. "National Strategic Development Plan 2019-2023: For Growht, Employment, Equity and Efficiency to Reach the Status of an Upper-Middle Income Country by 2030." Phnom Penh, Cambodia: Royal Government of Cambodia.

Sam, Sreymom. 2015. "Disaster Management Planning in Rural Cambodia." Issue 3 Volume 19. Cambodia Development Review. Phnom Penh, Cambodia: Cambodia Development Resource Institute (CDRI).

Sam, Sreymom, Sour Kim, Monin Nong, and Molideth Sarom. 2015. "Vulnerability Assessment in the Three Catchments." In *Climate Change and Water Governance in Cambodia: Challenge Adn Perspectives for Water Security and Climage Change in Selected Catchments, Cambodia,* 56–88. Phnom Penh, Cambodia: Cambodia Development Research Institute.

Sam, Sreymom, and Sokhem Pech, eds. 2015. C*limate Change and Water Governance in Cambodia: Challenge and Perspectives for Water Security and Climate Change in Selected Catchments, Cambodia.* Phnom Penh, Cambodia: Cambodia Development Resource Institute.

The World Bank. 2020. "Cambodia in the Time of COVID-19: Economic Update, May 2020." *World Bank.* Accessed December 9. https://www.worldbank.org/en/country/cambodia/publication/cambodia-in-the-time-of-covid-19-coronavirus-economic-update-may-2020.

UNESCAP. 2020. "Ready for the Dry Years: Building Resilience to Drought in South-East Asia." Bangkok, Thailand: UNESCAP.

United Nations. 2008. "Commission on the Status of Women: Report of the 52nd Session." New York: United Nations. https://www.un.org/womenwatch/daw/csw/52sess.htm.

Yusuf, Arief Anshory, and Herminia Francisco. 2009. "Climate Change Vulnerability Mapping for Southeast Asia." EEPSEA, IDRC Regional Office for Southeast and East Asia, Singapore, SG.

Annex 1: Calculation of index scores – potential impact, adaptive capacity and vulnerability

The research team introduced the purpose of the group discussion and guided participants to consider the situation of climate hazards that occurred in the past 10 years and how the community is vulnerable to climate change based on the key functions of (1) exposure, (2) sensitivity and (3) adaptative capacity. Exposure means how disasters such as flood, drought, windstorms and other hazards occurring in the past 10 years affect the community in terms of agriculture, crops, and water resources upon their observation and perception. Sensitivity denotes how agriculture, crops, and water resources in the village are impacted by flood, drought and windstorms. Then, participants discussed the adaptative capacity of the community to deal with the stresses. Community's adaptive capacity responding to climate change adaptation can be the responses in the short, medium and long term, and access to essential capitals. The capitals are the common resources including natural and physical infrastructures, social and financial assets, and effective governance.

Based on scores (exposure, sensitivity and adaptative capacity) provided by a participant to by sector (agriculture and water resource) impacted by flood, drought, windstorms, the vulnerability assessment is made upon calculated average score in each village attributed to the participant's perception of what level of the impacts. The participant gives score ranges from 1 to 5, which mean 1 is less harmful and 5 is strongly harmful while 0 denotes 'no effect' for exposure and sensitivity indicators. The same range is applied for adaptive capacity indicator; 1 is the less adaptive capacity and 5 is strong adaptive capacity while 0 is 'no adaptive capacity'.

Then scores given by the group of participants in a village is summarised in Table A1. For example, eight participants collectively provided a total score of 35 points over a total of 40 points and thus the result is 0.88 (35/40=0.88). All scores from groups are imputed into an excel spreadsheet to combine all components into the index by exposure, sensitivity and adaptive capacity.

Table A1: Example of the data entry form

Province	Commune	Village	Indicator	Sector	Flood	Drought	Windstorm	Averaged score
Preah Vihear	Brameh	Brameh	Exposure	Agriculture - rice	0.26	0.74	0.30	0.43
Preah Vihear	Brameh	Brameh	Exposure	Water	0.26	0.74	0.30	0.43
Preah Vihear	Brameh	Brameh	Sensitivity	Agriculture - rice	0.40	0.56	0.38	0.45
Preah Vihear	Brameh	Brameh	Sensitivity	Water	0.20	0.46	0.20	0.29
Preah Vihear	Brameh	Brameh	Adaptation	Agriculture - rice	0.38	0.32	0.20	0.30
Preah Vihear	Brameh	Brameh	Adaptation	Water	0.40	0.48	0.26	0.38
Preah Vihear	Preah Khlaing	Preah Khlaing	Exposure	Agriculture - rice	0.26	0.46	0.23	0.31
Preah Vihear	Preah Khlaing	Preah Khlaing	Exposure	Water	0.26	0.46	0.23	0.31
Preah Vihear	Preah Khlaing	Preah Khlaing	Sensitivity	Agriculture - rice	0.40	0.74	0.51	0.55
Preah Vihear	Preah Khlaing	Preah Khlaing	Sensitivity	Water	0.20	0.74	0.44	0.46
Preah Vihear	Preah Khlaing	Preah Khlaing	Adaptation	Agriculture - rice	0.30	0.26	0.38	0.31
Preah Vihear	Preah Khlaing	Preah Khlaing	Adaptation	Water	0.46	0.24	0.38	0.36

The vulnerability index is calculated upon the function of exposure, sensitivity, and adaptive capacity. And exposure and sensitive index is combined into [potential] impacts.

Table A2: Averaged scores of exposure, sensitivity and adaptive capacity by sector

Sector	Flood	Drought	Windstorm	Average
Agriculture				
Exposure	0.28	0.66	0.33	0.39
Sensitivity	0.32	0.68	0.38	0.46
Adaptation	0.38	0.29	0.31	0.33
Water				
Exposure	0.28	0.66	0.33	0.42
Sensitivity	0.20	0.58	0.32	0.37
Adaptation	0.43	0.40	0.33	0.38

Figure A1: Components of vulnerability

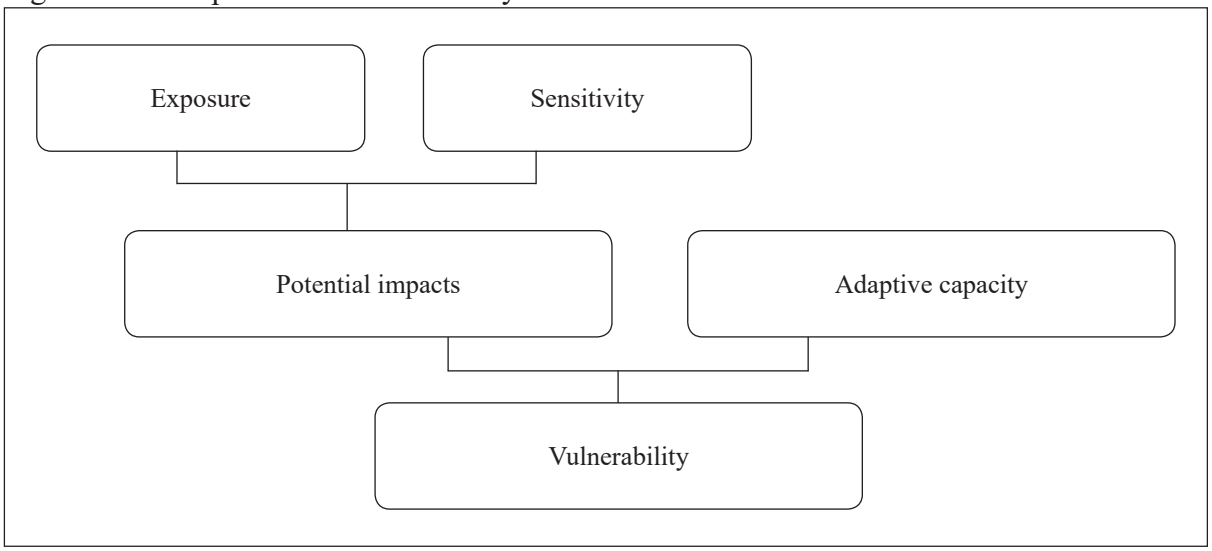


Table A3: Averaged scores of potenail impacts and adaptive capacity by sector

Agriculture	Flood	Drought	Windstorm	Average
Potential impacts	0.30	0.67	0.35	0.44
Adaptation	0.38	0.29	0.31	0.33
Vulnerability index	**0.04**	**0.75**	**0.02**	0.27
Water	Flood	Drought	Windstorm	Average
Potential impacts	0.24	0.62	0.32	0.39
Adaptation	0.43	0.40	0.33	0.38
Vulnerability index	**0.08**	**0.44**	**0.02**	0.18

Finally, the vulnerability index is derived from the components of averaged index scores of potential impacts minus averaged scores of adaptation. The indicator values are then normalised on a scale of 0.0 to 1.0, where 0.01 to 0.39 = low, 0.40 to 0.59 = medium, and 0.6 to 1.0 = high overall vulnerability.

Annex 2: List of study villages by province and list of FGDs and KIs

Agro-Ecological zone	Province	District	Commune	Village	FGD (# of female)	KIs
Tonle Sap floodplain	Batttambang	Ek Phnom	Preak Luong	Bak Amrak	9 (7)	2
				Sdey Kraom	9 (7)	
		Sangke	Ta Pon	Samdach	7 (5)	
				Tapon	8 (6)	
Coastal	Kampot	Teuk Chhou	Kampong Kraeng	Andong Chi Moeun	4 (3)	2
				Mak Brang	8 (6)	
			Stung Keo	Anlong Makbrang	9 (7)	
				Mlich Ku	6 (4)	
Mountain/ plateau	Preah Vihear	Tbaeng Mean Chey	Prameh	Prameh	8 (6)	2
			Preah Khlaing	Kraing Daung	8 (6)	
		Rovieng	Reaksa	Preal	7 (5)	
			Romdoh	Ovloek	10 (7)	
Mekong floodplain	Prey Veng	Ba Phnom	Rak Chey	Chheur Treng	10 (7)	2
				Schach Sor	10 (7)	
			Roung Damrei	Kdei Doung	10 (7)	
				Pong Pos	10 (7)	

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