*Insight: Cambodia Journal of Basic and Applied Research,* Volume 3 No. 2 (2021)


# The impact of climate change on food security among farmers in a coastal Area of Cambodia: a case study in Banteay Meas District, Kampot Province

KORN Sreyleak*
Ministry of Agriculture Forestry and Fisheries /General Directorate of Agriculture (GDA), No.54B/49F, Street 395-656, Sangkat Toeuk Laak III, Khan Tuol Kok, Phnom Penh, Cambodia
*Corresponding Author: KORN Sreyleak (sreyleak999rua@gmail.com)

**To cite this article:** Korn, S. (2021) The impact of climate change on food security among farmers in a coastal Area of Cambodia: a case study in Banteay Meas District, Kampot Province. *Cambodia Journal of Basic and Applied Research (CJBAR), 3(1),* 143–173.

## សង្ខិត្តន័យ

គ្រោះមហន្តរាយទាក់ទងទៅនឹងការប្រែប្រួលអាកាសធាតុមានដូចជា ទឹកជំនន់ គ្រោះរាំងស្ងួត ខ្យល់ព្យុះ និងរលកកំដៅ ដែលបានគំរាមកំហែងយ៉ាងធ្ងន់ធ្ងរដល់ភពផែនដីរបស់យើងក្នុងសតវត្សទីម្ភៃមួយនេះ។ ការខូចខាតទាំងផ្នែកមើលឃើញនិងទាំងផ្នែកមើលមិនឃើញមានទំហំខុសៗគ្នាទៅតាមប្រទេសនីមួយៗ។ អត្ថបទនេះមានគោលបំណងពិនិត្យលើការយល់ឃើញរបស់កសិករទាក់ទងនឹងផលប៉ះពាល់នៃការប្រែប្រួលអាកាសធាតុទៅលើការធ្វើស្រែ និងផ្តល់នូវយន្តការសមស្របដើម្បីកសាងសមត្ថភាពបន្សាំទៅនឹងការប្រែប្រួលអាកាសធាតុនៅកម្រិតមូលដ្ឋាន។ ការស្រាវជ្រាវនេះបានស្ទង់មតិកសិករចំនួន ២១៥នាក់ នៅឃុំចំនួន២ ក្នុងស្រុកបន្ទាយមាស ខេត្តកំពតដោយប្រើកម្រងសំណួរដែលបានរៀបចំ។ លទ្ធផលបង្ហាញថា កសិករតែងទទួលរងនូវតំទ្ធិពលនៃអសន្តិសុខស្បៀងជាញឹកញាប់អស់រយៈច្រើនទសវត្សរ៍មកហើយ។ អ្នកភូមិនៅឃុំត្នោតចុងស្រង់ងាយប្រឈមនឹងអសន្តិសុខស្បៀង បន្ទាប់ពីគ្រោះធម្មជាតិដូចជាទឹកជំនន់ ខ្យល់ព្យុះ គ្រោះរាំងស្ងួត និងការជ្រៀតចូលនូវសារធាតុប្រៃនៃទឹកសមុទ្រមកលើដីស្រែជាដើម។ កសិកររនៅឃុំបន្ទាយមាសខាងកើតបានជួបប្រទះនឹង

អសន្តិសុខស្បៀង និងភាពក្រីក្រយូរមកហើយ ព្រោះធ្វើស្រែពុំសូវបានផល ដោយសារទឹកជំនន់ ខ្យល់ព្យុះ និងកំណើននៃការជ្រៀតចូលនូវទឹកសមុទ្រមកលើដីស្រែ។ ការស្រាវជ្រាវក៏បានរកឃើញដែរថា យន្តការបន្សាំនៅថ្នាក់មូលដ្ឋានសម្រាប់ដោះស្រាយបញ្ហាប្រែប្រួលអាកាសធាតុអាចជួយបង្កើនសន្តិសុខស្បៀងបាន។ ជាងនេះទៅទៀត ស្ថានប័នពាក់ព័ន្ធសំខាន់ៗ ទាំងថ្នាក់ជាតិ និងទាំងថ្នាក់ក្រោមជាតិ គួរមានសកម្មភាពបន្ថែមដើម្បីជានាថា សហគមន៍ជនបទមានភាពធន់នឹងការប្រែប្រួលអាកាសធាតុ។ សកម្មភាពទាំងនេះគួរផ្តោតលើការអភិវឌ្ឍកសិកម្មប្រកបដោយនិរន្តរភាព តាមរយៈការអភិវឌ្ឍប្រព័ន្ធធារាសាស្ត្រ ការផ្តល់ពូជស្រូវដែលធន់នឹងភាពរាំងស្ងួត មធ្យោបាយនានាសម្រាប់ការពារសុវត្ថិភាពសង្គម និងគម្រោងអភិវឌ្ឍនានាដែលប្រជាជនក្នុងសហគមន៍ជាអ្នកកំណត់។ ដើម្បីអនុវត្តសកម្មភាពទាំងនេះឱ្យបានជោគជ័យ អ្នកធ្វើគោលនយោបាយ និងអ្នករៀបចំផែនការ ត្រូវបែងចែកនិងកំណត់ឱ្យបានច្បាស់រវាងអសន្តិសុខស្បៀងរយៈពេលវែង និងអសន្តិសុខស្បៀងរយៈពេលខ្លី។

## Abstract

Climate change-related disasters, such as floods, droughts, windstorms, and heat waves have emerged as a severe threat in the 21st century. Different countries experience different scales of both physical and perceived damage. This paper examines farmer perceptions of climate change impacts on rice production and introduces an appropriate mechanism to build adaptive capacity at the local level. This research is based on a survey of 215 respondents from two communes in *Banteay Meas* District, Kampot Province. The results demonstrate that food insecurity has been a frequently perceived impact among farmers over the past decade. Farmers in Tnoat Chong Srang have faced transitory food insecurity after natural calamities such as floods, storm surges, droughts, and seawater intrusion. Farmers in *Banteay Meas Khang Kaeut* have encountered chronic food insecurity and poverty caused by reduced rice production caused by floods, windstorms, and increasing seawater intrusion. The research found that local adaptation strategies for climatic hazards can increase food security. In addition, all key stakeholders, both at the national

and local levels, should take more action to ensure the resilience of rural communities. These actions should apply sustainable agricultural development focused on irrigation infrastructure, drought-tolerant rice varieties, social safety nets, and community-based projects selected by villagers. To successfully implement these actions policymakers and planners need to be able to clearly distinguish between chronic and transitory food insecurity.

**Keywords**: food security; small-scale farmer; coastal; agriculture; Cambodia

## Introduction

Climate change is a global challenge for development in the 21st century. In coastal areas, there has been an increase in the seawater temperature, rising sea levels, a decrease in sea ice, as well changes to seawater salinity, storm surges, and the conditions of the ocean circulation (IPCC, 2014). These effects have been apparent since the 20th century. For instance, the average sea level has risen from 10 to 20 cm since 1950. Likewise, sea ice cover in the Arctic Ocean has decreased between 10% and 15% over the same period (IPCC, 2014). Under current projections, it is anticipated that temperatures could increase by between 3 °C and 4 °C (Raghavan et al., 2019), and rainfall might increase by 40% by the end of the century. Reduced crop yields are likely to place pressure on global food supplies. An increase of just 2°C in temperature in Southeast Asia, alongside related impacts, such as tropical cyclones, sea level rises, saltwater intrusion and losses to pests and diseases are predicted to have a significant impact on food production (Wassmann et al., 2009). Such impacts on food security are also likely to trigger a reduction in economic growth in the region.

Globally, the number of people without sufficient food has increased from 804 million in 2016 to more than 820 million in 2018 (FAO, 2019). In Asia, around 418 million people experiencing food insecurity accounting for more than half of global hunger in 2020, with 282 million people in Africa accounting for another third (FAO, 2021). Climate variability and extreme weather events are the primary drivers of this rise. Approximately 28% of the global population lives in low-elevation coastal zones within 100 km of the coastline (Barbier, 2015). This is the experience of one-third of people in developing countries, and 47% of people in low-income economies. Widespread poverty in the coastal rural populations of many developing countries exacerbates the situation of those vulnerable to extreme short term climate change impacts, such as coastal flooding and storm surges, as well as long-term impacts caused by sea-level rise, seawater intrusion, and erosion (Barbier, 2015; FAO, 2015).

Cambodia is a predominantly rural country that relies heavily on rice as a critical commodity for economic growth, poverty alleviation and food security. Agriculture, especially rice cultivation, is a priority sector for rural development in the country as a staple food and a significant source of income (Yu & Diao, 2011). For instance, rice exports contributed around 20.7% of the GDP in 2019 (MAFF, 2019). Increasing rice yields via improved irrigation infrastructure and enhanced agricultural inputs have been prioritized in response to climate change impacts (Seaman et al., 2014). However, the significant impacts of climate change on agricultural infrastructure, and human health in coastal zones, often leave villagers with a

low capacity to mitigate shocks and stressors during the economic downturn experienced during floods and drought events.

Climate change impacts have led to altered land-use practices, inflated production and marketing costs, and the need to source income via off-farm activities. These factors have all significantly affected rice production over the past decade (CARD, 2014). Rapid changes to how water-related resources are managed in response to unpredictable natural disasters, and associated economic decline has resulted in extremely uncertain livelihoods for villagers. Many of which now may not be sustained without improvements in the adaptive capacity to cope with these imminent environmental and socio-economic dynamics.

Risks to agricultural production translate directly into the expansion of food insecurity and undernutrition for people who are heavily dependent on agricultural livelihoods. However, the development of the agricultural sector suffers from insufficient infrastructure, insecure land tenure, inefficient technology transfer and agricultural extension, less-than-comprehensive marketing information, limitations in managing natural hazards, and low public investment (Theng, 2010). For instance, insufficient irrigation infrastructure, coinciding with droughts has severely constrained rice production. Economic shocks and stresses occur frequently, invariably causing food shortages (FAO, 2017; Sok & Yu, 2015), especially among communities with a low adaptive capacity. Food security remains a priority issue if sustainable development and poverty reduction are to be realized (FAO, 2019).

In 2011, about 1.5 million people suffered from 630 million USD of damage associated with flooding in Cambodia. Drought, while less visible, is also costly, with around 7.8 million people affected (FAO et al., 2020). For instance, between 2015 and 2016, an El Niño weather event showed resulted in unseasonably low precipitation levels, and increased temperatures leading to the worst drought in Southeast Asia for over 50 years (WFP, 2020). Undernutrition remains a significant public health concern for Cambodians. It has been estimated that 15% of the population is undernourished. Up to 32% of children under five are stunted, 24% underweight, and 10% wasted. Generally, children living in rural areas are more likely to be stunted than children in urban areas (WFP, 2020). The Global Hunger Index Score (GHIS) remains high in Cambodia at 23.7% in 2018 (RGC, 2019) and food security is affected by a wide range of constraints. They include low agricultural productivity and diversification, a lack of sustainable access to natural resources for a significant proportion of the rural population, and insufficient rural employment. As a result, financial and economic crises continue to threaten the stability of food access for the rural poor (CARD, 2014).

In 2018, 10% of the Cambodian population remained below the national poverty line. Food security is expected to continue to be constrained by climate change impacts for at least the next 20 years in Cambodia due to a growing population, long coastlines, a heavy reliance on the agricultural sector, and dependence on natural resources (MRC, 2009) The Royal Government of Cambodia faces many challenges to improving this situation. While rice remains a priority economic sector contributing significantly to

food security, around 28% of the population is likely to be exposed to natural hazards annually (FAO et al., 2020). Sea-level rises in the Gulf of Thailand increase by 3 to 5.5 mm per year (IUCN, 2013), with Cambodia's 435 km of coastline likely to be impacted by saline intrusion in low-lying agricultural areas, diminishing rice production (IUCN, 2013).

The capacity to respond to emergencies in the country remains limited, while traditional agricultural systems remain highly vulnerable to a low adaptive capacity, characterized by a lack of diversification, and inefficient irrigation (SCO, 2016). This paper provides insight into the perceptions of rice farmers on the negative impacts of climate change and characterizes the types of food insecurity that occur as a result. Appropriate mechanisms for building adaptive capacity are discussed in light of these insights.

## Conceptualizing food insecurity in developing countries

Over the past decade, food insecurity has increasingly become a global issue as a result of growing conflict over climate-related resources (Drysdale et al., 2019). Food security was discussed in the global context as early as December 10, 1948, when the UN General Assembly adopted the Universal Declaration of Human Rights, which recognized the right to food as a core element of an adequate standard of living (UN, 1948). Then, in 1974, the World Food Conference in Rome (UN, 1974) prompted an international undertaking to develop a long-term plan for global food security to mitigate hazardous fluctuations in food reserves and prevent food shortages from occurring (Biswas & R Biswas, 1975). Since this time, various critical reviews

of global food production and consumption have led to some 200 definitions of food security being proposed (Napoli et al., 2011).

In 1986, the World Bank defined the food insecurity occurring in developing countries as either transitory or chronic (Reutlinger, 1986). Transitory food insecurity was associated with short-term and temporary socio-economic shocks, caused by factors such as peaks in global food prices, economic recessions, or natural disasters. Chronic food insecurity was associated with a long-term and persistent lack of capacity to meet basic minimum food requirements over an extended period due to poverty, inadequate access to food, or limited access to land resources (CARD, 2014; Reutlinger, 1986).

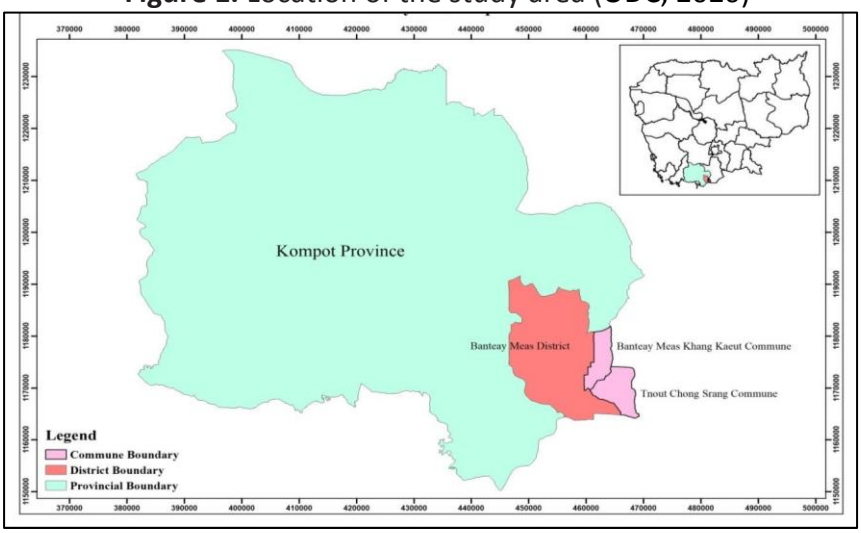
This is consistent with food insecurity in Cambodia. Beyond, the long-term environmental impacts of climate change compromising food security; short terms impact such as instability in food prices, food production, or household incomes also have an impact. In this context, poverty is closely related to food insecurity and malnutrition. Often food insecurity is intergenerational. Poor farmers tend to have a less balanced food intake and less capacity to provide food for children. This leads to lower levels of human development, and lower-income levels, which persist (CARD, 2014; Reutlinger, 1986). The aim of this paper is thus, to explore how these concepts may better articulate how climate change impacts rice farmers in a coastal area of Cambodia.

## Study Area and Methodology

Banteay Meas District in Kampot Province was purposively selected as the research site for this study due to its rural population and coastal location.

Within this district, stratified sampling was used to select two communes for a comparative study facing different situations concerning agricultural practices and capacity to respond to climate change impacts. The selected communes were *Banteay Meas Khang Kaeut* and *Tnoat Chong Srang* (see Figure.1). In line with Yamane's (1967) calculations, 215 interviewees were selected across six villages in these locations.

**Figure 1.** Location of the study area (ODC, 2020)




*Banteay Meas Khang Kaeut* is a rural commune with a population of 9024 people (4680 women) comprising 2111 households (MoP, 2020). In total 108 interviewees were sampled from three of the six villages in this commune. The majority of villagers in this commune are dependent on rice farming, home gardening, raising animals, and factory work as sources of income. *Tnoat Chong Srang* commune has a total population of 8410 people, comprising 2008 households. In total 105 interviewees were selected from three of the six villages in this commune. Farmers here are dependent on dry

land rice cropping and factory work for their income. During the past five years, villagers from this commune have migrated to Thailand seeking low skilled jobs in response to fluctuations in the rice market and high costs of production.

Information was collected from participants via a field survey, participant observation, focus group discussions, and other participatory rural appraisal methods. A range of key informants, such as government agencies, NGO staff, and local authorities were also consulted. Quantitative data were analyzed using the Statistical Package for the Social Sciences. A situation analysis, using statistical techniques for hypothesis testing; alongside the calculation of the mean, standard deviation, and gain coefficient of daily income across three sources (agriculture, non-agriculture, and others). This information was used to identify inequalities across each of the study communes. A chi-square test was used to test the relationship between access to land and household income. Further, a weighted average index (WAI), with a scale from (1) considerably low; (2) low; (3) moderate; (4) high; (5) very high, was used to assess the degree of satisfaction with available support mechanisms, institutional arrangements, and degree of dependency.

## Findings and Results

### *The current status of food shortages*

Over recent decades, a trend has emerged where income from a single source has not been sufficient to provide long-term security to a household in a rural area. Household spending on daily food consumption and agricultural inputs, such as fertilizers and pesticides, often exceeds agricultural incomes increasing the incidence of poverty rate in rural areas. In

each selected study area, almost all villagers access household income from more than one source. Agriculture contributes to job creation, providing food, and increasing the household income of the rural population. However, residents seek various forms of agricultural and non-agricultural income.

**Table 1.** Primary occupations between 2011 and 2020

| **Attributes** | **Banteay Meas Khang Kaeut** *(n=108)* | **Tnoat Chong Srang** *(n=107)* | **Overall** *(n=215)* |
|---|---|---|---|
| **Agricultural** | | | |
| Rice farming | 81 | 83 | 82.0 |
| Vegetable growing | 3.2 | 3.3 | 3.7 |
| Fishing | 0.0 | 0.8 | 0.4 |
| Livestock raising | 2.3 | 3.1 | 2.8 |
| **Sub-total** | ***86.5*** | ***90.2*** | ***88.9*** |
| **Non-agricultural** | | | |
| Self-employment | 3.2 | 0.9 | 2.1 |
| Waged labour | 3.0 | 6.0 | 4.5 |
| Self-employment | 3.1 | 1.0 | 1.5 |
| Waged Labour | 4.2 | 1.9 | 3.0 |
| **Sub-total** | **13.5** | **9.8** | **11.1** |

**Note:** 47.3% of respondents in Banteay Meas Khang Kaeut and 52.7% of respondents in Tnoat Chong Srang were engaged in more than one occupation.

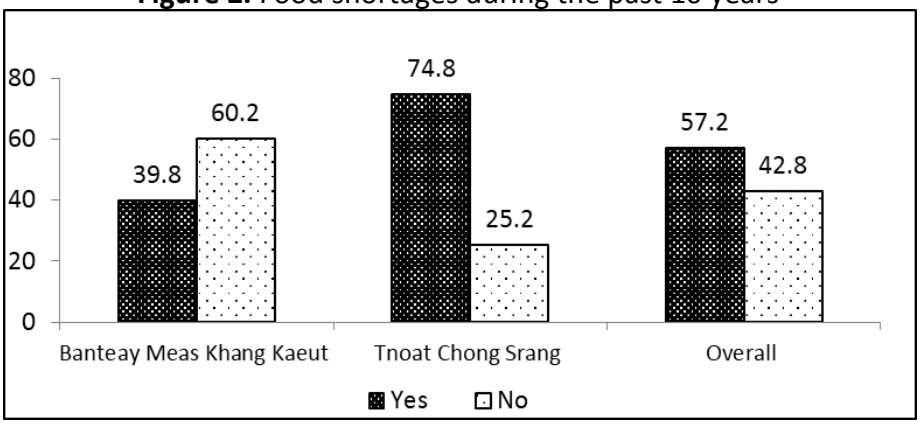
The majority of residents work primarily in the agricultural sector, including rice production (82%), home gardening (3.7%), animal raising (2.8%), and fishing (0.4%). The proportion of workers primarily engaged in non-agricultural employment is much less (4.5%), however, is a more significant percentage of Tnoat *Chong Srang* commune (6.0%) than Banteay Meas Khang Kaeut (3.0%). They were employed (3.0%). Another 2.1% of the respondents are engaged in non-agricultural self-employment. The focus group discussions and interviews revealed that over the past five years, many villagers in each of the communes have migrated to Cambodia and other

countries seeking non-agricultural work at garment factories, NGOs, or private companies. *Table 1* provides a summary of the primary occupations of research participants between 2010 and 2020.

The average land size across both study areas was 1.8 ha per household. Overall, more land was available to farmers in *Tnoat Chong Srang* (2.1 ha per household) than in *Banteay Meas Khang Kaeut*, which was only (1.4 ha per household). However, just over half (50.6%) of respondents had access to less than 1ha (41.0% in *Tnoat Chong Srang* and 60.2% in *Banteay Meas Khang Kaeut*). Just over half of respondents in *Tnoat Chong Srang* (50.6%) had access to between 2 and 4 ha of land, with 8.2% having access to more than 5 ha of land. In contrast only 38.6% of respondents in *Banteay Meas Khang Kaeut* as access to more than 1 ha of land resources, with no farmers accessing more than 5 ha. That demonstrates that comparatively, villagers in Tnoat Chong Srang have greater opportunities for agricultural production.

Figure 2 displays the results for the proportion of villagers who experienced food shortages between 2011 and 2020. A respondent's primary occupation was used to determine the number of months in which a household could afford to purchase rice. For instance, a household supported by a non-agricultural occupation may buy rice between seven and nine months each year. Overall, 57.2% of the villagers in the two study areas were found to have experienced a food shortage in the past (74.8% of respondents in *Tnoat Chong Srang* and 39.8% of respondents in *Banteay Meas Khang Kaeut*). Food shortages were found to be especially prevalent during the period between 2011 and 2015.

**Figure 2.** Food shortages during the past 10 years




## *The causes of food insecurity*

Overall, farmers in both communes have access to a similar amount of land sizes, however, the average landholding has increased by 33.5% over the past ten years. This has coincided with an increase in rice production of 58.1%; an increase in the proportion of farmers using their land for rice production to about 81.4%, and an increase in farmers who sell rice products to the market to 61.9%. This has led to an increased demand for land and other agricultural inputs, as well as an increase in the number of people working as farmers in both *Tnoat Chong Srang* (89.7%) and *Banteay Meas Khang Kaeut* (73.1%). This shift over the past decade has led to changes in income accessed from on- and off-farm activities in the two communes. Proportionally, off-farm income has decreased by 56.3% overall, however in *Banteay Meas Khang Kaeut* off-farm incomes still contributed around half of all income received.

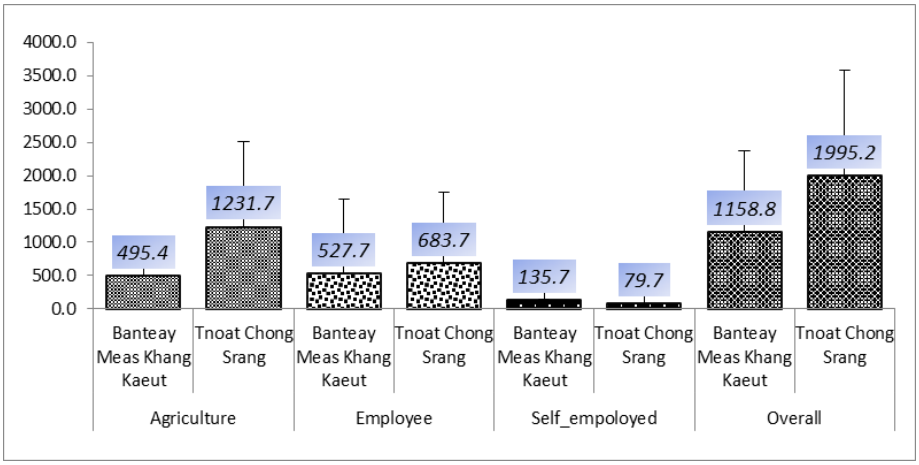
The variation between the average monthly incomes of residents in each commune, across different income categories, as compared with the rural

poverty line. This was analyzed using a t-test to identify whether this variation was statistically significant. Overall, the variation between the average monthly household income (1,575,000 riel/HH/month) and the rural poverty line (1,637,000 riel/HH/month) was found to be not statistically significant (P-value= 0.537). This implies that the average monthly income of the respondents was close to the rural poverty line overall. However, when this test was applied to each commune, average monthly payments in the *Tnoat Chong Srang* (1,995,000 riel/HH/month) (P-value=0.000) were found to be significantly higher than this measure, while average monthly payments in *Banteay Meas Khang Kaeut* (1,158,000 riel/HH/month) (P-value=0.000) were found to be significantly lower. Notably, farmers in *Tnoat Chong Srang* were found to have access to a greater diversity of economic activities, which influenced this income. They tended to access income from a greater diversity of sources, both on-farm (rice farming and gardening, animal raising, fishing), and off-farm (labour work, self-employment, or skilled labour).

Proportionally, the average monthly income for each household was considerably different across each source. Agricultural income accounted for an overall monthly household income of 861,840 riels, yet, this was significantly higher in the *Tnoat Chong Srang* (1,231,710 riels). In the *Banteay Meas Khang Kaeut,* monthly household agricultural income was much lower (495,390 riels), and exceeded by monthly household nonagricultural waged labour (605,340 riels), and self-employment (107,860 riels). This is a significant outcome, especially in *Banteay Meas Khang Kaeut*, where the

agriculture sector is an important livelihood resource. Non-agricultural work tends to benefit a smaller proportion of young people and in-migrants.

**Figure 3.** Average monthly household incomes by source




**Note:** average monthly incomes against the rural monthly HH consumption =1,637 thousand riels /HH/month

Farmers in *Tnoat Chong Srang* often access improved rice varieties from Vietnam, such as long-grain variety IR504. The rice seed is grown using more substantial agricultural inputs such as pesticides and fertilizers leading the higher production costs. That leads to local farmers borrowing money from Vietnamese merchants and local input suppliers on a promise that they will sell the harvested paddy to the merchant to repay the debt. This tends to result in minimal profits, with some households suggesting that they continue the practice for household consumption only. To supplement income from rice production, they work in construction and factory jobs or migrate to Phnom Penh, Sihanoukville, or other countries, such as Thailand and Korea. The farmers acknowledge a significant risk to their livelihood if Vietnamese partners decide to no longer purchase the rice and no substitute market is

found. Alternatively, farmers in *Banteay Meas Khang Kaeut* apply traditional wet rice cultivation methods with low production costs.

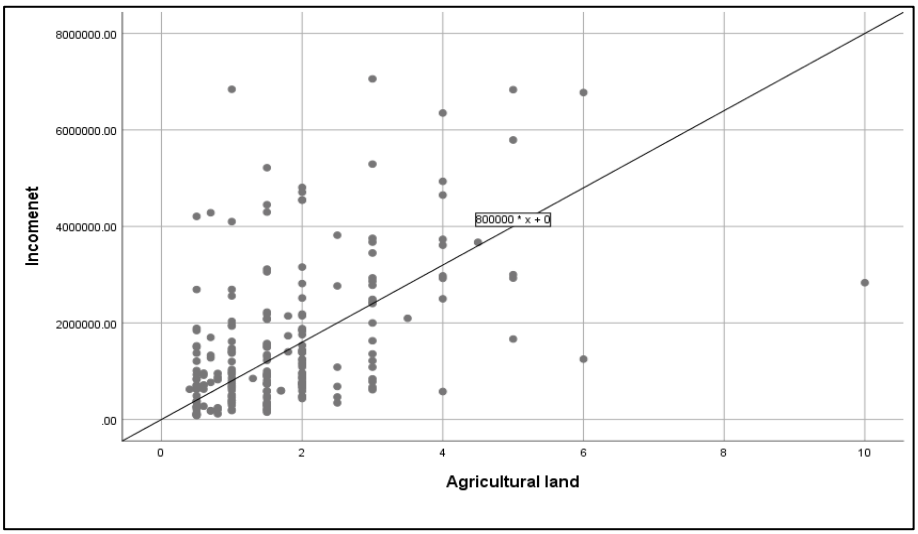
Although the monthly household income for respondents in *Tnoat Chong Srang* is higher than for those in *Banteay Meas Khang Kaeut*, food shortages are still commonly experienced due to the need to pay for agricultural inputs, such as fertilizers and chemical pesticides. Many farmers in *Banteay Meas Khang Kaeut* are required to see additional non-agricultural employment opportunities in other communities. The prices of staple foods and other commodities have fluctuated sharply in recent years linked to prices in international markets, which are not matched by increased incomes. Climate hazards have been another factor causing instability that severely impacts rice production via increased demand for scarce water supplies and low crop yields, especially in areas dependent on irrigation.

A chi-square analysis was also conducted to explore the relationship between monthly household income and the size of the landholding that respondents had access to. It was found that a statistically significant relationship exists between these two variables. Thus, if a household has access to a larger land area, they are likely to have a higher monthly household income.

Finally, a five-point weight averaged index was applied to measure the degree of severity of the food shortages experienced in each commune. Significant differences in severity were found, however overall the shortages were found to be moderate. In general, households tended to experience food shortages as a result of financial shortfalls when crops were lost due to

natural disasters. Interviews revealed that during these times, 70.7% of villagers would borrow money to purchase food for daily consumption (47.7% of respondents from *Banteay Meas Khang Kaeut* and 88.8% of respondents from *Tnoat Chong Srang*).

**Figure 4.** The relationship between income and agricultural land




## *Perceptions about the short-term impacts of climate change on food security*

Figure 5 outlines the perceived impacts of climate-related hazards over the last ten years in the study area. Overall, respondents expressed moderate concern about cooler temperatures, unexpected droughts, windstorms, increasing saltwater intrusion, unexpected flooding, and lightning, and significant concern about hotter temperatures. A weight averaged index revealed significant differences in the perceived impacts of climate change on the food security of farmers from each commune under study. For instance, significant differences in perceptions about increasing saltwater intrusion,

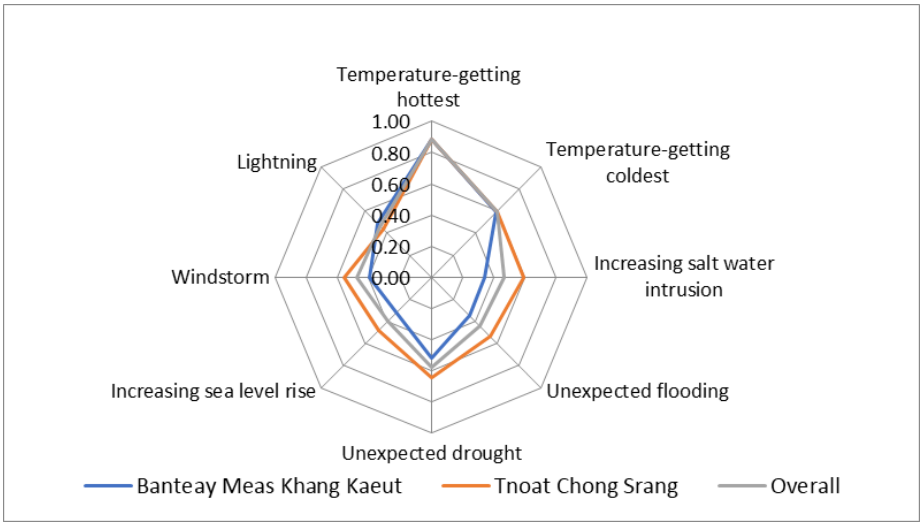
unexpected flooding, windstorms, rising sea levels, and thunder were revealed (P-Value=0.000). Respondents from *Tnoat Chong Srang* perceived there were greater challenges to food security as a result of climate change impacts than respondents from *Banteay Meas Khang Kaeut*. This is likely related to the flooding and droughts that impacted villagers in 2010, 2011, 2012, and 2015, which destroyed rice crops.

*Tnoat Chong Srang* commune is closely connected with Vietnam via *Prek Chik Vinh Te* and *Prek Ton Hon* canals that traverse the French border post No. 124. The commune also has links to the western arm of the Mekong River and the Gulf of Thailand. There is significant potential for the economic development of the rice cultivation area in the communed for both wet and dry production. However, this potential is at risk from sea-level rises in the Gulf of Thailand of about 5.5 mm per year. In recent years, natural disasters have occurred more frequently in *Tnoat Chong Srang* commune. For instance, 52 families were directly impacted when strong winds damaged 170 houses in 2020. Previously, in 2017, 9 households were impacted by violent storms. In total 43 dwellings were affected, with, four homes completely damaged. One farmer in the *Tnoat Chong Srang* recalled:

> "I have noticed changes in temperature over the last several years. It is getting hotter in the dry season. If I compared it to when I was young, the weather was cold between mid-December and the end of February, but three or four years ago, the weather became hotter. Over the last three years, our rice crops have been affected by salinity. In 2019, 1.5 hectares of rice were damaged, which caused the fields to dry out. Climate change has damaged my crops as a result of heavy rains and strong winds many times over the last

three years. My rice yield can sometimes be reduced after strong winds" (Farmer, Tnoat Chong Srang, October 2011).

**Figure 5.** Climate change and perceived natural hazards (2010-2020)




**Notes:** WAI = Weight Average Index measured on a five-point scale [Considerably Less (CL) = 0.00-0.20, Less (L) = 0.21-0.40, moderate (M) = 0.41-0.60, High (H) = 0.61-0.80, Very High (VH) = 0.81-1.00]; OA = Overall Assessment; *Significance at the 0.05 level; **Significance at the 0.01 level.

Many villagers expressed deep concern about recent increases in temperature and the increased frequency and intensity of droughts. For instance, in 2002, 2004, 2011, and 2015, respondents from *Tnoat Chong Srang* identified that they had noticed some water bodies drying out more frequently. The extension of irrigation systems has partially supported agricultural production during the dry season, however, insufficient water in *Tnoat Chong Srang*, threatens this livelihood activity due to low yield production. Farmers in *Tnaot Chong Srang* commune have created favourable conditions for growing dry-season rice, but are heavily reliant on irrigation to increase productivity.

The rehabilitation of irrigation systems built during the Khmer Rouge regime can enable two to three rice cultivation cycles per year. However, mismanagement of the distribution of this water has caused conflict and placed constraints on productivity. Other challenges faced in the commune include impacts from pests and diseases, especially during prolonged droughts, where saltwater intrusion problems increase. This reduces crop yields and, in some cases, causes crop failure. When this occurs, farmers often go into debt to buy agricultural inputs to produce rice for the market. However, the timing of this expenditure is often coupled with selling rice, when the market is weak.

### *Perceptions about long term trends related to climate change and their impact on food security*

Overall, the perceptions of respondents about the negative impacts of climate change on food security vary significantly across each commune studied. For instance, farmers from *Tnoat Chong Srang* tended to acknowledge the impact of food shortages and access to nutrition in the commune; while farmers in *Banteay Meas Khang Kaeut* were undecided about whether this was significant (see Table 2).

Meanwhile, climate change was identified to be a significant threat to household food security, caused conflict over scarce water resources and affected children's schooling in both communes. In *Banteay Meas Khang Kaeut*, where traditional rice production is prevalent, villagers were able to supplement available rice stores, with meat intake to improve health, social, and cultural outcomes from rice production. People gather aquatic creatures,

such as frogs, crabs, and snails, as well as other wild animals to supplement other meat consumption.

**Table 2.** Local awareness of climate change impacts on food security

| **Attributes** | **Banteay Meas Khang Kaeut** (n=108) | | **Tnoat Chong Srang** (n=107) | | **Overall** (n=215) | | **P-*value*** |
|---|---|---|---|---|---|---|---|
| | WAI | OA | WAI | OA | WAI | OA | |
| Climate change threatens household food security | 0.57 | U | 0.67 | A | 0.62 | A | 0.000*** |
| Climate change causes conflict over water resources | 0.60 | U | 0.65 | A | 0.62 | A | 0.025** |
| Climate change results in no choice for food | 0.64 | A | 0.68 | A | 0.66 | A | 0.007** |
| Climate change impacts child health | 0.67 | A | 0.63 | A | 0.65 | A | 0.015** |
| Climate change causes child malnutrition | 0.61 | A | 0.61 | A | 0.61 | A | 0.589 |
| Climate change impacts early childhood development | 0.62 | A | 0.65 | A | 0.63 | A | 0.010** |
| Climate change causes increased household debt | 0.74 | A | 0.69 | A | 0.71 | A | 0.002** |
| Climate change impacts children's schooling | 0.60 | U | 0.63 | A | 0.62 | A | 0.021** |

**Notes:** WAI = Weight Average Index measured on a five-point scale [Strongly disagree (SD) = 0.00-0.20, Disagree (D) = 0.21-0.40, Undecided (U) = 0.41-0.60, Agree (A) = 0.61-0.80, Strongly Agree (SA) = 0.81-1.00]; OA = Overall Assessment; *Significance at 0.05 level; **Significance at 0.01 level.

Mrs Norn Sony, a farmer who lives in *Banteay Meas Khang Kaeut*, stated: I have experienced food shortages almost every year for a period of about five or six months. I only have access to a small plot of land for rice farming

> and available non-agriculture work is not sufficient for meeting my daily expenses. I often borrow from relatives and sometimes from neighbours. My children do not enter the school because I cannot support them (Mrs Norn Sony, personal communication, October 2020).

Overall, the adaptive capacity of local people was found to be significantly different in terms of the use of water resources and other technical practices. There were differences in how farmers from each commune adapted their water consumption for rice cultivation, applied crop diversification practices, introduced drought-resistant rice varieties, accessed information about weather conditions, or used organic fertilizers. Farmers in *Tnoat Chong Srang* demonstrated a higher adaptive capacity to climate change than farmers in *Banteay Meas Khang Kaeut*.

Farmers in *Tnoat Chong Srang* have more frequently been impacted by climate change and as a result, have already altered their water consumption for rice cultivation via the use of ponds, and water conservation practices to reduce wastage during drought years. Other practices such as crop diversification, using organic fertilizers, developing on-farm water storage, planting fruit trees, and accessing reliable information about the weather have been applied to a moderate level; while the application of climate-smart agriculture practices, seasonal crop cultivation, and using drought-resistant rice varieties have been applied more intensively (see Table 3). Planting fruit trees has been used as a beneficial practise for improving the food security of respondents from both communes.

**Table 3.** Agricultural adaptations to climate change impacts

| **Attributes** | **Banteay Meas Khang Kaeut** (n=108) | | **Tnoat Chong Srang** (n=107) | | **Overall** (n=215) | | *P-value* |
|---|---|---|---|---|---|---|---|
| | WAI | OA | WAI | OA | WAI | OA | |
| Using less water for rice cultivation | 0.48 | M | 0.45 | M | 0.47 | M | 0.06 |
| Water harvesting using a farm pond, conservation practices | 0.48 | M | 0.43 | M | 0.45 | M | **0.010**** |
| Reducing water wastage during the drought seasons | 0.40 | L | 0.47 | M | 0.43 | M | ***0.000**** |
| Crop diversification practice | 0.44 | M | 0.42 | M | 0.43 | M | 0.320 |
| Making organic fertilizers in the community | 0.46 | M | 0.45 | M | 0.45 | M | 0.480 |
| On-farm water storage: water harvesting | 0.48 | M | 0.38 | L | 0.43 | M | ***0.000***** |
| Implementing climate-smart agricultural practices | 0.57 | M | 0.71 | H | 0.64 | H | ***0.000***** |
| Improving the use of seasonal crops | 0.61 | H | 0.50 | M | 0.56 | H | ***0.000***** |
| Planting fruit trees (mango, papaya banana, etc.) | 0.60 | M | 0.54 | M | 0.57 | M | ***0.000***** |
| Introducing drought-resistant varieties | 0.63 | H | 0.61 | H | 0.62 | H | 0.15 |
| Accessing information about the weather | 0.55 | M | 0.55 | M | 0.55 | M | 0.95 |

**Notes:** WAI = Weight Average Index measured on a five-point scale [Considerably Less (CL) = 0.00-0.20, Less (L) = 0.21-0.40, moderate (M) = 0.41-0.60, High (H) = 0.61-0.80, Very High (VH) = 0.81-1.00]; OA = Overall Assessment; *Significance at the 0.05 level; **Significance at the 0.01 level.

Using a weight averaged index revealed significant differences in the perceptions of the respondents about agricultural adaptations across the two communes (P-value=0.00). Table 4 indicates that farmer perceptions of adapting farming methods are stronger in *Tnoat Chong Srang* was better than in *Banteay Meas Khang Kaeut* for seed selection, water management, pest and disease management, and land levelling. Focus group discussion revealed that most farmers in the study lacked the technical skills and knowledge necessary to increase crop yields. For instance, farmers were constrained by a lack of understanding about how to use agricultural inputs, such as fertilizers and seeds effectively and efficiently. Improved awareness of these aspects is likely to improve productivity, as is the dissemination of knowledge about farming methods, such as crop husbandry, water monitoring, and pest management.

**Table 4.** The perception of agricultural adaptation and resilience

| **Attributes** | **Banteay Meas Khang Kaeut** (n=108) | | **Tnoat Chong Srang** (n=107) | | **Overall** (n=215) | | **P-*value*** |
|---|---|---|---|---|---|---|---|
| | WAI | OA | WAI | OA | WAI | OA | |
| Seed selection | 0.78 | H | 0.88 | VH | 0.83 | VH | ***0.000****** |
| Water management | 0.75 | H | 0.87 | VH | 0.81 | VH | ***0.000****** |
| Pests and disease management | 0.74 | H | 0.83 | VH | 0.78 | H | ***0.000****** |
| Land leveling | 0.76 | H | 0.84 | VH | 0.80 | H | ***0.000****** |

**Notes:** WAI = Weight Average Index measured on a five-point scale [Considerably Less (CL) = 0.00-0.20, Less (L) = 0.21-0.40, Moderate (M) = 0.41-0.60, High (H) = 0.61-0.80, Very High (VH) = 0.81-1.00]; OA = Overall Assessment; *Significance at the 0.05 level; **Significance at the 0.01 level.

The interviews with villagers found that each of the communes in the study is highly dependent on rain-fed rice farming. Households in *Tnoat Chong Srang* commune have proportionally higher access to irrigation systems

(86.0%), compared to those in Banteay Meas Khang Kaeut (29.6%). Those who live in Tnoat Chong Srang are also more likely to have access to water resources from the rivers or streams for both wet and dry season rice cultivation (78.5%) when compared with farmers from *Banteay Meas Khang Kaeut* (2.8%). Groundwater is also a significant and supplementary source in both Tnoat Chong Srang (12.1%) and Banteay Meas Khang Kaeut (1.9%). Groundwater is used both during drought years and after prolonged rainfall.

## Discussion and Conclusion

Storm surges and coastal flooding cause severe constraints on agricultural production and drive declining productivity (Zikra, 2015). When combined with the low socio-economic status of many countries in Asia, the impacts of weather events such as cyclones, storm surges, and floods have a significant adverse effect on the livelihoods, income, and food security of coastal farming communities (Huq et al., 2015). This study has revealed that these communities are expressing deep concern about increasing temperatures and sea-level rises and their impact on crop yields. Interviews with these farmers demonstrate that the level of concern about these climate impacts is related to differences in perceptions about other impacts such as saltwater intrusion, unexpected flooding, violent storms, and thunder. These differences can be ascribed to experiences with a decline in agricultural production, level of access to irrigation infrastructure, and longer terms environmental changes.

Cambodia has been affected by climate change almost every year since 2000. Since this time around 616,750 hectares of rice fields have been flooded, while 374,174 hectares of paddies have been destroyed (ADRC,

2003; Chan, 2001; Kent & Sanny, 2004). Between 2004 and 2005, some provinces of Cambodia experienced severe water shortages caused by drought; affecting 2 million people and 62,702 hectares of rice paddies (Mao, 2005). In 2016, serious droughts affected agricultural production in 18 provinces, causing 2.5 million to experience water scarcity (Laurien & Keating, 2019; MRC, 2019b). These events are reflected in this study, which found that farmers in *Tnoat Chong Srang* have faced impacts from many natural hazards over the past 10 years including floods, droughts, and windstorms. In particular, floods and droughts between 2010 and 2015 destroyed crops in the study area, especially rice.

Previous studies have shown that 42.2% of Cambodian farmers have experienced food shortages, including more severe food insecurity lasting for more than ten consecutive days. This has required them to seek support from others. Even brief periods of food shortages or starvation can result in serious deterioration of health (Sok et al., 2014). In this study, it was found that 57.2% of respondents have experienced a food shortage in the past 10 years (74.8% of respondents in *Tnoat Chong Srang*, and 39.8% of respondents in *Banteay Meas Khang Kaeut*).

These experiences have developed an understanding of how to manage water shortages for agricultural production, turning climate hazards into agrarian opportunities. These approaches make a significant contribution to sustainable development in the face of climate change impacts. They help to improve the resilience of rice farming systems and increase yields to ensure food security for smallholders in rural Cambodia. This study considered the

experience of farmers that were highly dependent on rain-fed rice farming. One commune, *Tnoat Chong Srang,* however, had significantly higher access to irrigation than the other.

Local adaptation strategies that respond to climate change impacts include: changing the timing of planting of crops; introducing new crop varieties including high-value crops; strengthening the extension services to rural families via appropriate technologies; and providing better information on production techniques and land management practices. These strategies are central to speeding up the adoption of appropriate adaptive practices. Technically support from NGOs will be required to play a significant role in improving household livelihoods through training, creating work opportunities for unskilled agricultural labour, and the provision of financial support.

In the future, all key stakeholders from the national to local level need to consider contributing towards: the enhanced resilience of rural communities and economies; the advancement of sustainable agriculture for farm households based on crop insurance, crop future trading, and income stabilization programs; the development of irrigation infrastructure; social safety nets and community-based projects; the selection of appropriate careers by villagers; and, clear differentiation between chronic and transitory food insecurity by policymakers, planners and practitioners. This study concludes by suggesting that future studies on this topic should (i) focus on the impact of saltwater intrusion on rice production; (ii) address sea-level rise and its impact on livelihoods in coastal zones; and (iii) consider the impact of

climate change on children's health-related quality of life and household food security indicators in rural communities.

## Acknowledgements

The author would like to thank the reviewers of this paper for their comments and acknowledges the support of Dr Seak Sophat, Program Coordinator of the Master of Science in Climate Change at the Royal University of Phnom Penh.

## References

*ADRC. (2003). Cambodia Country Report.* Asian Disaster Reduction Centre; Phnom Penh, Cambodia.

Barbier, E. B. (2015). *Climate change impacts on rural poverty in low-elevation coastal zones*. The World Bank.

CARD. (2014). *National Strategy for Food Security and Nutrition 2014-2018* Council for Agricultural and Rural Development.

Chan, S. (2001). *The Impact of Cambodia's Recent Floods.* Cambodia Development Review.

Drysdale, R., E, o., & Mosa Bob, U. (2019). *Adapting* the Coping Strategies Index to Measure Food insecurity in the Rural District of ILembe, South Africa. *Food, Culture & Society*, *22*(1), 95-110. https://doi.org/10.1080/15528014.2018.1547067

FAO. (2015). *Consolidating Capacities for Disaster Risk Reduction in Agriculture in Cambodia*.

FAO. (2017). *The Future of Food and Agriculture-Trends and Challenges*.

FAO. (2019). *Food Insecurity is More than Just Hunger*. Food and Agriculture Organization of the United Nations. Retrieved 19/02/2020 from 19/02/2020 http://www.fao.org/state-of-food-security-nutrition/en/.

FAO, UNICEF, & WFP. (2020). *Roadmap Developing a Risk-Informed and Shock-Responsive Social Protection System-Cambodia*. U. a. W. FAO.

FAO, I., UNICEF, WFP, WHO. (2021). The State of Food Security and Nutrition in the World 2021. *Transforming food systems for food security, improved nutrition and affordable healthy diets for all*(978-92-5-134325-8). https:// doi.org/10.4060/cb4474en.

Huq, Nazmul, Hugé, Jean, Boon, Emmanuel, Gain, & K, A. (2015). Climate Change Impacts in Agricultural Communities in Rural Areas of Coastal Bangladesh: A Tale of Many Stories. *Sustainability*, *7*(7), 8437-8460. https://doi.org/10.3390/su7078437

IPCC. (2014). *Asia In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.* C. o. W. G. I. t. t. F. A. R. o. t. I. P. o.C. Change.

IUCN. (2013). *Building Resilience to Climate Change Impacts: Coastal Southeast Asia Kampot Province, Cambodia*.

Kent, H., & Sanny, J. (2004). *Linkages between Flood and Drought Disasters and Cambodian Rural Livelihoods and Food Security*. Cambodian Red Cross Society.

Laurien, F., & Keating, A. (2019). Evidence from Measuring Community Flood Resilience in Asia. *Asian Development Bank Economics Working Paper Series*.

MAFF. (2019). *Agricultural Sector Strategic Development Plan 2019-2023*. Ministry of Agriculture, Forestry and Fisheries.

Mao, H. (2005). *Cambodia Country Paper for the Third Annual Mekong Flood Forum;* Vientiane, Lao PDR.

MoP. (2020). *Social Economy 2020*. Cambodia: Ministry of Planning.

MRC. (2009). Adaptation to climate change in the countries of the Lower Mekong Basin. *24*, 5-24.

MRC. (2019b). *Drought management strategy for the Lower Mekong Basin 2020-2025*. Mekong River Commission Secretariat.

Napoli, M., De Muro, P., & Mazziotta, M. (2011). *Towards a Food Insecurity Multidimensional Index (FIMI)*.

Raghavan, V, S., Ze, J., Hur, J., Jiandong, L., & Ngoc, N. (2019). ASEAN Food Security under the 2 C-4 C Global Warming Climate Change Scenarios. *1*, 37-52.

Reutlinger, S. (1986). *Poverty and Hunger: Issues and Options for Food Security in Developing Countries. A World Bank Policy Study*. ERIC.

RGC. (2019). *The Second National Strategy for Food Security and Nutrition 2019-2023*. Council for Agricultural and Rural Development Office of the Council of Ministers.

SCO. (2016). *El Niño-induced drought in Cambodia: Rapid Assessment Report*.

Seaman, J. A., Sawdon, G. E., & Acidri, J. (2014). The Household Economy Approach. Managing the Impact of Climate Change on Poverty and Food Security in Developing Countries. *Climate Risk Management*, *4*, 59-68. https://doi.org/10.1016/j.crm.2014.10.001.

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. https://doi.org/10.1080/07900627.2015.1012659.

Sok, S., Yu, X., & Wong, K.-K. (2014). Food Security in the Riverine Rural Communities of the Lower Mekong Basin, Cambodia. *Forum for Development Studies*, *41*(1), 53-74. https://doi.org/10.1080/08039410.2013.858077.

Theng, V. (2010). Review of Agricultural Policy and Policy Research. *Presentation made at the Cambodia Food Security and Agricultural Policy Stocktaking Roundtable*.

Wassmann, R., Jagadish, S., Heuer, S., Ismail, A., Redona, E., Serraj, R., Singh, R., Howell, G., Pathak, H., & Sumfleth, K. (2009). Climate Change Affecting Rice Production: The Physiological and Agronomic Basis for Possible Adaptation Strategies. *Advances in agronomy*, *101*, 59-122. https://doi.org/10.1016/S0065-2113(08)00802-X.

WFP. (2020). *WFP Cambodia Country Brief*. *World Food Programm*e; Cambodia.

Yu, B., & Diao, X. (2011). *Cambodia's Agricultural Strategy: Future Development Options for the Rice Sector*.

Zikra, M. (2015). Climate Change Impacts on Indonesian Coastal Areas. *Procedia Earth Planetary Science*, *14*, 57-63. https://doi.org/10.1016/j.proeps.2015.07.085.