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Climate vulnerability, agricultural dependency and climate change adaptation in rural Cambodia: a case study in Tramkak District, Takeo Province

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សង្ខិត្តន័យ

ប្រមាណ ៧៦% នៃប្រជាជនកម្ពុជារស់នៅទីជនបទ និងតំបន់ដាច់ស្រយាល ហើយចិញ្ចឹមជីវិតដោយផ្អែកលើស្រែចម្ការពឹងលើទឹកភ្លៀង។ ប៉ុន្មានឆ្នាំចុងក្រោយនេះ វិស័យកសិកម្មបានទទួលរងនូវផលប៉ះពាល់ជាអវិជ្ជមានពីការប្រែប្រួលអាកាសធាតុ។ ការស្រាវជ្រាវនេះវាយតម្លៃភាពងាយរងគ្រោះដោយការប្រែប្រួលអាកាសធាតុ ដែលកសិករបានជួបប្រទះ វាយតម្លៃការអនុវត្តការបន្សាំខ្លួន និងពិចារណាអំពីរបៀបដែលកសិករចូលរួមក្នុងការបន្សាំទៅនឹងការប្រែប្រួលអាកាសធាតុនៅខេត្តតាកែវ ប្រទេសកម្ពុជា។ របកគំហើញនៃការសិក្សាស្រាវជ្រាវបានបង្ហាញថា៖ (១) ភាពងាយរងគ្រោះពីការប្រែប្រួលអាកាសធាតុរបស់កសិករមានកម្រិតពីមធ្យមទៅខ្លាំង (ភាពរួស ឬវេទយិតភាព ០.៧៨ ភាពប្រឈម ០.៥៨ និងសម្ថតភាពបន្សាំ ០.៤២)។ ប្រជាកសិករបានទទួលរងនូវការប្រែប្រួលអាកាសធាតុកម្រិតខ្ពស់ រីឯការប្រឈមនឹងការប្រែប្រួលអាកាសធាតុមានកម្រិតមធ្យម។ កសិករភាគច្រើនយល់ឃើញថា ពួកគាត់បានរងគ្រោះដោយការប្រែប្រួលអាកាសធាតុ។ ឧទាហរណ៍ កសិករបានសង្កេតឃើញការប្រែប្រួលនៃកម្រិតទឹក និងការធ្លាក់ភ្លៀងមិនទៀងទាត់ ដែលនាំឲ្យប៉ះពាល់ដល់កម្រិតទឹក។ លើសពីនេះ សមត្ថភាពបន្សាំរបស់កសិករនៅមានកម្រិតទាប។ (២) ការអនុ

វត្តការសម្របខ្លួនទៅនឹងការប្រែប្រួលអាកាសធាតុរបស់កសិករមានត្រឹមតែវិធីសាស្ត្រធ្វើស្រែបីយ៉ាងប៉ុណ្ណោះគឺ ការព្រួសគ្រាប់ពូជស្រូវ ការស្ទូងស្រូវ និងការភ្ជួរដីឲ្យសើម។ លើសពីនេះ កសិករនៅតែប្រើវិធីដាំដុះតាមបែបប្រពៃណី និងការផ្លាស់ប្តូរពេលវេលានៃវដ្តដំណាំ ដោយសារតែការផ្លាស់ប្តូររបបទឹកភ្លៀង។ (៣) កត្តារួមផ្សំសំខាន់ៗ ចំនួនបួន ដែលលើកទឹកចិត្តកសិករឱ្យចូលរួមក្នុងសកម្មភាពបន្ស៊ាំនឹងការប្រែប្រួលអាកាសធាតុ គឺការកើនចំណេះដឹង ការទទួលបានជំនាញថ្មីៗ ការទទួលបានការអញ្ជើញចូលរួមសកម្មភាព និងការចូលជាសមាជិកសហគមន៍។ លើសពីនេះ កសិករទទួលបានឱកាសផ្លាស់ប្តូរចំណេះដឹងជាមួយសហគមន៍ដទៃ និងទទួលបានការគាំទ្រពីអង្គការក្រៅរដ្ឋាភិបាល និងរាជរដ្ឋាភិបាល។

Abstract

Around 76% of Cambodian people live in either rural or remote areas and are largely dependent on rain-fed agricultural production for subsistence livelihoods. In recent years, the agricultural sector has been negatively impacted by climate change. This study assesses climate vulnerability as experienced by rice farmers, assesses adaptation practices, and considers how farmers are involved in climate change adaptation in Takeo Province, Cambodia. It was found that: (1) climate vulnerability experienced by rice farmers in the study area ranged from medium to high (sensitivity 0.78, exposure 0.58, and adaptive capacity 0.42). Rice farmers have become highly sensitized and moderately exposed to climate change. The majority of the rice farmers perceived that they had become vulnerable to climate change. For instance, farmers had observed changes in water levels and irregular rainfall, affecting irrigation systems. Moreover, the adaptive capacity of rice farmers remained low. (2) Climate change adaptation practices of rice farmers were limited to three methods of rice cultivation, including broadcast sowing of rice seedlings, planting rice seedlings, and constructing wetlands. Additionally, the rice farmers still deployed traditional cultivation methods; while changing the timing of crop cycles due to changing rainfall patterns. (3) Four key contributors to encouraging rice farmers to participate in climate change adaptation activities include: improving knowledge; gaining new skills, receiving invitation letters to attend activities; and being a member of a community. In addition, rice farmers accessed opportunities to exchange knowledge with other communities and have received support from NGOs and the Royal Government of Cambodia.

Keywords: climate vulnerability, climate change adaptation, agriculture dependency, livelihoods

Introduction

Climate change has been acknowledged as a global issue of concern that requires joint national and international action. Cambodia is among the countries expected to be severely impacted by extreme weather, ranking as the 12th most vulnerable country globally between 1998 and 2018 (Eckstein et al., 2019), and the 19th most vulnerable between 1998 and 2017 (USAID, 2019). Climate change has become an increasingly concerning issue, especially concerning agricultural production (NCCC, 2013). At the same time, agriculture has contributed significantly to Cambodia's economic growth, job creation, poverty eradication, and food security for both rural and urban populations (Thomas et al., 2013). Cambodia has already experienced significant impacts from climate change, such as floods, droughts, typhoons and windstorms. Between 1996 and 2019, flooding caused 1,150 deaths, while lightning resulted in 1,031 deaths. Additionally, storms damaged 38,190 houses, while floods damaged 33,705 houses (NCDM, 2019).

Cambodia's high level of vulnerability to natural disasters is characterized by the frequency and intensity of extreme climatic events, and also increased climatic variability (Sour et al., 2014). Temperatures in Cambodia are expected to rise by between 0.5 C and 1.5 C by 2050 and by 3.1°C by 2090

(World Bank, 2021). Annual precipitation is expected to increase to around 1,400mm and 4,000mm in central low land and coastal zone regions, respectively (Heng & Pich, 2009). Increasing temperatures and precipitation are expected to reduce rainfall in the dry season, resulting in longer dry spells in the wet season, and an increase in the frequency of floods and droughts (Chem & Kim, 2013). For instance, a study on household vulnerability to climate change in *Kampong Spue* Province found that households experience stumpy exposure to climate impacts, moderate sensitivity, and low adaptive capacity. The study suggested that over half of the sampled population experienced average to very high vulnerability to climate change (Nyda et al., 2016).

In 2019, around 76% of the 16.5 million people living in Cambodia resided in rural areas and were largely dependent on agriculture activities for their livelihoods (World Bank, 2021). While the contribution of the agriculture sector to the Gross Domestic Product (GDP) reduced from 30.7% to 23.5% between 2014 and 2018 due to the growth of the manufacturing, construction, and services sectors, it is still significant (MoP, 2019). For instance, 53.4% of the national workforce is engaged in agricultural, forestry, and fishing activities (MoP, 2020). In 2016, rice cultivation alone occupied 3.11 million ha of land, with a total production of 9.95 million tons. Subsidiary crops such as vegetables, cassava, and maize occupied were cultivated on 93,200 ha of land producing 16 million tons; while other commodities such as soybean, peanuts, sesame, and sugar cane, were cultivated on 101,530 ha, producing 0.86 million tons (MAFF, 2017).

In contrast to this contribution, climate change has profoundly impacted Cambodia, especially the rice sector. For instance, between 1996 and 2019, drought had damaged more than one million hectares of rice production, whilst floods destroyed over two million hectares (NCDM, 2019). In 2012, drought impacted 11 out of 24 provinces, affecting 14,190 ha of rice paddies and destroying 3,151 ha of land (NCDM, 2014). Recently, flooding severely affected 10 provinces comprising 238 communes across 62 districts. Consequently, 93,319 households, were impacted with 11,579 being displaced. Approximately 51,824 ha of agricultural land was impacted (PCDM, 2019). Roughly 75% of Cambodian households owned less than 1 ha of agricultural land, with a further 17% owning between 1 and 3 ha (MoP, 2020). This exacerbates the level of climate risks experienced.

Increasingly frequent natural disasters and irregular results in damage to agricultural production, particularly rice cultivation disproportionally impact the vulnerable rural poor. This is particularly the case for rice farmers who have preserved traditional rain-fed methods that are dependent on climate-sensitive water resources. These farmers have limited livelihood diversity and poor access to assets to cope with disasters is remarkably poor (Bandeth et al., 2011). To respond effectively to extreme climatic events, it is important to understand their impact on vulnerable rural poor communities and their adaptive capacity. Enhancing adaptation practices required engaged participation from rural people, especially rice farmers, who have a high interest in responding to the serious impacts of change (UNDP, 2013).

Yet, the rural poor communities in Cambodia have limited adaptive capacity and until now, have lacked information and resources to support adaptation practices (UNDP, 2013). A low resilience to climate change impacts because of a shortage of financial resources (Phirun et al., 2014) and a lack of full participation from the community members (Sok et al., 2015). This exacerbates the situation for those in the country that are most vulnerable to these impacts (Phirun, 2013). Consequently, initiatives such as the Strategic Program for Climate Resilience led by the National Council for Sustainable Development have recommended increased local participation in the design and implementation of adaptation programs to better mobilize support for long-term community adaptation projects (MoE, 2013). With the context in mind, this research aims to 1) assess the vulnerability of rice farmers to climate change, 2) examine existing adaptation practices, and 3) identify key contributing factors that encourage farmers to become involved in climate change adaptation activities in Takeo Province, Cambodia.

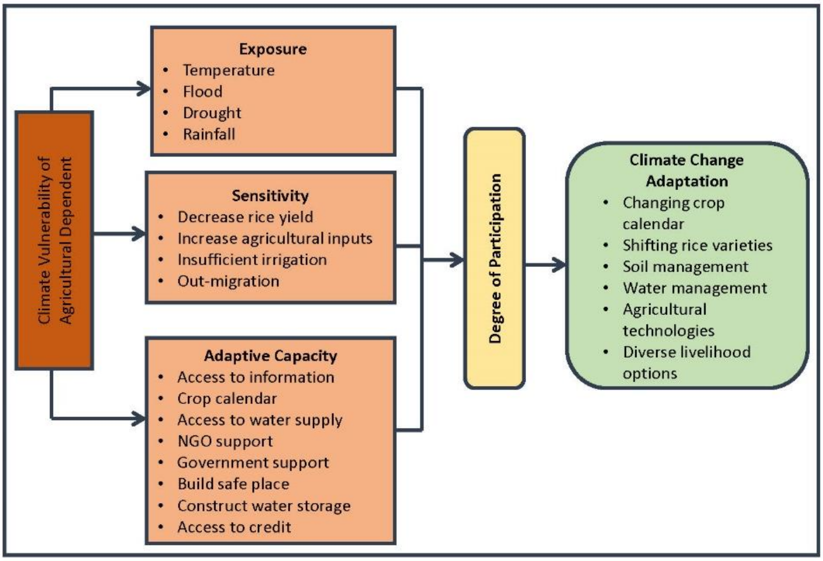
Vulnerability and adaptation: a conceptual framework

Cambodia has encountered a high incidence of natural disasters including floods and drought, due to the negative impacts of climate changes in terms of both exposure and vulnerability. The country is considered to be one of the most disaster-prone counties in Southeast Asia (World Bank, 2021) and is highly vulnerable to these impacts due to a dependency on climate-sensitive sectors such as agriculture, water resources, forestry, fisheries, and tourism (IPCC, 2014). Climate change impacts manifest as a consistent trend of rising temperatures and more frequent and intense extreme weather events such as cyclones, floods, hailstorms, and droughts (ADB, 2009). Efforts to adapt to these impacts have required comprehensive actions to reduce climate vulnerability.

The Intergovernmental Panel on Climate Change defines climate vulnerability as a function of the character, magnitude, and rate of climate variation to which a system is exposed and sensitized beyond its adaptive capacity. Vulnerability comprises three components - exposure, sensitivity, and adaptive capacity (IPCC, 2014). Exposure refers to the nature and degree to which a system experiences significant climatic variation such as droughts, floods, delayed rainfall, flash storms, and temperature surges. Sensitivity refers to the degree to which a system is adversely or beneficially affected by climate-related stimuli. For instance, Cambodian rice farmers may be considered highly sensitive to climate change impacts. Adaptive capacity refers to the ability of a system to adjust to climate change impacts to moderate any potential damage, take advantage of the opportunities it offers, and cope with its consequences (Mackay, 2008).

The concept of adaptation has been widely used in the context of climate change (Bryan et al., 2009) since it was introduced in the early 1990s. At this time, the concept was focused on humans responding to environmental variability (Adger & Vincent, 2005). Adaptation is defined in many different ways in the literature; however, the IPCC refers to *"the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some* *natural systems, human intervention may facilitate adjustment to the expected climate and its effects* (IPCC, 2014, p. 1758).

Figure 1. Conceptual framework



In the context of climate change, various methods can build the adaptive capacity to the serious impacts of climate change. Human livelihood systems, economic and natural resources, social networks, institutions, governance, and technology are the critical tools that may be used to support this capacity (Adger et al., 2007). Foster climate change adaptation practices, required the participation of the local people to be taken into account. For instance, Samaddar et al. (2020) highlighted tangible improvements in livelihood security resulting from engaged participation that enhances the skills of local people to operate effectively without acquiring external resources. Participation is an integral part of climate change adaptation initiatives, which are a relatively new agenda for many Cambodian people. This presents a challenge for practitioners who are required to motivate local people to engage in meaningful, constructive, and sustainable activities and interactions to bring about positive changes (CCCA, 2014).

Study Area and Research Methods

This research applied both exploratory and descriptive methodologies. An exploratory methodology has been used to ascertain the degree of climate change vulnerability experienced by those dependent on agricultural livelihoods in Takeo province. A descriptive approach was used to elaborate on adaptation practices that motivate the participation of the farmers in responding to climate vulnerability. As outlined in the conceptual framework, the study analyzes the degree of sensitivity, exposure, and adaptive capacity concerning climate vulnerability in a specific study area. The indicators of each of these attributes are listed in Table 1.

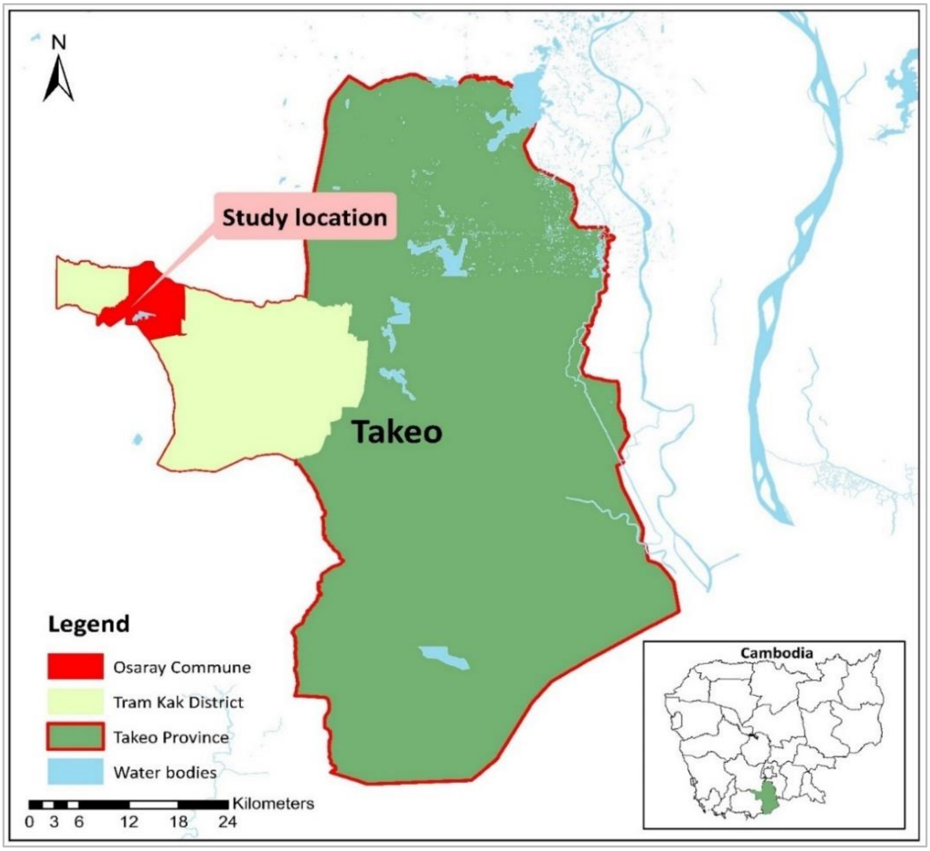
Both qualitative and quantitative approaches were applied to collect data via a structured questionnaire and semi-structured interview. Before conducting the fieldwork, a desk review was performed by gathering secondary sources and conducting a scoping visit to better understand the situation in the proposed study area. Qualitative analysis was applied to the key informant interviews held with influential stakeholders – including local authorities and NGO staff. The aim was to deepen the understanding of climate change impacts in the study area, the adaptation practices that have been applied, and how farmers have been involved in these practices. Quantitative analysis was used to present data on climate change vulnerability, adaptation practices, and key factors that encourage the farmer participation obtained via the household interviews. This analysis took into account the livelihood and socio-economic status of farmers.

Table 1. Vulnerability indicators in this study

Exposure indicators	**Measurement**
Degree to which rice farmers experienced (1) increasing temperatures; (2) decreasing water levels; (3) more frequent flooding; (4) more frequent drought; (5) more frequent flash storms; and (6) irregular rainfall.	**Social scale:** 1=Very low; 2=Low; 3=Moderate; 4=High; 5=Very high
Sensitivity Indicators	**Measurement**
Degree to which rice farmers experienced (1) impacts from a flash storm; (2) impacts from lightening leading to death; (3) impacts on rice paddies; (4) decreasing rice yields; (5) damage to equipment; (6) increased fertilizer use; (7) increasing insecticide use; (8) water scarcity; (9) a lack irrigation infrastructure; and (10) increased migration.	**Social scale:** 1=Very low; 2=Low; 3=Moderate; 4=High; 5=Very high
Adaptive capacity indicators	**Measurement**
The degree to which rice farmers (1) received climatic information; (2) changed crop cycles; (3) changed cultivation area; (4) accessed irrigation systems; (5) accessed credit; (6) received government or NGO support; (7) changed the location of cultivation; (8) established onsite water storages; and (9) constructing a safe place from flooding.	**Social scale:** 1=Very low; 2=Low; 3=Moderate; 4=High; 5=Very high

In 2020, Takeo province comprised 208,698 households and a population of 893,582 people (68% female), around 70% of whom lived in rural areas (MoP, 2020). In 2017, a total of 102,226 ha of land was cultivated, with 1,790 ha damaged (MoAFF, 2018). This province is classified as having medium susceptibility to droughts and high susceptibility to flooding (World Bank, 2017). *Osaray* Commune in *Tramkak* District was selected as the study area.

Figure 2. Study location



The commune comprised 12 villages with 3,293 households and a population of 13,549 people (MoP, 2020). Over half of this population (6,443 people) are dependent on agriculture for their livelihood and food security, with 5,993 people engaging in rice farming as a primary occupation. In 2014, *Osaray* Commune had a total of 2,886 ha of rice paddies under cultivation producing a total yield of 10,176 tons. However, this activity is affected by climate-related impacts such as lightning, droughts and in particular floods (DoP, 2015).

The study area was selected for three reasons: (1) Of the ten communes in *Tramkak* District, *Osaray* Commune is considered the most adversely affected by climate change impacts; (2) The traditionally high yield of rice production has recently seen a significant decrease; and (3) the commune is a target area for NGO activities focused on climate change awareness-raising and adaptive capacity building in response to climate vulnerability. Research participants were samples from three out of the twelve villages in the commune, namely *Tropeang Doung Tuek*, *Sokroam*, and *Domnak Khlong*. These villages were selected based on observations about access to water resources, such as reservoirs and natural streams to support agricultural production. A systematic random sampling approach was applied to recruit households to the interviewee cohort.

Yamane's (1967) formula (below) was used to select an appropriate sample size with a 9% of margin of error as shown in Table 2. In total 106 interviewees were selected (31 families in *Tropeang Doung Tuek* Village, 46 in *Sokroam* Village, and 29 families in *Domnak Khlong* Village) from 718 households. To randomly sample respondents, the researcher identified a starting point at the house of the village chief and followed the right side of the road interviewing every fifth household. The head of the household was selected as the interviewee when available, however, they were replaced with another knowledgeable person in the house if they were not.

$$n = \frac{N}{1 + N(e^2)}$$

Table 2. Study areas and sample size

Study site (village)	Population	Number of sample size
Tropeang Doung Tuek	210	31
Sokroam	312	46
Domnak Khlong	196	29
Total	**718**	**106**

Data analysis was conducted using the Statistical Package for Social Sciences and Excel. Both descriptive and inferential statistical analyses were applied for processing, collating, and analyzing the data. To understand the poverty profile of the farmers in each village, a sample t-test was applied to determine if there was any significant difference between household incomes derived from the survey and the World Bank poverty threshold. In addition, multiple regression was applied to determine the significance of the relationship between a range of other attributes and household income; and whether these associations contributed toward participation in building climate resilience in each community.

Chi-squared analysis was used to determine the nature of the correlation between adaptive capacity with poverty status and primary occupation. Income and livelihood conditions are expected to benefit from improved adaptation practices as it enables financial and other resources to be acquired to manage climate vulnerability. Finally, vulnerability to climate change and other key contributors to promoting participation in climate change adaptation activities were transformed into a five-point weighted average index (0.00-0.20=Very low; 0.21-0.40=Low; 0.41-0.60=Moderate; 0.61-0.80=High; and 0.81-1.00=Very high).

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Results and Findings

Livelihood and socioeconomic characteristics

In the study area, rice cultivation was considered to be the main source of livelihood and food security, with labour work as a secondary source of income, and small-scale business as a tertiary but equivalent source of income. Due to the study being remote, 88.7% of respondents were found to be highly dependent on rice production for daily subsistence. Several other agricultural activities, such as planting cash crops including pumpkins, watermelons, corn, and soybeans were also applied but these were predominately used for daily consumption, rather than producing a significant income. Rice cultivation usually commences in early April or May, while cash-crop cultivation is generally used as a livelihood strategy in the dry season once rice harvesting is completed in November or December each year.

Multiple regression analysis was applied to determine the correlation of various factors with daily household income. The resulting correlation, $R^2 = 0.25$; $F(6,96) = 6.730$; $*p < 0.05$ was derived from including three out of six proposed attributes, which were found to have a significant association with household income. These attributes included the number of income sources, and primary occupation, which correlated positively with household income; and the number of members of the household, which correlated negatively with household income. Another three proposed attributes were found to have no significant correlation with household income. i.e. level of education, age, and quantity of rice produced annually. Attaining a higher level of education is often not well-linked to higher income levels from traditional rice farming methods, as these skills are often attained on the job from other family members. Similarly, annual rice yields did not correlate with household income due to challenges with drought conditions, with insufficient irrigation allocations available for year-round rice cultivation.

Table 3. Key attributes and their correlation with daily household income respondents

Attributes	Unstandardized Coefficients		ß	P-value
	B	Std. Error		
Number of jobs held	0.33	0.13	0.24	**0.010****
Education level	0.04	0.04	0.10	0.290
Number of household members	-0.31	0.07	-0.39	**0.000*****
Age of respondent	0.00	0.01	-0.04	0.670
Number of rice crops per year	-0.65	0.50	-0.11	0.200
Primary occupation	0.21	0.09	0.21	**0.010****

The reason rice farming persisted as a key livelihood activity was because of its value as a cultural obligation inherited from ancestors. Owning agricultural land also enabled households to grow crops for subsistence use in the dry season. Respondents were not only involved in rice production as a livelihood activity, but were also engaged in other income-generating activities, such as poultry, and other livestock raising, as well as planting cash crops. Family members also seek employment in domestic garment factories outside of the village during the dry season, returning when rice cultivation recommences. It was also found that on average households comprised 4.4 members, with 56.6% of respondents belonging to a household with between

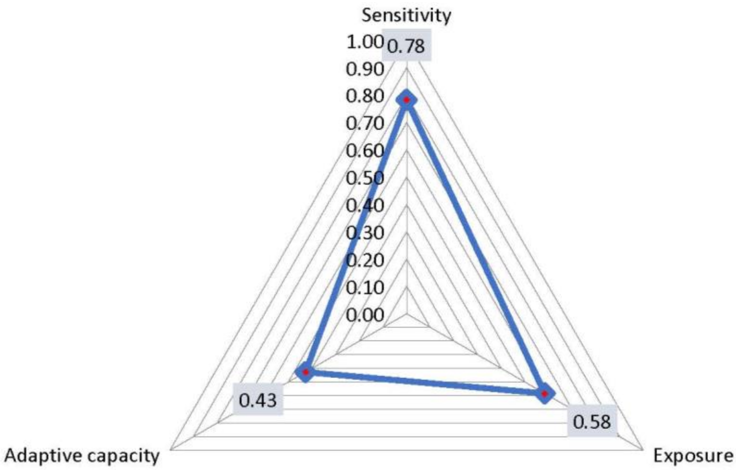
4 and 6 people. Most households reported having a high number of aging or young dependents, which had a negative association with increased household income. Usually, household income was generated by either one or two family members only.

A *t*-test was applied to investigate the statistical significance of differences between average household income and the 2015 Cambodian poverty line (0.98 USD per capita per day). It was found that the average income of respondents was significantly higher than this benchmark at 1.46 USD per capita per day, $t(103) = 4.014$, $p = 0.00$). Local livelihoods in the study area may be considered to be diversified – comprising other activities such as planting cash crops, animal husbandry, and labour work in garment factories. Further analysis showed that three quarters (75%) of respondents were able to access an income of more than 2.00 USD per capita per day. The poverty rate in Cambodia has decreased considerably in recent years, although the decline now is more gradual than in the past. For instance, the poverty rate decreased from 47.8% to 13.5% between 2007 and 2014 (ADB, 2014). In the study area, 80.2% of respondents lived above the poverty line defined by the Royal Government of Cambodia.

Vulnerability of farmers to climate change impacts

Figure 3 demonstrates that respondents have been seriously threatened by negative climate change impacts and have experienced high levels of climate vulnerability over the past five years. Respondents indicated a high level of sensitivity (WAI=0.78) to these impacts, as involvement in agricultural production had become constrained due to exposure (WAI=0.58) to climate change events. At the same time, the adaptive capacity of respondents was found to be considerably limited, with WAI at 0.43.

Figure 3. Weighted average index indicating the climate vulnerability of respondents



Note: 0.00-0.20=Very low; 0.21-0.40=Low; 0.41-0.60=Moderate; 0.61-0.80=High; and 0.81-1.00=Very high

Table 4 assesses and represents the climate vulnerability of the rice farmers. It also presents the analysis of the seven attributes of the exposure to climate change impacts. Respondents were found to be most commonly exposed to irregular or delayed rainfall (WAI = 0.92 and 0.91, respectively). Very low precipitation levels forced respondents to delay farming activities, which impacted yields. For instance, some rice paddies were left fallow because of water shortages. Beyond the impacts of delayed rainfall, rice yields were found to have continuously declined, while the price obtained for crops fluctuated. It was observed that while the annual rainy season has typically occurred between late April and September, recently rain events have been delayed until rainfall in August or September, even as late as October in some years. The season has become shorter and later than previously. This delay is the primary cause of decreases in water levels in the study area, with dykes and ponds drying up.

Other challenging exposure attributes, included increasing temperatures, water shortages, fewer unexpected flood events and increases in unexpected droughts WAI = 0.78, 0.81, 0.82, and 0.89, respectively. Conversely, exposure to flash storms and high winds was less significant. Around 83% of respondents perceived that temperatures had increased, unexpected flood events had decreased, and unexpected drought had increased, rainfall had been delayed over the past five years. This result aligns with a series of severe drought events that occurred between 2013 and 2016, which reduce rice yields, increased the level of insect damage to crops, and required respondents to leave rice paddies fallow. Overall, 97% of respondents reported that drought was the most significant challenge for those dependent on rain-fed agriculture for their livelihoods.

Sensitivity to climate change was indicated by 10 attributes (Table 4), with two attributes found to have very high sensitivity, namely a lack of water supply for rice cultivation (WAI=0.82) and damaged rice paddies (WAI=0.81). Respondents also indicated a high level of sensitivity to three other attributes were indicated, namely low rice yields (WAI=0.80), a lack of water for irrigation (WAI=0.79), and increase out-migration for employment (WAI=0.64). These results are explained by delayed rainfall experienced in the study area and a high level of dependence on rain-fed agricultural systems.

Respondents did not report high sensitivity to flash storms or thunder, nor were they sensitive to the need for additional farming inputs such as fertilizers or pesticides.

Table 4. Climate change vulnerability assessment in the study area

Exposure	WAI	Sensitivity	WAI	Adaptive capacity	WAI
Hotter temperatures	0.78	Violent storms	0.28	Access to climatic information	0.48
Decreased water levels	0.81	Thunder leading to death	0.28	Change crop cycles	0.64
Decreases in unexpected flooding	0.82	Damaged rice paddies	0.81	Number of rice crops per year	0.45
Increase in unexpected drought	0.89	Low rice yield	0.80	Access to irrigation	0.42
Frequency of windstorms	0.35	Damaged equipment	0.60	Access to credit or crop insurance	0.66
Irregular rainfall	0.92	Increased fertilizer use	0.45	NGO support	0.42
Delayed rainfall	0.91	Increase pesticide use	0.38	Government support	0.38
		Lack of water supply	0.82	Changed farmland	0.32
		Lack of water for irrigation	0.79	Construct water storage reservoirs	0.43
		Increase out-migration	0.64	Building protection dykes (flood)	0.28
				Build a safe place (flood)	0.21

Note: 0.00-0.20=Very low; 0.21-0.40=Low; 0.41-0.60=Moderate; 0.61-0.80=High; and 0.81-1.00=Very high.

Almost 70% of respondents indicated a medium or very high sensitivity to climate change impacts, particularly concerning damages to rice paddies and decreasing rice yields. The vast majority (90%) of respondents suggested that damage to rice paddies was a major climate change impact, resulting in a reduction of yield of between 1 and 1.3 tons per ha per annum only. In total, it was reported that around 4,000 ha of cultivated paddy rice was destroyed due to climate change, particularly drought events. Drought alone was reported to have affected around 3,556 ha of rice paddies, while flood affect around 1,995 ha. Drought events were revealed to be the most significant impact and were linked to other attributes such as decreases in water levels, and a lack of irrigation, which was experienced by 85% of respondents. A low adaptive capacity to manage these serious impacts was also reported, with many respondents (67.6%) becoming indebted to outstanding loans.

The adaptive capacity of respondents was also reported to be weak (Table 4), with nine out of 11 attributes being ranked from low to moderate. Only two attributes were considered to be strong, namely, access to finance (WAI=0.66) and changes to crop cycles (WAI=0.64). Flood Infrastructure attributes such as building safe places to better manage flood events (WAI=0.21) and building flood protection dykes (WAI=0.28) ranked lowly as no serious flood events had been experienced in the study area since 2012. Few respondents had constructed small water storage reservoirs as an alternative water supply (WAI=0.43). Additionally, changing farmland or crop rotation was not seriously taken into account (WAI=0.32) while support from NGOs and government agencies was ranked as moderate (WAI=0.42) and low (WAI=0.38), respectively. Respondents were also limited to one crop per annum due to either limitation in water supply or access to irrigation.

Only a minority (18.7%) of respondents perceived that they possessed a strong adaptive capacity to deal with climate change impacts. They were aware of the need to change how they managed crop cycles and could access credit or crop insurance from microfinance institutions (MFIs), yet the majority of respondents access loans to purchase agricultural inputs such as fertilizers, pesticides and labour to plant crops, which needed to be secured with collateral in their land. Some households sent family members away to jobs in the garment factories and construction work to raise additional income to support the family and conduct ongoing agricultural activities.

The key informant interviews revealed that local authorities had played a crucial role in responding to climate change impacts through facilitating the development of climate action plans and integrating adaptation activities into the commune investment and development plans. These plans incorporate issues raised at the village level and tend to be mostly well integrated but are rarely supported by the development partners, especially the government, as the plans are principally focused on building physical infrastructure and providing public services. Of interest are the efforts that had been made by commune authorities to work collaboratively with local NGOs to raise awareness on climate impacts and adaptation strategies [personal communication with *Tropeang Doung Tuek* village chief, 12 June 2016].

However, as local NGO partners have no long-term execution and implementation strategies, consequently it is difficult for a community to prepare to implement the community activities by themselves when projects end. Communities often failed to take ownership of planning and implementation of activities, when NGO programs are phased out [personal communication with NGO officer, 12 June 2016]. Limitations in the capacity of the community leaders, and the commitment and willingness of the community committee to continue to allocate resources (especially financial resources) act as significant constraints to ongoing climate adaptation activities. A lack of government support to continue formulating plans, implementing activities, and monitoring and evaluating results exacerbates the absence of a long-term plan to address climate vulnerability [personal communication with the *Osaray* Commune Council, 10 June 2016).

Respondents are discouraged by limitations in knowledge, support, and appropriate government investment in this capacity via the commune plan. Although NGOs play a vital role in partnership with the government to address local issues, short-term project implementation is unlikely to result in the sustainable capacity of respondents to adapt to climate change impacts [personal communication with an NGO official in *Tramkak* District, 11 June 2016].

Climate change adaptation practices

Water management strategies and irrigation systems play a vital role in ensuring the respondents have sufficient water for agricultural purposes when dealing with climate change impacts. As ensuring there are sufficient irrigation resource is a key requirement for this end in the study area, water reservoirs capable of storing water for agriculture are a consideration. However, the function of these reservoirs is challenged because of irregular rainfall. Table 5 presents the results of a chi-squared (X^2) test that demonstrates a significant correlation exists between access to irrigation and the degree of climate vulnerability experienced by respondents, X^2 (1, N = 105) = 16.39, $p = 0.000$. Respondents who are not able to access sufficient irrigation were found to have very high climate vulnerability when compared to those who do. This suggests that adaptation practices focused on developing irrigation infrastructure across the entire commune may be effective in reducing climate vulnerability and adapting to climate change.

Because of changing rainfall patterns and water shortage in the commune, respondents had applied various adaptation strategies to respond to climate change impacts. For instance, respondents reported that they had both broadcast rice seeds, planted rice seedlings, and constructed wetlands for rice cultivation. Before broadcasting and planting seed, respondents had applied soil management techniques including ploughing rice fields to improve soil quality soil and reduce the prevalence of insects. Other methods applied included selecting new rice varieties and changing crop cycles.

Table 5. Association between climate vulnerability and access to irrigation

Attributes	**Access to the irrigation**				X^2	**P-*value***
Degree of climate		No	Yes	Total		
vulnerability of	Low	6	15	21	16.39	***0.000******
respondents	High	64	21	85		
	Total	70	36	106		

Note: $X^2(1, N = 105) = 16.39$; $\boldsymbol{p = 0.000}$, *p < 0.05; **p < 0.03; ***p = 0.000; Significant variables are shown in **bold**.

Shifting long-term rice varieties to medium-, and short-term rice varieties produced significant improvements for respondents. However, overall, the adaptation activities that were implemented were not sufficient in overcoming the continued use of traditional cultivation methods. These approaches are highly sensitive to climate impacts and constrain the capacity of respondents. Few interviewees had applied modern agricultural techniques that enable enhanced adaptation to climate change impacts. For instance, only 6.9% of the respondents had applied crop rotation techniques; 0.9% had applied integrated rice farming; 0.4% had applied water management strategies to optimise groundwater usage, and 0.4% of respondents had applied the system of rice intensification principles to their rice paddies.

Climate adaptation projects should consider the need to strengthen leadership capacities within communities including the identification of climate risks; mapping of available resources; planning; engaging participation; and monitoring and evaluating outcomes. Moreover, adaptation projects should also consider how improved knowledge may be transferred to communities. This includes a focus on selecting appropriate rice varieties; producing rice seedlings with the capacity to cope with variable climatic conditions; rice cultivation methods; maintaining irrigation systems for sustainable water resource management; land use planning; value-adding; and sharing accurate and reliable knowledge about weather conditions and the lessons learned from the occurrence of natural disasters, such droughts and flash-storms. Additionally, the diversification of livelihood options is central to developing a capacity to cope with climate change impacts. When respondents can utilize their resources for responding to damages, they are less likely to be trapped within a cycle of indebtedness and poverty.

To determine the significance of the relationship between adaptive capacity and poverty status, a chi-squared analysis was conducted. No significant association between poverty status and adaptive capacity was found, X^2 (1, N = 106) = 0.447, $p > 0.05$. The income accessed by respondents was found to be derived mainly from on-farm sources (rice cultivation, horticulture, and livestock raising), and was highly vulnerable to negative climate change impacts. Villages situated far away from irrigation systems, i.e.

Sokrom and *Damnak Khlong*, were extremely affected by drought conditions. Both poor and non-poor respondents were highly sensitive to this climate variability.

Table 6. Relationship between adaptive capacity, poverty status, and primary income source

Attributes		**Adaptive capacity**			**X^2**	**P-*value***
		Weak	High	Total		
a. Poverty status	Below	34	6	40	0.44	0.5040
	Above	59	7	66		
	Total	93	13	106		
b. Primary income source	On-farm	86	9	95	6.23	***0.010*****
	Off-farm	7	4	11		
	Total	93	13	106		

Note: **a**. $X^2(1, N = 106) = 0.447$; $P = 0.504$**;** **b**. $X^2(1, N = 106) = 6.625$; $\mathbf{P = 0.01}$ * $p < 0.05$; ** $p < 0.03$; *** $p=0.000$; Significant correlations are indicated in **bold**.

An additional chi-squared analysis illustrated that a significant relationship between adaptive capacity and primary occupation exists, especially for those who engage in on-farm activities as a primary occupation, $X^2(1, N = 106) = 6.625$, $p < 0.05$. These respondents had a weaker adaptive capacity than those with access to off-farm income. For instance, respondents with access to off-farm employment were more likely to be able to respond to climate change impacts. Overall, the daily household income of respondents was around USD 2.00 per capita, which is slightly higher than the national poverty line. For those dependent on agricultural production only, this income is likely to decrease rather than increase, when faced with the threat of natural disasters.

Participation in climate change adaptation

Climate change adaptation is a new agenda for many Cambodian people. Motivating engagement in this agenda is still a challenge. Local participation is vital for ensuring adaptation practices are representative of the concerns of the community. This may be achieved via building capacity in policy-making, planning, impact assessment, social mapping, resource mobilization, and advocacy about climate change. Opportunities to be engaged in community meetings that involve the active participation of community members in developing proposals for local authorities (commune councils) and development partners are required, as are opportunities to become organizers and leaders of such events. For these reasons, the level of participation in climate change adaptation activities remains a concern.

Thus, logistic regression was used to determine the motivation factors that significantly influence the participation of respondents in climate change adaptation activities. Four attributes (improving knowledge, receiving an invitation, being a member of a community, and accessing new skills) were found to have a significant correlation with motivation to participate, R^2 = 0.66, F (9, 96) = 20.605; $p < 0.05$. Respondents indicated that as a result of participation, they had likely improved their knowledge and been equipped with new skills. In this sense, participation was a crucial part of developing adaptive capacity. NGOs had worked in villages to provide training on how to manage water, cultivate rice sustainably, manage soil, and select appropriate rice varieties to cope with climate change impacts. Respondents were also provided with training on climate change mitigation and adaptation, convening community meetings to identify problems, and identifying solutions [personal communication with an NGO official in Tramkak district, 11 June 2016]. Other factors that enhance community participation in climate adaptation practices were found to include receiving a personal invitation to become involved, and being part of a community.

Table 7. Key contributors to motivating rice farmers to participate in climate change adaptation

Attributes	**Unstandardized Coefficients**		**Beta**	***P-value***
	B	Std. Error		
Improved knowledge	0.37	0.08	0.42	***0.000****
Obtain community support	0.20	0.15	0.09	0.19
Accessed community resources	-0.01	0.08	0.00	0.94
Increased rice yield	-0.01	0.09	-0.01	0.93
Received an invitation	0.43	0.07	0.44	***0.000****
Became a community member	-0.25	0.11	-0.17	***0.030****
Received government support	0.04	0.07	0.04	0.59
Received NGO support	-0.05	0.08	-0.05	0.52
Equipped with a new skill	0.33	0.08	0.38	***0.000****

Note: R^2 = 0.66, *F* (9, 96) = 20.605; *$*p < 0.05$; $**p < 0.03$; $*** p = 0.000$*; Significant correlations are indicated in **bold**.

For instance, more than half of the respondents who participated in activities did not have essential roles in meeting as an organizer or facilitator. They had been invited to join events but were not closely involved. Interestingly, of the one-third of participants invited to discuss issues related to climate change and raise them with development partners, few were assigned to important roles as decision-makers, planners (5.3%), or on the event organizing committees (2.0%). While participation is a critical requirement for building adaptive capacity, the frequency of participation of respondents was very low as they had concentrated on daily household income-generation, rather than activities. Commune investment plans and NGO support are typically intended to build capacity to cope with climate change impacts. In general, it may be observed that commune council activities focused on building physical infrastructures and livelihood development; while NGOs had support awareness-raising, and developing knowledge, and skills.

Discussion

Cambodia remains highly vulnerable to natural disasters, particularly floods, droughts, and windstorms due to the negative impacts of climate change (Sour et al., 2014). Rural communities face high vulnerability to climate change characterised by three factors - sensitivity, exposure, and adaptive capacity. In the study area, respondents have been exposed to climate change impacts such as irregular rainfall, frequent flooding, droughts, and flash storms that had seriously impacted rice production over the past five years. Yet, traditional rice production systems are high sensitivity to climate variability. Adaptive capacity in this context was perceived to be relatively low and long-term support from stakeholders such as government agencies and development partners remains uncertain.

Local (commune) development planning focuses more on physical infrastructure such as roads, rather than supporting climate change adaptation activities, especially those linked to household livelihoods [personal communication with *Osaray* commune council, 10 June 2016]. NGOs implement short term projects to build adaptive capacity related to agricultural production, however, they are limited in their scope and often fail to sustain an ongoing response to deal with serious climate change impacts. Meanwhile, interviewees were observed to have some capacity to access information about climate change, crop insurance, the capacity to produce one crop of rice per year; yet were constrained by insufficient irrigation infrastructure, and limited access to NGO and government support [personal communication with an NGO official in *Tramkak* district, 11 June 2016]. This left interviewees with a limited skills base with which to address climate change impacts.

If the interviewees were able to further diversify agricultural production methods, they would save a greater adaptive capacity. Despite changing crop cycles and selecting more appropriate rice varieties, villagers will tend to apply traditional rice cultivation methods. For instance, broadcasting seeds by default as they are dependent on rain-fed irrigation. Achieving changes to climate adaptation practices required capital and the full engagement of community members (Phirun et al., 2014; Sok et al., 2015). Although a large reservoir and irrigation system is located close to the commune, it is not sufficient irrigation to respond to the needs of all those who require water resources for adapted rice production practices and also has a constrained capacity due to variable rainfall.

Selecting new crop varieties and planting dates, and increasing fertilizer use were the main adaptation methods available to interviewees (Abid et al., 2014). For instance, changing from long-term rice crops to medium or short-term rice varieties was found to be a significant approach to coping with climate change impacts. Consequently, 23.0% and 31.7% of interview respondents had used short-term and medium-term rice varieties, respectively. Many farmers cultivate rice during the rainy season between June-September and harvest between October and December each year. Few interviewees were able to cultivate rice paddies in both the wet and dry and rainy seasons due to a lack of water resources. Those who did were less vulnerable to climate change impacts.

Most farmers broadcast seed (31.9%), rather than planting rice seedlings (31.5%) or constructing wetlands (28.0%). Using the long-term rice varieties resulted in a high sensitivity to climate impacts due to the length of time water resources were required and damage from insects. Beyond selecting shorter-term crop varieties, interviewees revealed that they also shifted planting dates to avoid low rainfall periods, constructed wetlands, and planted rice seedlings instead of broadcasting seeds to cope with climate change. For instance, 45.3% of respondents changed the date they planted crops due to variable rainfall and low water levels early in the rainy season. Interviewees also revealed that they conducted other income-generating activities such as raising poultry and other livestock and planting cash crops to sell at the local market.

Various climate adaptation activities were also implemented by the commune council in collaboration with NGOs to engage local people in building adaptive capacity to cope with climate change. Participation is an essential component of these activities and people must have the opportunity to be involved in a community need assessment, project design, implementation, monitoring, and evaluation. Further critical appraising ideas, settling shared long-term goals, and contributing resources can also promote the sustainability of these activities. Eliciting meaningful, constructive feedback from participants is required to create interactions that lead to positive long term changes (CCCA, 2014).

Successful participation is characterised by situations where it contributes to tangible livelihood outcomes and develops the skills required for the activities to continue without acquiring external resources (Samaddar et al., 2020). This required developing an understanding of the key motivators of participants. In the study areas, interviewees indicated that they were more likely to participate in activities if they were regularly invited to and the experience involved accessing new knowledge or skills. This was the experience of most interviewees, who had previously attended training, and participated in savings groups facilitated by NGOs in partnership with local authorities. They had also been invited to meetings to define issues, and plan, implement and evaluate projects [personal communication with an NGO official in *Tramkak* district, 11 June 2016]. However, often it can be hard to engage the participation of rice farmers as they are concerned about spending time generating income.

Sometimes, participation is motivated by accessing a per-diem in the short term rather than thinking about a long-term development vision. It is important to reflect on this when considering the four key contributors found to have encouraged the interviewees to participate in climate change adaptation activities. These include: receiving an invitation to attend a meeting; being a member of a community; being equipped with new skills (such as climate change adaptation techniques); and accessing improved knowledge. The frequency of participation was found to be a factor that required improvement, as infrequent involvement resulted in limited improvements in adaptive capacity. More than half of the respondents were found to have participated in climate adaptation activities within the past two years. However, in most cases, this did not include active and frequent participation. Constraints to participation were identified as low educational attainment and the need to spend time in income-generating activities. Interviewees were motivated by accessing practical information about rice production and marketing. To foster greater participation, local people should be engaged in making decisions about climate change adaptation [personal communication with an NGO official in *Tramkak* district, 11 June 2016].

Conclusion

The study found that the climate vulnerability of interviewees was assessed as medium to high (sensitivity 0.78, exposure 0.58, and adaptive capacity 0.42). This reflects the level of climate impacts that had been experienced in the past five years. Low water levels, irregular rainfall, and insufficient irrigation infrastructure had resulted in significant negative impacts. Moreover, the adaptive capacity of the respondents was also assessed as low, due to a dependence on rain-fed irrigation. Interviewees were found to have altered their cropping cycles, yet were still using long-term crop varieties. To reduce the climate vulnerability: (i) irrigation systems or small dykes across rice paddies must be constructed and maintained; (ii) training and technical support need to be provided in diversified livelihood options, particularly for off-farm income generation; (iii) the adaptive capacity of a rice farmer in responding to climate change impacts needs to be enhanced with the support of climate change and agricultural experts; (iv) the commune investment plan should focus attention some financial resources on climate change adaptation and livelihood development; and (v) full participation in climate adaptation practices should be encouraged, providing opportunities for local people to take leadership roles.

This study had several limitations related to the timing and budget for conducting the fieldwork. This research did not receive a grant, thus the resources available to support data collection were limited and constrained. The research applied a small sample size to build a case study as was not it was not nationally representative. The results represent only the location of the study. Finally, this study focused primarily on the climate vulnerability of rice farmers, and the adaptation practices and key motivating factors involved in promoting participation in climate change adaptation activities. The researcher did not intend to study the policies of national and local governments in promoting adaptation practices, nor the government budget and policies required to reduce climate vulnerability.

Further research is required to continue to guide the improvement of the adaptive capacity and level of participation of rice farmers in climate change adaptation activities. This research should focus on: (i) the roles of rice farmers in building adaptive capacity and resilience to climate change impacts; (ii) promoting sustainable livelihoods while considering the context of climate change; and (iii) climate change financing and government policies that may build climate-resilient communities.

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References

Abid, M., Scheffran, J., Schneider, U. A., & Ashfaq, M. J. E. S. D. (2015). Farmers' perceptions of and adaptation strategies to climate change and their determinants: the case of Punjab province, Pakistan. *Earth System Dynamics*, *6*(1), 225-243.

ADB. (2014). *Cambodia: Country poverty analysis 2014*. Mandaluyong City, Philippines: Asian Development Bank, 2014.

Adger, W.N., & Vincent, K. (2005). Uncertainty in adaptive capacity. *Comptes Rendus Geoscience, 399-410.*

Adger, W.N., S. Agrawala, M.M.Q. Mirza, C. Conde, K. O'Brien, J. Pulhin, R. Pulwarty, B. Smit., & K. Takahashi. (2007). Assessment of adaptation practices, options, constraints and capacity. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 717-743.

Bandeth, R., Chhun, C., & Phirun, N., (2011). *Agricultural development and climate change: the case of Cambodia*. CDRI Working Paper Series No. 65, Phnom Penh, Cambodia.

CCCA. (2014). Climate change practice note: stakeholder's participation, Cambodia: Cambodia Climate Change Alliance 2014.

Chem, P., & Kim, S., (2013). *Vulnerability, Adaptive Capacity, and Water Governance in the Tonle Sap Basin,* Annual Development Review 2013-14: Phnom Penh: CDRI.

DoP. (2015). *Documentary on commune status in 2015.* Takeo Provincial Department of Planning. Cambodia.

Eckstein, D., Künzel, V., Schäfer, L., & Winges, M. (2019). Global climate risk index 2020. *Bonn: Germanwatch*.

Heng, C. T., & Pech, R. (2009). Vulnerability and adaptation assessment to climate change in the agriculture sector in Cambodia. In *Workshop on building climate resilience in the agriculture sector of Asia and the Pacific. ADB, Manila, Philippines*.

IPCC. (2014). Climate change 2014: *Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of working group II to the fifth assessment report of the Intergovernmental Panel on climate change. Cambridge University Press, Cambridge, United Kingdom and New York, USA.*

Mackay, A. (2008). Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. *Journal of Environmental Quality*, *37*(6), 2407.

MAFF. (2017). Annual report for agriculture, forestry and fisheries 2016-2017 and direction 2017-2018. Phnom Penh, Cambodia.

MoE. (2013). *Synthesis Report on Vulnerability and Adaptation Assessment for Key Sectors Including Strategic and Operational Recommendations.* Phnom Penh, Cambodia.

MoP. (2019). *General population census of the Kingdom of Cambodia 2019*. National Institute of Statistics of Ministry of Planning. Phnom Penh, Cambodia.

MoP. (2020). *Cambodia socio-economic survey 2019-20*, National Institute of Statistics. Phnom Penh, Cambodia.

NCCC. (2013). *Cambodia climate change strategic plan 2014-2023*, National Climate Change Committee of Royal Government of Cambodia. Phnom Penh, Cambodia.

NCDM. (2014). *Country Report of Cambodia Disaster Management*. Phnom Penh, Cambodia.

NCDM. (2019). *Disaster loss and damage database for Kingdom of Cambodia 2019*. Phnom Penh, Cambodia.

Nyda, C., Hoeurn, C., & Bunnak, P. (2016). *Quantitative Analysis of Household Vulnerability to Climate Change in Kampong Speu Province, Cambodia* (No. rr20160316). Economy and Environment Program for Southeast Asia (EEPSEA).

PCDM. (2019). *Situation report No. 3* – floods in Cambodia, Humanitarian response forum as of 2 October 2019. Phnom Penh, Cambodia.

Phirun, N. (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: CDRI).

Phirun, N., Sam, S., Lonn, P., & Ouch, C. (2014). *Adaptation capacity of rural people in the main agro-ecological Zones in Cambodia*, Phnom Penh: CDRI.

Samaddar, S., Oteng-Ababio, M., Dayour, F., Ayaribila, A., Obeng, F. K., Ziem, R., & Yokomatsu, M. (2021). Successful Community Participation in Climate Change Adaptation Programs: on Whose Terms?. *Environmental Management*, *67*(4), 747-762.

Sok, S., & Yu, X. (2015). Adaptation, resilience and sustainable livelihoods in the communities of the Lower Mekong Basin, Cambodia. *International Journal of Water Resources Development*, *31*(4), 575-588.

Sour, K., Phalla, C. H. E. M., Sovannarith, S., Somatra, K. S., & Sokhem, P. (2014). Methods and tools applied for climate change vulnerability and adaptation assessment in Cambodia's Tonle Sap Basin. *Phnom Penh: Cambodia's leading independent development policy research institute (CDRI)*.

Thomas, T. S., Ponlok, T., Bansok, R., De Lopez, T., Chiang, C., Phirun, N., & Chhun, C. (2013). *Cambodian agriculture: Adaptation to climate change impact* (Vol. 1285). Intl Food Policy Res Inst.

UNDP. (2013). Cambodia community-based adaptation programme: The case study in Cambodia community-based adaptation: *Two examples from rural affected communities*, UNDP Cambodia.

USAID. (2019). *Climate Risk Profile Cambodia*. USAID. Retrieved 12 October 2020.

World Bank. (2021). *Climate Risk Profile*: Cambodia (2021): The World Bank Group and Asian Development Bank.