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Climate Change Resilience and Food Security through Water Management in the Basedth district of Kampong Speu province

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ការសិក្សាស្រាវជ្រាវនេះ ស្វែងយល់អំពីភាពធន់នឹងបម្រែបម្រួលអាកាសធាតុក្នុងវិស័យទឹក និងសន្តិសុខស្បៀងរបស់កសិករក្រីក្រតាមជនបទនៅប្រទេសកម្ពុជា។ ការសិក្សាស្រាវជ្រាវនេះបានវិភាគទិន្នន័យតាមបែបបរិមាណវិស័យផង និងគុណវិស័យផង ដោយសិក្សាទៅលើគ្រួសារជនបទចំនួន ១០៣ គ្រួសារ នៅឃុំស្វាយចចិប និងឃុំទួលសាលា ស្រុកបរសេដ្ឋ ខេត្តកំពង់ស្ពឺ។ បទសម្ភាសលម្អិតត្រូវបានធ្វើឡើងជាមួយគ្រួសារក្រីក្រ មេភូមិ ក្រុមប្រឹក្សាឃុំ និងមន្ត្រីកសិកម្មស្រុក។ លទ្ធផលស្រាវជ្រាវបានបង្ហាញថា តំបន់ដែលបានសិក្សាពុំមានប្រព័ន្ធជាវាស្ត្រ និងប្រភពទឹកគ្រប់គ្រាន់សម្រាប់ធ្វើកសិកម្ម និងការប្រើប្រាស់ក្នុងជីវភាពរស់នៅប្រចាំថ្ងៃរបស់កសិករឡើយ។ ជាងនេះទៅទៀត សម្ភារស្តុកទឹក និងយន្តការដោះស្រាយសម្រាប់ភាពធន់នឹងផលប៉ះពាល់នៃការប្រែប្រួលអាកាសធាតុក៏នៅមានកម្រិតនៅឡើយដែរ។ មិនតែប៉ុណ្ណោះ កសិករភាគច្រើនបានចំណាយថវិកាផ្ទាល់ខ្លួន ដើម្បីបានទឹកប្រើប្រាស់គ្រប់គ្រាន់សម្រាប់ការដាំដុះ និងចិញ្ចឹមសត្វ។ កសិករក្នុងតំបន់នោះមានការប្រឈមនឹងការខ្វះខាតស្បៀងអាហារ ដោយសារការគាំទ្ររបស់រដ្ឋាភិបាល និងអង្គការក្រៅរដ្ឋាភិបាលអាចជួយដោះទាល់បានបានត្រឹមមួយរយៈខ្លីប៉ុណ្ណោះ ហើយពួកគាត់ភាគច្រើនបានខ្ចីប្រាក់ពីអ្នកជិតខាង និងប្រើប្រាស់ធនធានដែលមានស្រាប់ដើម្បីដោះស្រាយជាបណ្តោះអាសន្ន។

ABSTRACT

This article explores climate change resilience in the water sector, and its relation to food security of poor farmers in rural of Cambodia. The research analyzed both quantitative and qualitative data by conducting a survey of 103 farmer households in Svay Chacheb and Tuol Sala communes of Basedth District, Kampong Speu province. Detailed interviews were conducted with poor households, village chiefs, commune councilors, and agriculture officials at the district level. The study found that the famers do not receive sufficient water for rice cultivation and daily consumption from the existing irrigation systems and wetlands. Additionally, storage equipment and mechanisms for resilience to the effects of climate change are limited. Most farmers spend in order to obtain sufficient water for agriculture activities such as growing crops and raising livestock. The farmers need to borrow from their

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neighbors and use their own existing resources when they are faced with a food shortage because support mechanisms from government agencies and Non-governmental Organization (NGOs) are limited.

1. Introduction

In Cambodia, the Mekong River and Tonle Sap Lake are the primary sources of water, and they offer many advantages to the agriculture sector in terms of food production for the people in their area (Sok et al, 2014). The Mekong River enters Cambodia in the northeast in the province of Steung Treng, at the border with Laos. The river flows southwest through the provinces of Kratie, Kompong Cham, and Kandal, before meeting up with the Tonle Sap River in Phnom Penh. The Tonle Sap Lake has a total catchment of 67,600 km^2, making it the largest freshwater lake in Southeast Asia. It contributed 62% of the total water supply in Cambodia in the days of the Angkor civilization. Water is essential for all aspects of social and economic development, and human well-being. It is necessary for agriculture, forestry, fisheries, health, and disaster response (Beard, 2007). The Law on Water Resources Management (LWRM) and policy framework was approved in 2007 as part of the National Policy on Water Resources Management (WRM) aimed at making a Strategic Plan on Water Resources Management Development (UNDP, 2011). Irrigation infrastructure is central to the strategy for effective water management, and it benefits to rice production (Wokker et al, 2014).

Currently, water management is applied but varies in terms of time and location (McCornick et al, 2013). The adaptative strategy in the water sector has focused on water storage options that aim to promote agricultural productivity and food security to mitigate the negative impacts of climate change, specifically for poor households (McCartney and Smakhtin, 2010). In the rural areas of Cambodia, the people traditionally access water by using rivers, lakes, ponds, and shallow dug wells (Irvine et al, 2006). To be aligned with global commitments under the World Summit on Sustainable Development (WSSD) Johannesburg Plan of Implementation (2002), water should be treated as an essential need for basic human well-being, impacting both food security and economic activities. Water is critical for food security in developing countries, in order to achieve access to high-quality food and healthy lives (FAO, 2009). Moreover, water is the basis for developing all sectors of the national economy (Ojendal, 2000).

From early 2000 until now, poverty mitigation and economic growth have advanced as a result of the use of water resources. This sector is critical to all aspects of human and economic development, as it is essential to agriculture, forestry, fisheries, health, and disaster management (MOWRAM, 2012). Water is arguably the most essential resource for sustainable livelihoods and food security. It is important for peoples' work, sources of income, food, and other aspects of their livelihoods (Sok et al, 2014). Each year in Cambodia, during the wet season, there is 75,000 million m3 of surface water running off the land. However, only 1% of water in the country was used by humans. Of that amount, 95% was used for agriculture, energy, and health benefits. Water supports all terrestrial and freshwater biodiversity, underpins most features of human well-being and is essential for sustainable development. Water resources can be strengthened or they can be weakened by climate change. Human health, food, and energy security, urbanization, and industrial growth are issue areas where policies and actions fundamentally relate to sustainable development (Shiva, 2016).

Cambodia is highly dependent on agriculture, and it is highly vulnerable to the impacts of climate change on the water sector (NCCC, 2013). Moreover, the quality of the water sector affects food production, predominantly in rural areas, which is negatively impacted by climate change (UNDP, 2011). Regarding climate change, between 2025 and 2050, the increased risk of water scarcity is predicted in most of Cambodia's agricultural areas (MoE, 2016). This problem already occurred in 2002, 2012, 2015, and 2016. In 2016, it affected development in all regions of the country. It was the first time that The Royal Government of Cambodia (RGoC) declared an emergency. Climate change is the main factor that impacts the water sector and

water resource development plans. Cambodia has been severely affected by natural hazards. In addition, water scarcity poses a very serious problem for rain and agriculture-dependent households (Chhinh and Poch, 2012). Kampong Speu province is an area of Cambodia that was frequently affected by drought, and the significant effects of climate change have been observed in the province. In 2002, this province was severely impacted by drought, and farmers recognize that droughts have a substantial negative influence on their livelihood and food security (Chhinh & Millington, 2015).

The effects of climate change will severely impact developing countries (Leary et al. 2008). Cambodia is highly dependent on natural resources. Among the 17 provinces in Cambodia, Kampong Speu is the third most vulnerable province, with increased poverty and experiencing water scarcity more often and intensely than other provinces (Chhinh & Cheb, 2013). It is an area more vulnerable to problems stemming from climate change, especially floods and droughts. The World Bank observed in its 2010 global assessment, that people would be impacted by climate change through is effects on the water sector. This is because water is key to meeting social and economic development objectives. This is the actual situation in Cambodia (UNEP, 2009).

This research investigates climate change resilience in the water sector and food security through water management. It aims to: (I) explore the causes and severity of water shortages related to the impacts of climate change in a drought-prone area; (ii) draw out the public perception of local people on the impacts of climate change on food security during water shortages; and, (iii) examine how local community, government agencies and non-governmental organizations (NGOs) act to improve community resilience from the negative impacts of climate change.

2. Materials and methods

This research was conducted in Kampong Speu Province. This province is located 48 km to the West of Phnom Penh. It borders Phnom Penh to the East, Kandal and Takeo provinces to the South, Pursat and Kampong Chhnang Provinces to the North, and Koh Kong Province to the West (Touch & Oh, 2018). There is a total of 1,375 villages in the province (Hammett et al, 2019), which are composed of 195,882 households, making up a total a population of 868,201 people including 450,145 females, and an average household size of 4.4 persons (MoP, 2019) (**Fig. 1**).

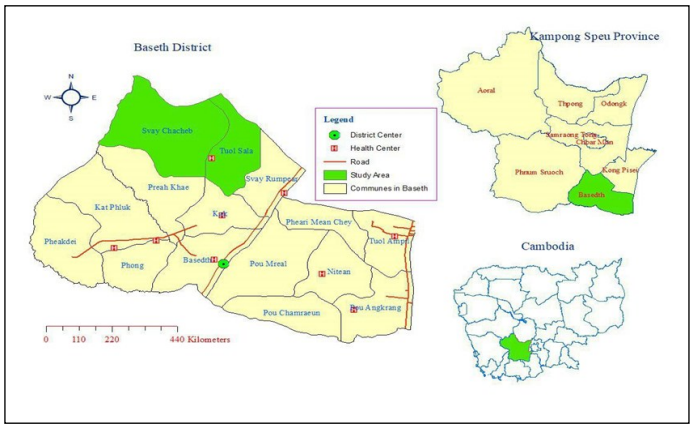

Fig. 1. Maps of Kampong Speu province and Baseth District.

Baseth District has the second-largest district population in Kampong Speu Province; only the Samraong Tong district is larger. Baseth district has 32,938 households and 136,971 people, including 72,146 females, and an average household size of 4.2 persons (MoP, 2019). This province has a system of dams to retain runoff water from nearby mountains and to control floods. These dams have played a crucial role in rice cultivation and for providing a water supply for communities in the Baseth district. The storage quantities have significantly decreased, creating a water shortage for irrigation and household use in the dry season (UNIES, 2008).

This study employed exploratory and descriptive approaches to examine community applied strategies to cope with water scarcity affected by climate change and building resilience for improving water availability to be able to support daily water consumption and agriculture-related activities in the Baseth district of Kampong Speu Provinces. The study site was selected on the basis of purposive sampling design. The study communes were selected by using a stratified sampling design reflecting the division between communes with an irrigation system and communes without an irrigation system. The household level sample has been selected using a

snowball method in order to identify low-income families that are vulnerable to the negative effects of climate change. A sample size of 103 villagers were selected and contacted for interviews in the two communes, with an acceptable rate of error of 6% (Yamane, 1967).

A quantitative approach was used for data processing and analysis. A T-test was applied to compare the differences in water usage between the communes with irrigation systems and those without irrigation systems. A Weighted Average Index (WAI) was used to evaluate the local community's perception and degree of satisfaction related to water scarcity as well as the impact of climate change on water scarcity and food security. Qualitative techniques were employed to analyse and supplement the quantitative data, mainly by using problem analysis to understand the current water shortage effects caused by climate change and the encountered water scarcity problems impacting daily consumption and agriculture. The perceptions of local people were recorded regarding the severity of climate change impacts that are now affecting the water sector, water shortages in the community during periods of water scarcity, and on how local communities engaged with government agencies and NGOs to improve community resilience to water scarcity. The data comes from the survey and from key informant interviews. The primary and secondary data were triangulated.

3. Results and discussion

3.1 The negative impact of water scarcity on the agricultural sector due to climate change

In Cambodia, the agricultural sector is dependent on water for raising crops and livestock. Water management is very important for supporting consumption in households, communities, and other sectors such as education, health and industry in Cambodia. Climate change has negatively impacted the agricultural sector, it makes rainfall irregular, results in global warming, and prolongs the dry season. It also impacts those living in rural areas. Out of the total, 68.9% of farmers were using water from the rain, and 40.8% of them used reservoir (from dams) or canal water for agriculture (**Fig. 2**). The irrigation system was found to be inadequate because some small canals were broken, some of the wells were dry, and some of lakes had no water from November to March. The poor households found it challenging to access the water for agricultural production, and they cannot achieve sufficient yields to support

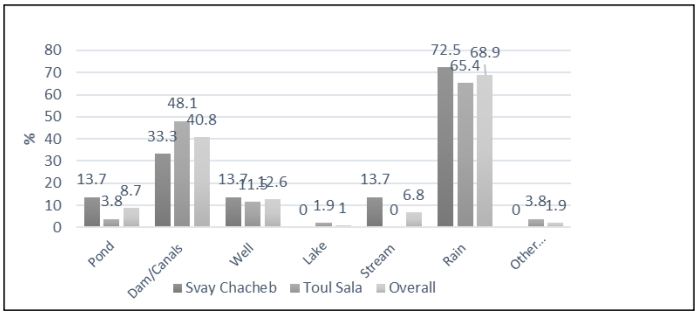

Fig. 2. Sources of water for agriculture.

Villagers in Toul Sala commune are farmers focused on rice cultivation, making water is very important for them. In addition to rice farming, they also grow vegetables, raise livestock, and farm fish for both consumption and for increasing household income. Villagers need more irrigation systems, community ponds, and wells in their commune. Also, in the process of agriculture production, the farmers spent money (approximately 100,000 riels per family) for production inputs such as the purchase of pump machines, pump motors, and equipment for water storage.

Table 1 illustrates the degree of Importance of water use in the agricultural sector. Respondents rated the importance of water use for different activities. They rated rice farming with a high degree of importance. The respondents rated gardening, raising livestock, and fish farming as involving a moderate degree of water use. The respondents in both Communes shared similar views regarding to the importance of water use in those agricultural activities. In general, water is life to farmers, but they have to depend on rain for agricultural activities. Irrigation systems have played a key role by increasing the access to water among farmers, but current provisions from irrigation systems were found to be inadequate.

3.2 Impact of water scarcity on food security in Tuol Sala and Svay Chacheb communes

Water is very important for cultivation of all crops. The farmers in the rural areas mostly depend on rice farming. 81% of respondents face

Table 1. Importance of Water Use in Agriculture Activities.

Attributes	Svay Chacheb		Tuol Sala		Overall		*P*-Value
	WAI	OA	WAI	OA	WAI	OA	OA
Rice farming	0.71	H	0.80	H	0.76	H	0.02
Gardening	0.49	M	0.58	M	0.54	M	0.02
Raising Livestock	0.48	M	0.47	M	0.47	M	0.77
Fish farming	0.48	M	0.52	M	0.50	M	0.52

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.

food insecurity related to insufficient food productivity. This entails no stock of rice for monthly consumption. Water shortage is a primary cause of inadequate yields for small farmers.

The survey also found that, food was very common for farmers in rural areas, especially poor households (those holding ID poor designation). Primarily, they faced problems with access to food and food safety. In Tuol Sala commune, the irrigation system was insufficient, the water provided did not meet the amount needed for daily consumption or agriculture businesses. The amount obtained from rainfall was insufficient for agricultural production, especially rice production. The survey showed that, 82.7% of respondents faced food shortages during 4-5 months per year (June- October) (**Fig 3&4**).

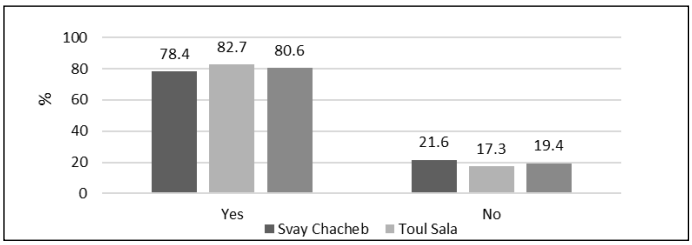

Fig. 3. Food shortage.

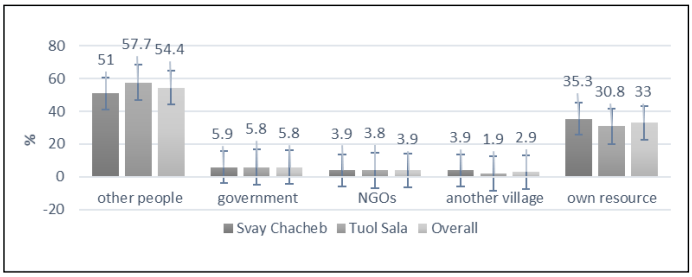

Fig. 4. Addressing food shortages from the impact of climate change.

In Cambodia, poor households can be found in both urban and rural areas. Those families do not have appropriate housing, less land, low knowledge, a lot of members (5-7 persons), and less income. The results of the survey showed that when villagers faced a food shortage, 54% of respondents addressed the problem by borrowing from others, while 33% use their own resources and 2.9% found support from other villages. Overall, the two communes have similar solutions and support mechanisms. Non-governmental organizations and government agencies provided funds to support them, but only for short periods of time. So, climate change resilience policies and strategies for agriculture should be applied in those areas.

In Cambodia, climate change has affected the whole country. The irrigation system is still limited. Most poor people do not fully understand the impact of climate change on their daily livelihood. On the other hand, the dissemination of the concept of climate change is not widespread among the rural population. The Weighted Average Index (WAI) found the respondents endured a high degree of severity of negative impacts of climate change on livelihoods, and very high degree of severity of negative impacts of climate change on food shortages. All types of jobs in the districts studied are linked to water resources. So, water scarcity reduces livelihood activities. In general, farmers in the areas studied did not have alternative livelihoods in other sectors and young people have to migrate to urban areas in search of jobs. For those living in the communities studied, agriculture is the source of their livelihood. As a result, water is very important for their jobs and their personal consumption.

3.3 Mechanisms for supporting the water supply for agriculture and consumption

In the Tuol Sala commune, there were two

Table 2. Local perceptions of the impacts of climate change on food security.

Attributes	Svay Chacheb (n=51)		Tuol Sala (n=52)		Overall (n=103)		*P*-Value
	WAI	OA	WAI	OA	WAI	OA	OA
Severity of impact on livelihoods	0.80	H	0.78	H	0.79	H	0.75
Severity of food shortages	0.82	VH	0.79	H	0.81	VH	0.34

WAI = Weighted 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.

water storage reservoirs, five small Dams, seven natural lakes, and 185 wells supplying 17 villages. All sources dried out from March to April. In some areas, it is not possible to access the groundwater resources. Svay Chacheb commune did not experience water scarcity problems as it has 7 water storage reservoirs, and 5 Dams for supplying 15 villages. All these sources resulted from support from the government and from non-governmental organizations (**Fig.5**).

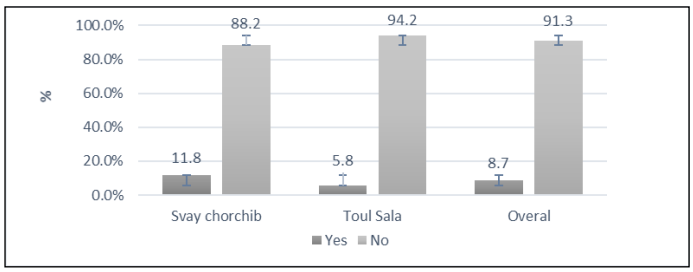

Fig. 5. Water support in the areas studied.

However, based on the results of the study, each household has little water storage equipment. 8.7% were supported by the government and non-governmental organizations. According to key informant interviews with the village chiefs and commune councils, during a period of drought, The Department of Rural Development, in collaboration with District Agriculture Office and Commune administration and Village authorities, intervened to pump water for distribution to address the impact of water shortages on access for agriculture, especially rice farming. But for daily consumption, the farmers need to find a solution by themselves. These problems of water scarcity result from inadequate irrigation supplies or from wells that cannot access water. It is necessary for the government and non-governmental organizations to research water demand for each village, and plan projects and implement policies accordingly.

Climate change substantially affects water resources. The farmers have employed multiple methods for improving resilience. According the information collected (see **Fig. 6**), the farmers used four approaches to resilience to the impact of climate change. These were: to dig a pond or well; to utilize water storage equipment; to save money; and to do nothing. Overall, 72% of respondents used water storage equipment for water management. Only 20% of respondents opted to dig a pond or well when faced with a water shortage. In the Toul Sala commune, approximately 85% of respondents used water storage equipment, which was higher than the amount found for Svay Chacheb commune.

The household survey data provides preliminary information on vulnerability, knowledge, and the demographic effects of extreme weather and climate change events in both communes studied. Results show that climate change hazards (droughts) pose a risk to agricultural production and to water supplies. The study assessed the resilience to climate change experienced by villagers and the severity of its impacts on the water sector and food security. Local stability in the area studied is markedly low as the agriculture industry and water supply are highly vulnerable to drought. In this way, the study identifies how climate change affects Cambodia's water resources and food security. This study provides information to answer questions about why the water supply is insufficient for agriculture and daily consumption. As well, it shows that water scarcity does impact food security, and that water security is caused by climate change.

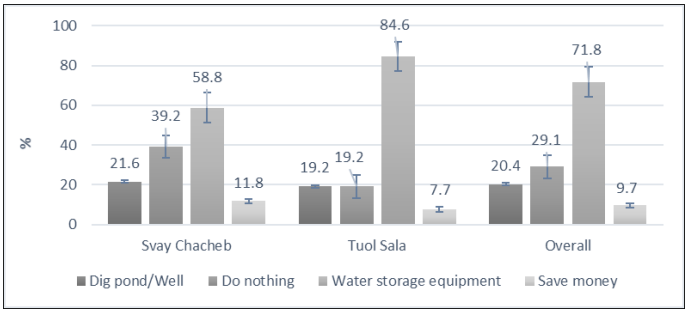

Fig. 6. Approach to Increasing Resilience to Climate Change

The study has analyzed the effects of climate change on important factors such as livelihoods.

3.4 Not enough water for agriculture and consumption in the area studied

Water shortage is a major global issue and will be exacerbated by increases in population and climate change. Various studies have explored how both of these factors might affect global water scarcity in the future by using population projections and simulated changes in climate based on global climate models (GCMs) combined with water resource models (Alcamo et al., 2007; Arnell et al., 2011). A substantial proportion of the uncertainty in the global-scale effect of climate change on water scarcity is due to uncertainty in the estimates for East Asia and South Asia. Additionally, an investigation into scenarios related to the impact of global mean temperature change shows rapid increases in water scarcity due to climate change across many regions of the globe (based on projected temperature increases of 2 ℃ and stabilizing at a 4 ℃ increase (Gosling & Arnell, 2016).

Cambodia has abundant water supplies overall. However, as Cambodia only has one rainy season a year, the problem for access to water is more about the regional and seasonal distribution of resources. As economic development and population growth put water resources under growing stress, understanding the interactions and interconnections between water, environment, and society is an absolute necessity for balanced and fair management of the water supply in the basin (Keskinen, 2006). Resilience-oriented actions to cope with the impacts of climate change impacts include several plans enacted by the government, including the rehabilitation and construction of new irrigation infrastructure such as canals, pumping stations, flood protection barriers, and water control gates.

Furthermore, the government has expanded the reach of irrigation systems, developed technology for improved land and water use, explored alternative water sources, and improved operational and institutional performance. Since the middle of the year 2000, there has been much interest and investment in irrigation systems, with over USD 1.3 billion (20% government, 80% development partners) going into the restoration of present irrigation arrangements and into the construction of several large new irrigation systems and reservoirs. Further funding in the amount of at least USD 2.5 billion will be invested in irrigation and the development of the water supply resources by 2033. Prior to recent investments, 1,926 of 2,500 irrigation schemes needed to be completely rehabilitated, and water delivery was found to be inefficient (Monin, 2021).

The impacts of climate change on agriculture and water resources are severe because those sectors are inherently sensitive to climate conditions and among the most vulnerable to drought. Climate hazards can impact agriculture, reduce resource productivity, causing loss and damage equivalent to 17% of national GDP by 2050 (Monin, 2021). Local people in the area studied commonly face water scarcity, which can badly affect human health and agricultural productivity. Consequently, people may need to spend money to buy water. The limited irrigation and water resource can make it difficult for people in the community to work in agriculture. Insufficient equipment for water storage results in people in the study area lacking water for daily consumption. It is challenging to live in such a situation, and the livelihoods of low-income families cannot be improved.

3.5 Water scarcity has a substantial negative impact on food security

Cambodia has a large diversity of water sources. However, the capacity to adopt these sources for use in agricultural production and daily life was found to be limited. Various government development policies promote improved access to water for the agriculture sector, supported by the state, international agencies, and

non-governmental organizations (Bunthan, 2006). Water security is significant for development. Agriculture accounts for 69% of water use, while industry uses 23% and domestic use takes 8%. Maintenance techniques, skills, and ways to sustain usage of the existing water supplies need to be disseminated to the consumers of water resources. Water management, water treatment, irrigation and drainage systems, and other water-related courses must be expressly incorporated into the academic programs of higher education because those practices and systems play a critical role in the in the livelihoods of the rural poor (Muukkonen, 2007).

In practice, access to water depends on proximity to the water basin or irrigation systems. Water resources are essential for the socio-economic performance of Cambodia. However, long-term planning does not seem to be a vital element in Cambodian water management, locals do not seem to be able to effectively voice their interests when it comes to water use (Sokhem & Sunada, 2006). Although water resources have supported the livelihoods of people in Cambodia in the past, in recent decades, social challenges and natural resources decline have put access to water at risk. The state pays an important role in creating rules and supporting stronger controls related to water resources. Annual climatic changes are a significant problem in agriculture. Moreover, farming techniques are not very effective because agricultural production in Cambodia remains heavily dependent on the weather (Muukkonen, 2007). The people in the area studied area face food shortages linked to small land use for agriculture and water shortages. Water scarcity reduced yields of crops, resulting in less profit for the farmer. Rural villagers were found to be very concerned about the changing weather, and water resources were found to be moderately vulnerable to drought.

3.6 Water scarcity is caused by climate change

The water resources in all regions range from low to high vulnerability. Drought can compound local communities' low resilience capacity which is linked to factors such as poverty, poor infrastructure, lack of social safety and resilience, little shared understanding of the causes and effects of climate change, and inadequate hazard predictions and warnings (even though droughts are becoming increasingly frequent). Local households and communities deal with climate risks mainly by depending on natural resources, which will not be enough to mitigate climate change (WWAP, 2016).

The results show that local people were very concerned with the impact of climate change on the water sector. In 2019, there was a short drought and it affected water use for the agriculture sector and daily consumption for members of the community. In each household, water storage equipment is limited. Government and local NGOs should have more projects for pond restoration and infrastructure (irrigation systems) development, as well as campaigns for climate change awareness.

Government agencies, should be careful with yearly data collection related to water supplies, because it is very important for sustainable water management to ensure that enough water is provided on time. The irrigation systems, wells, ponds, and dams should be restored, and new construction should occur to meet the demand. Non-governmental organizations should work closely with government agencies to find more funding for rural development. The local community must take care of water resources, and there should be support for related properties from stakeholders.

4. Conclusion

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

The shock of the Covid-19 pandemic has coincided with other shocks and trends such as the

risk of economic crisis and financial collapse, the disruption of supply chains, and impacts on the poor due to a lack of alternative livelihood opportunities and the absence of social safety nets. The Covid-19 outbreak has shed new light on agriculture and the imperative of ensuring food security. The impacts of climate change on water resources and agriculture vary depending on location and on the levels of exposure and resilience capacity. Agriculture and water are among the high priority sectors for achieving the targets of the Cambodia Sustainable Development Goals, Cambodia Climate Change Strategic Plan 2014-2023, and Cambodia's Nationally Determined Contributions under the UN Framework Convention on Climate Change.

This research set out to identify groups of people who are vulnerable, especially poor families, to climate change and their resilience and practices coping with climate hazards. In Cambodia, the agriculture sector depends on water for raising crops and raising livestock. Water management is very important for use in households, communities, and industry. There are three findings of the research in the area studied. First, the negative impact of water scarcity on the agriculture sector caused by climate change. Climate change increases rainfall irregularity, average temperatures, and the length of the dry season. This has a substantial negative impact on those living in rural areas who depend on rainfall for water and on agriculture for their livelihoods. Research found that 69% percent of water used by farmers came from rain, while 41% came dams or irrigation canals.

The irrigation system was found to be insufficient, as some small canals were broken, some wells were dry, and the ponds had no water between November and March. The poor households find it challenging to access water for agricultural production and this reduces the harvest yields. Farmers found it necessary to use additional water sources (pond, well, lake, or stream), if their area had them. In the areas studied, irrigation systems and water sources were limited. Many wells, ponds, and canals had little or no water in the dry season, or a low level of access for farmers. This impacted both agricultural activities and daily consumption. Water scarcity was found to be detrimental to the livelihoods of villagers in terms of its impact on rice farming, vegetable farming, raising livestock, and farming fish. More access to water was needed (through irrigation and reservoirs) for household income and consumption. For agricultural production the farmers spent money for agriculture production equipment (pump machine, pump motor, and water storage containers) which amounted to approximately 100,000 riels/family.

The second impact of water scarcity is on food security. Water is very important for all agriculture. The farmers in the rural areas mostly depend on rice cultivation. Food insecurity consistently affects farmers in rural areas, especially poor families. 81% of the respondents, were found to suffer from it. They indicated that they had no rice stocks stored for consumption. Water shortages impact their small agriculture lands, reducing yields. The survey also found that, in Tuol Sala commune, the irrigation system was inadequate, and the water provision was not enough for daily consumption or agriculture business. Water supplied by rainfall was insufficient for agricultural production, especially rice farming. The survey found that 83% of respondents faced food shortages from 4-5 months per year (June-October). The Weighted Average Index (WAI) found the respondents endured a high degree of severity of negative impacts of climate change on livelihoods, and very high degree of severity of negative impacts of climate change on food shortages. Farmers should be applying resilience practices to reduce the impact of climate change on food insecurity and livelihoods.

Mechanisms for supporting water provisions for agriculture and consumption, in the Tuol Sala commune, include: 2 water storage reservoirs, 5 small dams, 7 natural lakes, and 185 wells to provide for 17 villages. All sources frequently dry out during the period from March to April. Moreover, in some areas water cannot be collected from the underground water table. Svay Chacheb commune has 7 water storage reservoirs, and 5 dams to provide for 15 villages. All these were made possible by support from the government and donors. However, based on the result of the studies, each household has little water storage equipment in their families. 8.7% of respondent

received support from government and/or nongovernmental organizations, while 91.3% found a solution by themselves.

According to key informant interviews with the village chiefs and commune councils, during periods of drought, The Department of Rural Development, in collaboration with District Agriculture Office and Commune administration and Village authorities, intervened to pump water for distribution to address the impact of water shortages on access for agriculture, especially rice growing. However, for daily consumption, the farmers needed to solve the problem of water shortages by themselves. The problem of water scarcity was found to result from stoppages of irrigation systems and wells that had run dry. It is suggested that the government and nongovernmental organizations should be researching water demand for each village in order to prepare for planning and to support projects.

Climate change substantially affects the water sector. Farmers have used multiple methods to improve resilience. According the research findings (see figure 6), farmers use two approaches to resilience to the impacts of climate change on water supply. The first is digging ponds and wells, the second is employing water storage equipment. Overall, 72% of respondents indicated that they employed water storage equipment for water management. Only 20% of respondents indicated that they dug a pond or well to support their family when facing a water shortage. In Tuol Sala commune, 85% of respondents indicated that they used such methods, which was notably higher than the rate in Svay Chacheb commune. Farmer needs increase the use of water storage equipment to cope with climate change. Local community adaptive capacity levels for both agriculture and water resources were assessed to be low, as well as provision of information relating to the impacts of climate change on water development and water resource management.

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Declaration of competing interest

The authors declare that they have no competing interests.

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