Desk study of the nexus on climate, nutrition, and social security in Cambodia

Study Report

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ABBREVIATIONS

ADB	African Development Bank
APHRODITE	Asian Precipitation-Highly Resolved Observational Data Integration Towards Evaluation of the Water Resources
CARD	Council for Agricultural and Rural Development
CCPAP	Climate Change Priority Action Plan of MAFF
CIAS19	Cambodia Inter-Censal Agriculture Survey 2019
CMIP	Coupled Model Intercomparison Project
CRVA	Climate Risk and Vulnerability Assessment
CORDEX	Coordinated Regional climate Downscaling Experiment
CORDEX SEA	Coordinated Regional climate Downscaling Experiment for Southeast Asia
ESMs	Earth System Models
EWS	Early warning systems
FAO	Food and Agriculture Organization
FIES	food insecurity Experience Scale
FRP	Food Reserve Programme
g	Grams
GBN	Global Business Network (GIZ Programme)
GDP	Gross Domestic Product
GCM	General Circulation Models
GHI	Global Hunger Index
GLAM	General Large-Area Model
GMT	Global Mean Temperature
ha	Hectares
Hb	Haemoglobin
HbE	Haemoglobin E
HEF	Health Equity Fund
IFREDI	Cambodia's Inland Fisheries Research and Development Institute
IPCC	Intergovernmental Panel on Climate Change
ISIMIP	Intersectoral Impact Modelling Intercomparison Project
IYCF	Infant and Young Child Feeding
kcal	Kilocalories
KfW	Kreditanstalt für Wiederaufbau
KHR	Cambodian Riel
km	Kilometres
MAD	Minimum Acceptable Diets
MAFF	Ministry of Agriculture, Forestry and Fisheries
MDD	Minimum Dietary Diversity
MDD-W	Minimum Dietary Diversity for Women
MEF	Ministry of Economy and Finance
MMF	Minimum Meal Frequency
MoEYS	Ministry of Education, Youth and Sport
MoLVT	Ministry of Labour and Vocational Training
MoSVY	Ministry of Social Affair, Veteran and Youth

MOWRAM	Ministry of Water Resources and Meteorology
NBS	Nutrition Baseline Survey
NCDM	National Committee for Disaster Management
NDC	Nationally Determined Contributions
NSPC	National Social Protection Council
NSPPF	National Social Protection Policy Framework
OECD	Organization for Economic Cooperation and Development
PPM	Parts Per Million
PPP	Purchasing Power Parity (GDP per capita)
PwD	People with Disability
RCMs	Regional Climate Models
RCP	Representative Concentration Pathway
SDG	Sustainable Development Goals
SSPs	Shared Socio-economic Pathways
t	Tonnes
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States Dollar
WFP	World Food Programme
WHO	World Health Organisation
WRA	Women of Reproductive Age
µg/L	Microgram per Litre

Executive Summary

Status of food and nutrition security in Cambodia

- Food availability is not a barrier to consuming a nutritious diet for most Cambodians.
- Physical access to livestock and markets is good throughout the country.
- Majority (75.4%) of the total holdings of the country are small scale, 3.2 hectares (ha), contributing only 14% to the total production. The huge productivity gap compared to non-small farms makes them net food purchasers and hampers their access to nutritious diet. In 2017, 22% of the population had poor access to healthy diet due to non-affordability of recommended healthy dietary components.
- Utilisation pillar of food security is weak, despite economic progress, 9.6 million Cambodians are moderately or severely food insecure, overall the failure to meet energy requirements in the population is low (6% in 2021), with suboptimal intakes of various food groups/ dietary components.
- Food stability in terms of cereal and fish production is good.
- Only 32% of breastfed children (between 6-23 months of age) reach a minimum acceptable diet (MAD due to low minimum dietary diversity (MDD) (40%), while minimum meal frequency (MMF) was reached for over 74% of children[1].
- Cambodia faces a nutrition crisis[2] since stunting levels were classified as of high risk[3] (24.5%) in 2014 and continue to be of high risk (20.8) in 2022 for children up to 23 months of age and of high risk (32.4%) for children between 6 to 59 months in 2014 and still remain high (21.9% in 0-59 months) in 2022. Similarly, wasting levels were in high risk in both 0-23 months (11.5%) and 6-59 months (9.7%) children in 2014 which dropped to medium risk in both the age groups (9.8% in 0-23 months, 9.5% in 24-59 months). More than half (55%) of children in 2014 from 6-23 months were reported to be anaemic, though not primarily due to iron deficiency anaemia as haemoglobinopathies were also prevalent.
- In the women in reproductive age (WRA) group, anemia continues to be a problem of public health importance in 2014 (over 40% of WRA), though the causes of anemia were iron deficiency anemia, haemoglobinopathies and sickle cell anemia in almost the same proportions.

Climate change in Cambodia

- Cambodia has been categorised as a country that is "highly vulnerable" to the effects of climate change (12th most impacted country, globally).
- Cambodia's temperature projections to the end of the century see a year-on-year increase of between 0.013°C and 0.036°C, or between ~+0.39°C and ~+1.1°C by 2050; rainfall trends are less clear with some models predicting slight annual average decreases in the northeast, while the northwest may see slight increases in precipitation during the wet season.
- Climate risks in Cambodia are largely due to a high 'climate variability' (irregular rainfall, worsening floods, and prolonged, unpredictable droughts) and the impacts these have on important sectors that have

[1] *Note: The indicators minimum acceptable diet (MAD), minimum dietary diversity (MDD) and minimum meal frequency (MMF) are three of eight core indicators for assessing infant and young child feeding (IYCF), practices developed by the World Health Organization (WHO) and finalized at the WHO global consensus meeting on indicators of IYCF in 2007.*

[2] Cambodia Demographic and Health Survey (CDHS) 2014 and CDHS, 2022

[3] de Onis, M., et al. (2018). Prevalence thresholds for wasting, overweight and stunting in children under 5 years. Public health nutrition, 22(1), 175-179.

low adaptive capacities, specifically the agriculture, forestry and fisheries, rural infrastructure and health sectors.

- Food production is predicted to be negatively impacted by increasing temperatures and the impact that more erratic, unpredictable rainfall patterns and drought events have on the agricultural sector. There is also some evidence of a likely reduction in protein and micronutrient concentrations in rice due to higher atmospheric CO_2 levels.
- Elevated atmospheric CO_2 concentrations are predicted to increase yield potentials of rice, though these benefits are unlikely to be achieved without the adoption of significant adaptation improvements (e.g., irrigation, access to improved drought/ flood resilient varieties, soil health and soil protection measures, on-slope and in-stream rainwater harvesting, and landscape management).

Social security situation and vulnerability of WRA, children <5 years old and smallholders to climate change

- Farmers in Cambodia are exposed to significant risks and constraints that make the outcome of farming activities uncertain and often scarcely remunerating. Further challenges have recently arisen due to changes in climatic patterns and in dynamics of international trade, that have both exacerbated the unpredictability and the low profitability of agricultural activities.
- According to the German development bank *Kreditanstalt für Wiederaufbau* (KfW) scoping study for supporting agricultural insurance (November 2018), rice, vegetable and high-value crop growers are expected to be the main potential users of insurance products in the future. Potential crop insurance products are likely to be indemnity (yield guarantee). Some of the major issues that may influence the development of agricultural insurance in Cambodia are: (1) small size of the sector and lack of technical knowledge and expertise on both the public and private sectors side; (2) inadequate insurance regulation; (3) need for individually tailored and/or customisable insurance solutions for the diverse set of crops that are cultivated in Cambodia (but lack of local expertise to develop such solutions); and (4) need for further processing of data on agricultural production and weather variables.
- Cambodia will require a diverse range of agricultural insurance products such as yield guarantee, weather and yield indexes, as well as Catastrophic risk mitigation-level programs for the national and provincial governments.
- Cambodia should consider:
  - Introducing a voluntary insurance program with certain mandatory requirements for the farmers to fulfil in order to be eligible for government assistance in case of severe or catastrophic weather events
  - Developing a separate catastrophic risk mitigation program to provide support to rural population, i.e., subsistence farmers
  - Supporting agricultural insurance schemes with a subsidy program
  - Encouraging financial institutions to bundle agricultural loans with insurance products
  - Facilitating the application of new technologies such as remote-sensing technologies and reanalysed weather data services
  - Facilitating provision of technical assistance to both insurance companies and government agencies

Adaptation options and needs

- Adaptation of food production systems include the following: use of climate-resilient cultivars and breeds (drought and heat stress resistant); Sustainable intensification to increase yields of rice – dominant stapple

crop in Cambodia; Conservation agriculture (CA) techniques that minimise inputs and reduce environmental impacts such as nutrient leaching; Improved water management in rice paddy and home gardens.

- Diversification through development of mixed systems (rice-duck, rice-fish and agroforestry systems) can generate multiple ecological benefits and buffer climate shocks.
- Diversification of aquaculture species can help minimise economic losses from production shocks.
- In home gardens, root vegetables such as edible cassava pumpkin should be promoted as they are particularly resilient to climate variability and shocks.
- Agriculture diversification to increase livestock and vegetables production is a key strategy to address both climate risks on food availability and underutilisation of and lack of access to diverse food, essential to a healthy nutritious diet.
- Implementing CA, System of Rice Intensification (SRI) and climate-smart agriculture (CSA) type farming practices in general can provide the conditions needed to manage water, farmland and crop production sustainably and productively into the future. Special care should be taken to address inequity, such as unequal power relations in decision-making at the household level, to ensure WRA fully benefit from the implementation of these techniques and practices, and effectively reduce labour burden and increase purchase power.
- Adaptation targeting social resilience include Home Grown School Feeding (HGSF), Cash-based social assistance, Social Health Insurance (SHI) programme and a temporary, shock-specific cash transfer programme.
- The Cambodian Government, and MAFF in particular, have developed a number of Priority Adaptation Actions for addressing the impacts of climate change on agricultural productivity. The Ministry of Women's Affairs have also identified Priority Adaptation Actions related to nutrition (Climate Change Priority Action Plan (CCPAP) 2016-2020 & Nationally Determined Contribution, 2020).

Policy recommendations

- The resilience of food production systems in Cambodia and the achievement of sustainable intensification of food production under both current and future climate conditions depend on the successful promotion and adoption of climate adaptation strategies targeting the following priority areas: 1) water resources, 2) soil health, and 3) crop yields and income.
- Implementation through integrated social protection and payment for ecosystem services mechanisms can help target poorer households.
- Home gardens play a central role for food security and nutrition of the target group. Increasing their resilience and development through the adoption of technologies and conservation practices that improve soil health and water management is a priority. Capacity building activity is another priority action.
- School feeding program and cash support are essential mechanisms for ensuring food security and nutrition of children of vulnerable households, WRA and smallholding households, and are effective schemes to address acute food and/or income shortages during climate shocks.
- Four specific priorities for improving food security and nutrition status of the target group include healthy diets for all (targeting food availability, access and utilisation), empowerment of youth, women and the vulnerable, resilient and sustainable livelihoods, and just, inclusive and participative governance for a more inclusive food system.

1 Introduction

This desk study aims to provide targeted and systemic information on the effects of climate change on food and nutrition security of selected vulnerable populations in Cambodia, as well as their current adaptive capacity through existing social security programs and future adaptation needs under projected climate change in the next 30 years up to 2050.

The vulnerable populations targeted in this study (hereafter mentioned as "the target group") consist of

- women of reproductive age (WRA) from 15-49 years,
- young children up to two years of age, and
- small scale farmers

in the provinces of Kampong Thom and Kampot (hereafter mentioned as "target area" or "intervention area").

The main objectives of the study on the nexus of climate, nutrition, and social security in Cambodia are:

1. Brief analysis of country **climate information** and **early warning systems**, including relevant and available data for the target area.
2. Analysis of the **effects of climate change** with the perspective until 2050 on the target group in the target areas.
3. An assessment of which **existing measures** are already (1) climate-adaptive in the sense of ensuring sustainable healthy nutrition and (2) corresponding to an adaptive social security system.
4. Recommendations on what **additional measures** need to be considered in the short, medium, and long-term to **mitigate the effects** of climate change on the food situation and the adaptive social security systems (e.g., improved seeds, crop varieties and breeds, crop and livestock diversification, sustainable practices and technologies, and reconfiguration of food systems).

This study report presents a profile for Cambodia concerning food and nutrition security of the target group (section 2), climate situation, climate change and exposure (section 3), existing social protection systems and vulnerability (section 4). A summary of climate risks and vulnerability hotspots is presented in section 5. The study then examines adaptation needs and options (section 6) and proposes policy recommendations based on an appraisal of adaptation options targeting food security and nutrition (section 7). In addition, this report presents a brief assessment of national climate information and early warning systems (EWS) and their relevance and availability for the target areas (Annex 1).

1.1 Introduction to the CRVA

The CRVA follows the IPCC approach to climate risks, in which vulnerability along with climate hazards driving impacts and exposure are the three components.

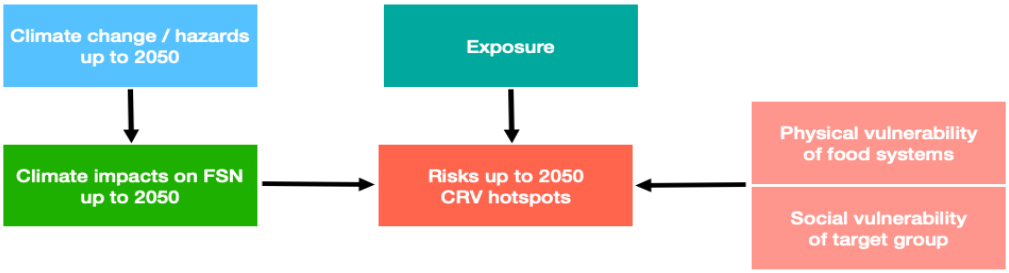


Figure 1: Diagram of the CRVA approach

1.2 Geographical characteristics of Cambodia

Cambodia is a country in Southeast Asia, neighbouring Laos, Thailand, and Vietnam, with a 443 kilometre (km) coastal region on the Gulf of Thailand. Cambodia has a total surface area of 181,040 km^2, with 176,520 km^2 of land, among which 32% are cultivated, and 47% are forested[4]. The country's main freshwater sources come from the Mekong River, flowing from Laos in the north to the Mekong Delta of Vietnam in the south. The Tonle Sap Lake is almost 10% of the country's surface area during the peak of the southwest monsoon season. Cambodia's topography includes the low-lying central plains of the Mekong, which are mountainous and highland regions.

Figure 2: Map of Cambodia

The population of Cambodia is approximately 16.5 million people (2019), with a predominantly rural population (76%). Cambodia's population relies heavily on agriculture and fisheries, providing 25% of gross domestic product (GDP) and employing 49% of the country's labour force. Aquaculture and fishing from the Tonle Sap Lake constitute the main protein food source[5]. Rural areas (small scale farmers) are on the front line of a changing climate. Floods and droughts frequently threaten the food system and will increase in frequency and intensity in the future[6].

[4] (Food and Agriculture Organization of the United Nations, 2021)

[5] (World Bank and Asian Development, 2021)

[6] (World Food Programme, 2022)

2 Food and nutrition security situation

Take away points

- Food availability is not a barrier to consuming a nutritious diet for most Cambodians.
- Physical access to livestock and markets is good throughout the country.
- Majority (75.4%) of the total holdings of the country are small scale, 3.2 hectares (ha), contributing only 14% to the total production, having huge productivity gap from non-small farms, making them net food purchasers, hampering their access to nutritious diet. In 2017, 22% of the population had poor access to healthy diet due to non-affordability of recommended healthy dietary components.
- Utilisation pillar of food security is weak, despite economic progress, 9.6 million Cambodians are moderately or severely food insecure, overall, the failure to meet energy requirements in the population is low (6% in 2021), with suboptimal intakes of various food groups/ dietary components.
- Food stability in terms of cereal and fish production is good.
- Only 32% of breastfed children (between 6-23 months of age) reach a minimum acceptable diet (MAD due to low minimum dietary diversity (MDD) (40%), while minimum meal frequency (MMF) was reached for over 74% of children[7].
- Cambodia faces a nutrition crisis[8] since stunting levels were classified as of high risk (24.5% in 2014 and 20.8% in 2022) for children up to 23 months of age and of high risk (32.4%) for children between 6 to 59 months. Similarly, wasting levels were in high risk in both 0-23 months (11.5%) and 6-59 months (9.7%) children in 2014 and dropped to medium risk in 2022 (9.8% in 0-23 months and 9.5% in 24-59 months). More than half (55%) of children from 6-23 months were reported to be anaemic in 2014, though not primarily due to iron deficiency anaemia as haemoglobinopathies were also prevalent.
- In the WRA group, anaemia continues to be a problem of public health importance in 2014 (over 40% of WRA), though the causes of anaemia were iron deficiency anaemia, haemoglobinopathies and sickle cell anaemia in almost the same proportions.

This section covers the state of food security and nutrition in Cambodia with a discussion on availability, access, utilisation, and stability, as well as nutrition status in young children and WRA based on available national data of Cambodia.

Properly nourished children have better educational achievements and better potential to delay the onset of non-communicable diseases in adult life, are more productive, and learn better. The foundation is laid in the first thousand days of life, starting from conception to two years of age, when most effects of child malnutrition are irreversible[9], especially poor cognitive development with potential to reduce scholastic achievements and thereby long-term earning potential[10]. Infant and young child feeding practices are essential for optimal nutritional status in the first thousand days of life.

[7] *Note: The indicators minimum acceptable diet (MAD), minimum dietary diversity (MDD) and minimum meal frequency (MMF) are three of eight core indicators for assessing infant and young child feeding (IYCF), practices developed by the World Health Organization (WHO) and finalized at the WHO global consensus meeting on indicators of IYCF in 2007.*

[8] CDHS, 2014 and CDHS, 2022

[9] *Note: Studies have shown that children can have a 2nd opportunity to catch-up growth during the teen years.*

[10] (FHI Solutions LLC., 2022)

2.1 Food production systems

Cambodia is endowed with a diverse food system and rich culinary history. Agriculture in Cambodia is mostly traditional and subsistence oriented, centred on paddy rice production. Crop yields remain low, relying on low input and rainfed production systems.

Supply chains are short due to smaller urban populations, resulting in many local, fragmented markets. Food losses are high due to inadequate storage and distribution infrastructure. Food is mainly sold in informal market outlets, including independently owned small shops, street vendors, and local public markets. Supermarkets and fast food are beginning to grow in number but are mainly seen in more developed localities.

Starchy staples are highly available: the quantity, diversity, and prices of foods available are season dependent. Processed and packaged foods have started to emerge in retail stores.

The Cambodian diet consists largely of staple grains, roots and tubers, legumes, and some seasonal fruits and vegetables, with less access to animal-sourced foods[11].

- **Crop production**

The ten most important food crops grown in Cambodia in terms of harvested areas are rice, cassava, maize, soybean, vegetables, sugarcane, beans, sesame seed, bananas, and oil palm fruit (Figure 3).

Figure 3: Harvest area, production, and yield of major crops in Cambodia[12]

Crop	Harvest area (ha)	Production (t)	Yield (t/ha)
Paddy rice	2,917,391	10,960,000	3.8
Cassava	254,820	7,663,505	30.1
Maize	175,117	950,000	5.4
Soybeans	110,000	180,000	1.6
Fresh vegetables	97,787	624,613	6.4
Sugar cane	95,040	2,123,185	22.3
Beans	68,245	78,947	1.2
Sesame seed	4,000	30,000	0.8
Bananas	30,042	139,811	4.7
Oil palm fruit	24762	266929	10.8

Rice is the most important cereal staple in the daily diet of Cambodians and the main crop grown in the country. There are many types of rice grown in Cambodia, which can be divided into aromatic and white rice, with *Jasmine* and *White Gold* being the most popular varieties. Harvested areas reached nearly 3 million ha and

[11] (Espino, et al., 2021)

[12] (Food and Agriculture Organization of the United Nations, 2021)

production 11 million tonnes (t) in 2020, with resulting average rice yield of 3.8 t/ha – well below potential yield, despite a sharp increase since the 1990s. Rice is mostly grown during the wet season (87% of the harvested area[13]). Irrigation infrastructure in Cambodia is underdeveloped, and little rice is irrigated.

- **Home gardens**

Home gardening is a traditional land use practice carried out around a homestead production consisting of mixed planting of herbs and species, leafy vegetables, roots, fruits, shrubs, grasses in a small plot to provide food, spices, medicines, and construction materials that are grown and maintained by the family members. Home gardens make an essential contribution to the food and nutrition security of poor rural households in Cambodia[14].

Case Study Example[15]

Kampong Thom, Popok Commune, most farmers grow some vegetables under the traditional "chamkar" system (small home plots), for household consumption and sale for extra income. Sowing of most vegetables begins with the onset of the dry season, whereas harvests are largely throughout the wet season. Just around 2% of households regard horticulture as their main livelihood activity and grow vegetables all year round for sale to local markets.

Fruit trees such as mango and lemon, and livestock including cattle, pig, ducks, and chicken are commonly integrated into the horticulture system. Due to its marketability, lemon is a particularly important fruit for female-headed households in need of extra income. Vegetables are important for household nutrition, especially for children.

Threats to horticulture systems include lack of water during the dry season and limited irrigation capacity resulting in low yields and fruitless trees; heavy rains spoiling vegetables; high incidence of diseases (citrus canker and leaf blight) and pests (leaf miner, citrus mealybug, stem borer and lemon tree caterpillar); low technical skill for pruning, weak access to improved varieties and markets; limited support from agricultural extension services and horticulture related agencies.

- **Capture fisheries and aquaculture**

Fish, molluscs, and crustaceans, whether fresh, dried, smoked or salted, constitute an import part of healthy, diverse diets across Cambodia. In fact, the rate of fish consumption per capita in Cambodia is one of the highest in the world[16]. In 2020, GIZ's programme *Global Business Network* (GBN) estimated that 234,000 household are involved in capture fishing activities, while a further 51,000 households practice or are in some way involved in aquaculture activities. Altogether, the fisheries subsector makes up 22% of agricultural GDP.

The zone with the largest number of households involved in capture fishing activity is the Tonle Sap Lake Zone, with 111,000 holdings reporting capture fishing activity[17]. The zone with the largest number of households involved in aquaculture is the Plain Zone, with 33,000 agricultural households reporting aquaculture activity[18]. Out of households that practice capture fishing it is estimated that approximately 75% of the catch is used for household consumption, with the remaining 25% being sold.

[13] (Ministry of Agriculture, Forestry and Fisheries, 2006)

[14] (Depenbusch, Schreinemachers, Brown, & al, 2022)

[15] (Russell, et al., 2022)

[16] (EuroCham Cambodia, 2020)

[17] (Corporate Innovation Asia , 2019)

[18] (Cambodia Inter-Censal Agriculture Survey , 2019)

The most prevalent aquaculture activity in Cambodia is pond-based aquaculture, with 41,000 agricultural households reporting its use. The Plain Zone reported the largest area devoted to pond culture, followed by the Tonle Sap Lake Zone[19].

Both forms of production, capture fishing and aquaculture, provide important economic benefits, as well as direct access to protein and other nutritious elements of a healthy diet for many resource-poor households, especially across the central plains and coastal areas.

Rice field fisheries, or fishing in and around rice fields, especially during the flood season, is an integral source of income, food, and nutrition in Cambodia. Many rural households are involved in rice field fisheries for subsistence and/or to supplement their livelihoods. In the Tonle Sap region's rice farming areas, rice field fisheries provide households with 62% of the fish they consume and up to 65% of households regularly or occasionally sell their catch.

- **Livestock**

Between 2012 and 2020, the livestock sector grew by approximately 50%. In 2021, livestock production constituted 2.6% of the national GDP. In the year 2020, half a million cattle, from a total stock of approximately 3 million heads, were slaughtered for their meat. Cattle production is almost exclusively a non-commercial small-scale activity. Pig production is also dominated by non-commercial, small-scale farming, though the number of commercially produced pigs has doubled in the last five years to the point where smallholders and commercial enterprises contribute near equal production (Figure 4).

According to GIZ's GBN programme, chicken raising has seen the greatest increase within the livestock sector in the last five years, though 80% of chicken rearing remains as non-commercial small-scale operations.

Figure 4: Meat production in 2020[20]

Commodity	Cattle	Pig	Chicken	Eggs
Production 2020	459,630	1,969,911	16,863,000	486,496,000

- **Trade partners**

Exports

In 2019, the top five partner countries and regions to which Cambodia exported food products were Vietnam (39.80%), China (19.43%), the United States (9.16%), Korea Republic (8.76%) and Australia (4.27%). The total value of food product exports was 197,154,000 USD[21]. Cambodia currently exports just over 5% of its rice production to China (2.1%), France (0.7%), Vietnam (0.4%) and Malaysia (0.4%). Cambodia exported 690,829 t of rice in 2020, at an average price of around 900 USD/t[22].

Imports

In 2019 the top 5 partner countries from which Cambodia imports food products are Thailand (32.15%), Indonesia (16.40%), Vietnam (10.44%) and Singapore (7.10%)[23]. Food imports are mainly in the form of processed foods. The Cambodian Livestock Association calculated in 2020, that the country imports approximately 1

[19] (Cambodia Inter-Censal Agriculture Survey , 2019)

[20] (Food and Agriculture Organization of the United Nations, 2021)

[21] (World Integrated Trade Solution , 2022)

[22] (Cambodia Rice Federation, 2021)

[23] (World Integrated Trade Solution , 2022)

billion United States Dollars (USD) of meat/ livestock and vegetables annually, mainly from Thailand, China, and Vietnam. Pigs, chickens, and ducks were highlighted as the dominant imported commodities. At 400 million USD annually, two fifth of this total expenditure is on pigs. According to the Ministry of Agriculture, Forestry and Fisheries (MAFF), vegetable imports amount to approximately 200 million USD per year.

Cambodia is a net importer of agricultural products for the last several years, resulting in agricultural trade deficit of 1.26 billion US dollars in 2018. Top agricultural products for export include cassava, rice, rubber, nuts, and animal feeds. At the same time, Cambodia imports massive amounts of high-value commodities (i.e., cigarettes, sugar, non-alcoholic beverages, and beer). The country is seen to export low-value agricultural primary products (i.e., fresh manioc or sliced cassava) and import high- value manufactured products and processed foods (i.e., starch, flour, and prepared meats)[24].

2.2 Status of food availability

Food availability is not a barrier to consuming a nutritious diet for most Cambodians. Figure 5 shows that Cambodia's national dietary energy supply was 2,700 kcal/capita/day in 2019, above WHO's recommendation. However, nearly 60% of this daily energy supply comes from cereals, chiefly rice. This is considerably higher than the global average (Figure 5), and suggests a lack of dietary diversity, especially regarding consumption of vegetables and fruits: only 144 g of fruits and vegetables are consumed daily, whilst recommendation is 400 g/capita/day. As fruits and vegetables are key source of vitamins and fibres, this could suggest a deficit in those. Sugar consumption is slightly above recommendation (11% instead of 10%)[25].

Fats and oils, who according to WHO's recommendation should provide 30% (70-90 g/capita/day for a total ~2000 kcal/day diet) of all energy needs, constitute a very small of energy intake in Cambodia ~4% (less than 40 g/capita/day) (Figure 6). A lack of fat in the diet contributes to poor absorption of vitamin A and another fat-soluble micronutrient.

WHO recommendations for a healthy diet[26]

According to WHO, a healthy diet comprises a combination of different foods, including:

- Staples like cereals (wheat, barley, rye, maize, or rice) or starchy tubers or roots (potato, yam, taro, or cassava) and whole grains (e.g., unprocessed maize, millet, oats, wheat, and brown rice)
- Legumes (lentils and beans)
- Fruit and vegetables
- Foods from animal sources (meat, fish, eggs and milk)

Nuts and whole grains (e.g., unprocessed maize, millet, oats, wheat, and brown rice) are a healthy source of protein, fibres and nutrients such as iron and zinc.

The WHO recommends the following specific intake:

- A person of healthy body weight should consume about 2000[27] kilocalories (kcal) per day
- Total fat should not exceed 30% of total energy intake. Unsaturated fats (found in fish, avocado, nuts, sunflower, soybean, canola, and olive oils) are preferable to saturated fats (found in fatty meat, butter, palm and coconut oil, cream, cheese, ghee and lard)
- Sugars consumption should be less than 10% of total energy intake, equivalent to 50 grams (g). Further reduction to less than 5% of total energy intake is suggested for additional health benefits
- At least 400 g (i.e., five portions) of fruit and vegetables per day, excluding potatoes, sweet potatoes, cassava and other starchy roots
- Less than 5 g of salt

[24] (Piseth, Monyoudom, & Tynarath, 2021)

[25] (Food and Agriculture Organization of the United Nations, 2021)

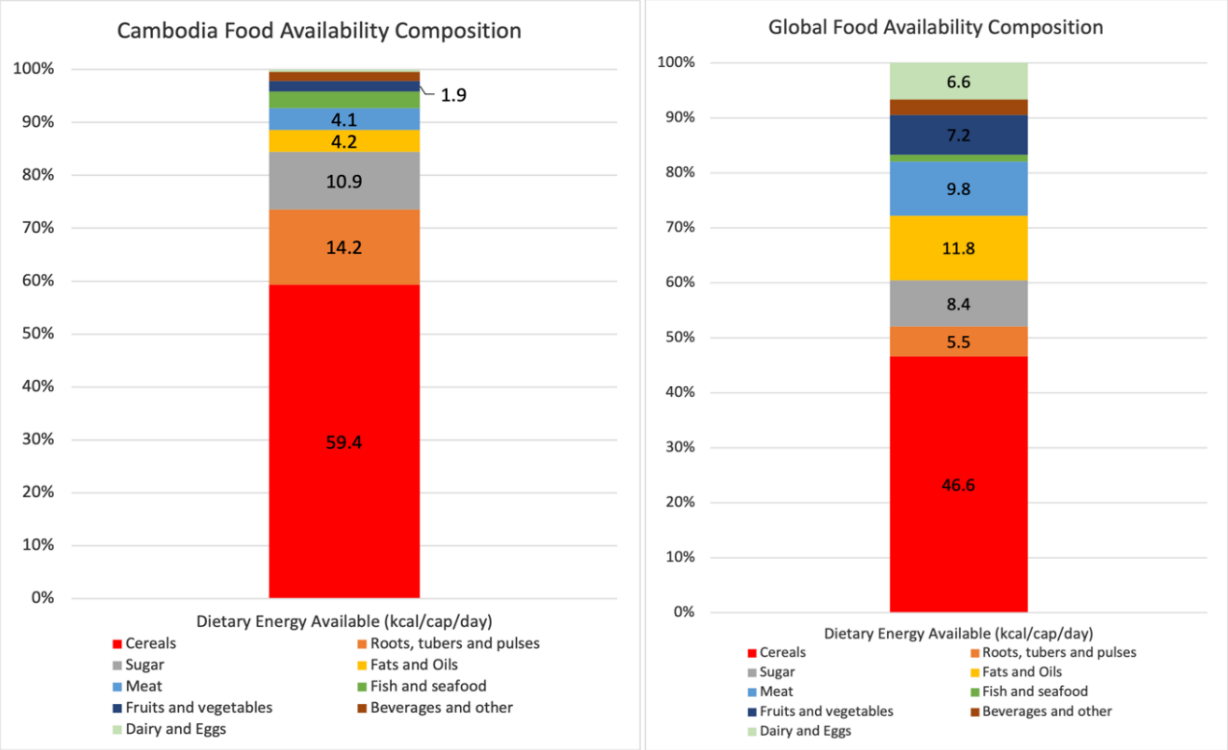
[26] (World Health Organization, 2020)

[27] Note: the recommended kcal consumption vary depending on different factors as height, weight, gender, general movement and physical activity.

Figure 5: Healthy diet recommendation compared to food availability situation in Cambodia in 2019[28]

	Total energy intake (kcal/capita/day)	Fruits and vegetables (g/capita/day)	Total fat (% of total energy)/ (g/capita/day)	Sugars (% of total energy)/ (g/capita/day)
Recommendation WHO	2,000	400	30/ 70-90	10/ 50
Cambodia	2,700	144	4/ 39	11/ 66

Figure 6: Status of food availability (Cambodia vs Global) (FAOSTAT 2019)



In terms of energy supply (Figure 6), roots, tubers and pulses (~14%) are the second most important food group for energy needs, whereas at global scale, fats and oils are the second most important food group. Meat also provides a far lower contribution (4%) to Cambodia's energy requirements than the global average (10%). At ~11%, sugars provide a slightly higher proportion of energy needs in Cambodia than is normal across other countries (~8%). Dairy and eggs, at less than 1% of total dietary energy intake, provide almost no energy benefits to Cambodians (Figure 6).

[28] (Food and Agriculture Organization of the United Nations, 2021)

Figure 7: Key food availability indicators in Cambodia[29]

Indicator with units	Supply national level (2010)	Supply national level (2019)	Recommended level
Energy supply (kcal/capita/day)	2,539	2,700	2,000
Share of dietary energy supply from cereals, roots, tubers (%)	71	68	50-60
Total protein supply (g/capita/day)	62	66	50-60[30]
Protein supply from animal origin (g/capita/day)	18	19	14-28
Fat supply (g/capita/day)	35	39	70-90[31]
Legumes supply (g/capita/day)	11	15	65-100
Vegetables (g/capita/day)	96	103	300
Fruits (g/capita/day)	67	41	200
Eggs (g/capita/day)	3	3	100
Milk (g/capita/day)	5	5	250

In terms of total protein supply (Figure 7), the average Cambodian diet provides adequate protein (66 g/capita/day) with adequate supply of protein being of animal origin (19 g/capita/day). Figure 8 shows that ~70% of the animal-origin protein comes from fish and seafood, while just 23% comes from meat (mainly beef, pork and chicken). Pulses (chiefly soybeans and beans) provide nearly 8 g (~12%) of total daily protein intake. Milk and eggs provide less than 1% of the total protein supply to Cambodian diets. Cambodians consume ~39 g/capita/day of fats and oils (Figure 7), out of which ~35% is derived from animal products and the remaining ~65% from vegetable sources. Palm oil as well as rice and rice-products are the dominant vegetable-based sources of oils and fats, while pig meat is providing most animal-derived oils and fats.

Figure 8: Distribution of energy supply per food items[32]

Food item	energy (kcal/capita/day)	energy (% total)
Rice and products	1563	58
Sugar (Raw Equivalent)	260	10
Cassava and products	234	9
Pig meat	66	2
Freshwater Fish	62	2
Palm Oil	58	2
Beans	51	2
Soyabeans	49	2
Beer	37	1
Soyabean Oil	28	1

[29] (Food and Agriculture Organization of the United Nations, 2021)

[30] *Note: 0.5-1.0 g per kg of body weight, based on 50-60kg reference weight of women and men respectively.*

[31] *Note: 10-15% of recommended energy.*

[32] (Food and Agriculture Organization of the United Nations, 2021)

Figure 9: Distribution of fat supply per food items[33]

Food item	fat supply (g/capita/day)	fat supply (% total)
Palm Oil	6.61	21
Pig meat	6.31	20
Rice and products	5.17	16
Soyabean Oil	3.17	10
Sesame seed	2.36	7
Freshwater Fish	2.25	7
Soyabeans	1.72	5
Fats, Animals, Raw	1.53	5
Coconut Oil	1.43	5
Bovine Meat	1.16	4

Figure 10: Distribution of protein supply per food items[34]

Food item	Protein supply (g/capita/day)	Protein supply (%)
Rice and products	31.86	49
Freshwater Fish	9.82	15
Soyabeans	4.56	7
Beans	3.21	5
Marine Fish, Other	2.59	4
Cassava and products	2.29	3
Pig meat	2.03	3
Bovine Meat	1.6	2
Vegetables, other	1.45	2
Sesame seed	0.77	1
Poultry Meat	0.66	1
Wheat and products	0.65	1
Offal's, Edible	0.56	1
Groundnuts	0.42	1
Beer	0.38	1
Milk - Excluding Butter	0.35	1
Eggs	0.34	1

[33] (Food and Agriculture Organization of the United Nations, 2021)

[34] (Food and Agriculture Organization of the United Nations, 2021)

2.3 Status of food access

- **Economic Access**

The GDP of Cambodia has been rising at 7-8% per year and the average GDP per capita/ purchasing power parity (PPP) was 4,511.4 USD in 2021[35]. However, the data on inequality in per capita caloric intake measured as the coefficient of variation of habitual caloric consumption distribution (real number) is low, suggesting equity in caloric intake (0.24, 2020) with not much (2.9) incidence of habitual caloric losses at retail distribution level, indicating less food wastage[36]. The productivity gap between small and non-small farms is large. Labour productivity data of the smallholders is equal to a PPP of 13,182 Cambodian Riel (KHR), equivalent to 9.02 USD per labour day, against non-small farms with 78,554 KHR, being 53.8 USD PPP per labour-day[37]. Inequalities exist in incomes of small and non-small farms, with 22% with poor access to a healthy diet due to the non-affordability of various dietary components such as fruits, vegetables and milk[38]. During the agricultural year 2019, the small-scale holders generated only 14% of the total volume of products produced in the country (3,522,926,998 out of 24,901,492,423 PPP)[39]. These figures reveal a lack of economic access to food for farmers with small scale holdings throughout the year, leading to widespread food insecurity.

As per food insecurity experience scale (FIES)[40], the state of food insecurity is very high in Cambodia, with a 9.6 million population moderately or severely food insecure. In the 2018-2020 three-year average period, 7.4 million (44.8%) of the population suffered from mild to moderate food insecurity, and 2.2 million (13.4%) had severe food insecurity[41]. Majority of the food products need to be purchased from the market: fruit (72%), vegetables (66%), root crops (58%), beans and pulses (71%), fish (75%) and meat/ animal products (82%)[42].

While the country has exhibited strong economic performance, made great strides towards sustained and broad-based economic development and poverty has reduced exponentially in the past two decades, [43]. Most agricultural households produce their rice needs but rely on markets and foraging to access nutrient-rich foods.

Non affordability of non-cereal components of diet was reported to be very high (20-25%) among the population of Kampot Coastal region[44]. As per National Institute of Statistics, Cambodia in 2015, stunting levels were classified as high (25.2%) in 2014 and remained high with upward trend (28.4%) in 2022 with 8.3% severely stunted in 2014 which dropped to low risk level (5.7%) in 2022. Wasting (weight-for-height <-2 SD) levels were in medium risk category (8.2%) in Kampot province in 2014 which remained in medium risk category (9.6%) though showing an upward trend. Severe wasting ((weight-for-height <-3 SD) was very low (0.9%) in 2014 and increased (3.6%) to low category in 2022Non affordability of non-cereal components of diet was reported to be 10-15% in Kampong Thom region[45]. As per National Institute of Statistics, in Cambodia, in 2015, stunting levels were classified as very high (37.4%) and high wasting levels (13%) in Kampong Thom in 2014. In 2022, stunting levels (28.5%) dropped to high levels and wasting (8.9%) also were classified in medium category showing slight improvement in nutritional status.

[35] (International Monetary Fund, 2021)

[36] (Food and Agriculture Organization of the United Nations, 2021)

[37] (Cambodia Inter-Censal Agriculture Survey , 2019)

[38] (Fill the Nutrient Gap Cambodia, March 2017)

[39] (Cambodia Inter-Censal Agriculture Survey , 2019)

[40] FAO, 2014. The food insecurity experience scale: One metric for the world, Voices-Of-The-Hungry@fao.org

[41] (Food and Agriculture Organization of the United Nations, 2021)

[42] (Fill the Nutrient Gap Cambodia, March 2017)

[43] (Fill the Nutrient Gap Cambodia, March 2017)

[44] Cost of Diet Analysis, 2017.

[45] Cost of Diet Analysis, 2017.

- **Physical Access**

Road transport has modal share of more than 90% for passenger and freight. The total road length in Cambodia is more than 61,000 km. Rail lines density was 0.4 km per 100 km² of land area in 2003[46]; in 2019 also the modal share of railways for passenger and freight is negligible[47]. Food access of some population groups living in remote areas is thus poor.

Majority (75.4%) of the country's total holdings are small scale, with less than 3.2 ha of land. Tropical livestock unit[48] was lower than 2.85, indicating access to, on-average, two types of livestock at the household level. Access to livestock and markets is good throughout the country[49], but some population groups in remote rural area may struggle to access markets.

2.4 Status of food utilisation

In addition to the provision of sufficient, accessible, and stable food, the proper use/ utilisation of food to acquire adequate nutrition and maintain health and wellbeing is also essential in ensuring food security at all levels. This includes the way people physically handle the food with clean water under appropriate sanitary conditions, as well as the knowledge to prepare and consume food, since the cooking fuel used also has implications on health of the people and the environment. An unhealthy environment and respiratory disease are a determinant of human capacity to utilise nutrients. Prevalence of the population whose habitual food consumption is insufficient to provide the dietary energy levels required to maintain a normal active and healthy life, was low (6.2%) in the population, translating into 1 million people not consuming sufficient energy. In 2020, less than one third (27.8%) of households had access to safely managed drinking water services, which uses an improved design and construction of water sources to deliver safe drinking water located on the premises, available when needed and free from faecal and chemical contamination. Majority households (65.6%) used only basic source of water service, delivering improved source of water for which water collection time is not more than 30 minutes for a round trip, including queuing. Sanitation facilities with no open defecation was 71.2%[50].

Only 32.9% of the Cambodian households use a clean fuel stove as a primary source. Two-thirds of households that use a clean fuel stove as their primary stove use it in combination with a biomass stove and only 11.1% use it exclusively. LPG stove is the most popular (30.9%) type of clean fuel stove followed by fuel (wood, cow dung etc.). In Cambodia 66.7% of households use a biomass stove as their primary stove. Among them, 35.1% use an improved cookstove (ICS), 26.8% use a traditional cookstove, and 4.8% use a three-stone stove. Nearly 62% of households with a biomass stove use firewood as their primary cooking fuel; the next most common fuel is charcoal (4.8%). The share of households using clean fuels has increased consistently, rising 17% per year between 1997 and 2014, and just over 20% per year from 2014-2017[51]. Clean fuel is necessary for human respiratory health and reduces drivers of deforestation and its adverse effects (increased soil erosion, water run-off and flooding, global warming, climate change etc.).

Cambodia faces a nutrition crisis, as stunting levels in children were in high-risk category (20.8%) from the age of 0-23 months and (21.9%) in the age between 24 0-59 months. Similarly, wasting levels were in medium in both the age groups, children between 0-23 months (9.8%) and 0-59 months (9.5%)[52]. More than half (55%)

[46] (Food and Agriculture Organization of the United Nations, 2021)

[47] (Asian Development Bank, September 2019)

[48] *Note: Tropical Livestock Units are livestock numbers converted to a common unit. An increased number of animals per adult available to support the household indicates improved food security and household resilience and is a direct indicator of food security risk.*

[49] (Fill the Nutrient Gap Cambodia, March 2017)

[50] (Food and Agriculture Organization of the United Nations, 2021)

[51] (Rutu, et al., 2018)

[52] CDHS, 2022

of children from 6-23 months were reported to be anaemic caused by micronutrient deficiencies, thalassemia[53], and helminth[54] infections in 2014. Micronutrient deficiencies in children were reported in 2014, with the highest being vitamin D deficiency (33.1%) followed by vitamin A deficiency (9.2%) and vitamin B deficiency (8%). Consequently, only 32% of breastfed children between the age of 6-23 months consumed a MAD, primarily due to 40% taking diet with MDD and 74% taking meals with MMF. Most children are fed watery rice porridge (*borbor*), and few mothers enrich the porridge with nutrient dense foods, such as fish, meat and vegetables[55]. The cost of nutritious foods, time restrictions and women returning to work are cited as the main barriers to provide appropriate complementary child feeding[56].

2.5 Status of nutrition security

The Global Hunger Index (GHI), measuring inadequate food supply for population and child undernutrition (stunting and wasting levels), was with a score of 17 at moderate level of severity in 2021 (rank 69 out of 166 countries)[57].

Maternal undernutrition in WRA was 14%, classified as thinness (Body Mass Index < 18.5) with 30.9% suffering from vitamin D deficiency, 19.2% folic acid deficiency, and 3.2% with vitamin A deficiency[58]. Contrastingly, 18% are overweight or obese, and this trend appears to be increasing steadily[59]. Region-specific studies suggest that MDD for Women (MDD-W) is poor, with low consumption of nutrient-rich foods such as beans, nuts, dairy, eggs and vitamin A-rich fruits and vegetables[60]. Dietary intakes of the population are generally poor as they fail to meet the minimum and maximum targets of each food group that should be included in their diet[61].

Iron deficiency anaemia was only 3% in WRA group (15-49 years), with low serum ferritin concentrations of less than 15 Microgram per Litre (µg/L). About 33.9% WRA had low tissue iron level measured as elevated soluble transferrin receptors concentrations (>83.000 µg/L). Though soluble transferrin receptor values are inversely related to iron deficiency, elevated values may also indicate thalassemia, sickle cell anaemia or megaloblastic anaemia. Haemoglobin, an oxygen transporting protein in red blood cells and its type denote different interpretation, for example, A1 is the normal form of haemoglobin (Hb), Hb A1 >95%. However, many genetic disorders induce different types of Hb. Some of these disorders, such as haemoglobin E (HbE), result in a structurally different Hb protein, leading to shorter red blood cell life spans and lower Hb concentrations, other disorders, such as α- and β-thalassemia, are caused by deletion of part of the protein and result in lower production of Hb. A combination of different disorders, such as HbE and β-thalassemia, is also possible and quite common in Cambodia. HbE can be present in one of the two genes (heterozygote HbE) or in both genes (homozygote HbE). Heterozygote HbE is expected when HbE levels are between 20% and 30% of total Hb. Homozygote HbE is expected when levels are above 80% of total Hb. In a sub sample of WRA in 2014, 41% of them %) while 28% had heterozygote HbE and 6% had homozygote HbE.

[53] Thalassemias are inherited blood disorders characterized by decreased hemoglobin production.

[54] Helminths, also commonly known as parasitic worms, are large multicellular parasites, which can generally be seen with the naked eye when they are mature. They are often referred to as intestinal worms even though not all helminths reside in the intestines.

[55] (National Institute of Statistics Cambodia 2015)

[56] (Fill the Nutrient Gap Cambodia March 2017)

[57] (Grebmer & Bernstein, 2020)

[58] (National Institute of Statistics Cambodia, 2015)

[59] (Greffeuille, et al., 2016)

[60] (MUSEFO Project Report, 2021)

[61] (Trufts University, 2019)

2.6 Status of food stability

Production trends of most of the food groups have either remained stable (total meat, milk, eggs) or increased (vegetable oil, raw sugar) from 2000 to 2019, indicating food stability, similarly per capita food supply variability was 26% indicating stability in 2019 concerning food consumption data over time[62]. This indicator uses the data on dietary energy supply to measure annual fluctuations in the per capita food supply (in kcal), represented as the standard deviation over the previous five years' per capita food supply. Food supply variability results from a combination of instability and responses in production, trade, consumption, and storage and changes in government policies such as trade restrictions, taxes and subsidies, stockholding, and public distribution.

Approximately 34% of agricultural household holdings reported experiencing some form of severe shock during the last 12 months, including weather events like typhoons, floods, landslides or droughts and other impactful events including infestations, crop disease, or livestock disease. The three main issues reported were drought, food insecurity, insect infestation, livestock/ poultry disease and their prevalence throughout Cambodia[63].

3 Climate change in Cambodia

Take away points

- Cambodia has been categorised as a country that is "highly vulnerable" to the effects of climate change (12th most impacted country, globally).
- Cambodia's temperature projections to the end of the century see a year-on-year increase of between 0.013°C and 0.036°C, or between ~+0.39°C and ~+1.1°C by 2050; rainfall trends are less clear with some models predicting slight annual average decreases in the northeast, while the northwest may see slight increases in precipitation during the wet season.
- Climate risks in Cambodia are largely due to a high 'climate variability' (irregular rainfall, worsening floods, and prolonged, unpredictable droughts) and the impacts these have on important sectors that have low adaptive capacities, specifically the agriculture, forestry and fisheries, rural infrastructure and health sectors.
- Food production is predicted to be negatively impacted by increasing temperatures and the impact that more erratic, unpredictable rainfall patterns and drought events have on the agricultural sector. There is also some evidence of a likely reduction in protein and micronutrient concentrations in rice due to higher atmospheric CO_2 levels.
- Elevated atmospheric CO_2 concentrations are predicted to increase yield potentials of rice, though these benefits are unlikely to be achieved without the adoption of significant adaptation improvements (e.g., irrigation, access to improved drought/ flood resilient varieties, soil health and soil protection measures, on-slope and in-stream rainwater harvesting, and landscape management).

3.1 Observed changes in Cambodia's climate

Cambodians are noticing changes in the weather and their environment – temperatures are getting hotter, and the intensity of storms is increasing. As a nation, Cambodia is experiencing a shorter, more intense wet season and a long hotter dry season.

3.1.1 Temperature

- Temperature increases have been observed, with an approximate increase of 0.18°C per decade since the 1960s.

[62] (Food and Agriculture Organization of the United Nations, 2021)

Note: all data are derived from CMIP6 climate data provided via the World Bank's Climate Knowledge Portal: https://climateknowledgeportal.worldbank.org/country/cambodia.

[63] (Ministry of Agriculture, Forestry and Fisheries, 2018)

- Temperature increases have increased most rapidly during the country's dry season (November to April), increasing by 0.20°C to 0.23°C per decade.
- Temperatures have increase during the rainy season (May to October), but not as significantly, with increases between 0.13°C and 0.16°C per decade.
- The number of 'hot days' in the country has increased over the last century, by as much as 46 days per year.

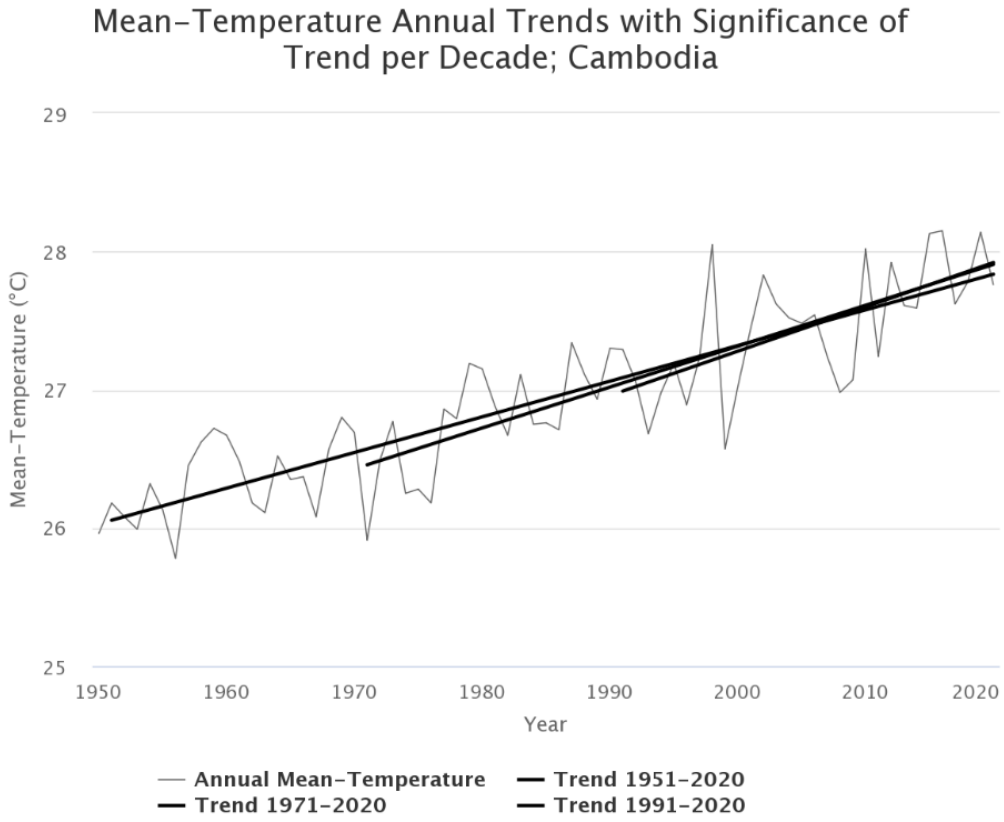


Figure 11: Cambodia mean-temperature annual trends with significance of trend per decade

3.1.2 Precipitation

- While rainfall was observed to increase in some areas since the 1960s, no statistically significant changes were detected over the 20th century, either in terms of annual rainfall or extreme events.
- However, precipitation variability is linked to the El Niño Southern Oscillation phenomenon, with years of strong El Niño correlated with years of moderate and severe drought over the 20th century.
- Observation data show a slightly stronger drying trend in Kampong Thom than in Kampot.
- Over the past decade, some inland provinces have experienced less than 600 mm of rainfall annually, while precipitation has reached 3,800 mm in coastal areas[64].
- The average annual rainfall from 1994 to 2004 has fluctuated between 1,400 mm and 1,970 mm per year. In lowland areas, annual rainfall ranges from 1,000 mm to 1,700 mm, while in the highlands it ranges from 1,000 mm to 2,700 mm, and in coastal areas from 1,000 mm to 3,000 mm.

[64] Cambodia's Second National Communication (MoE, November 2015)

3.1.3 Sea levels

Sea levels are rising. Over the period 1993-2015, sea levels rose by 0.055 m.

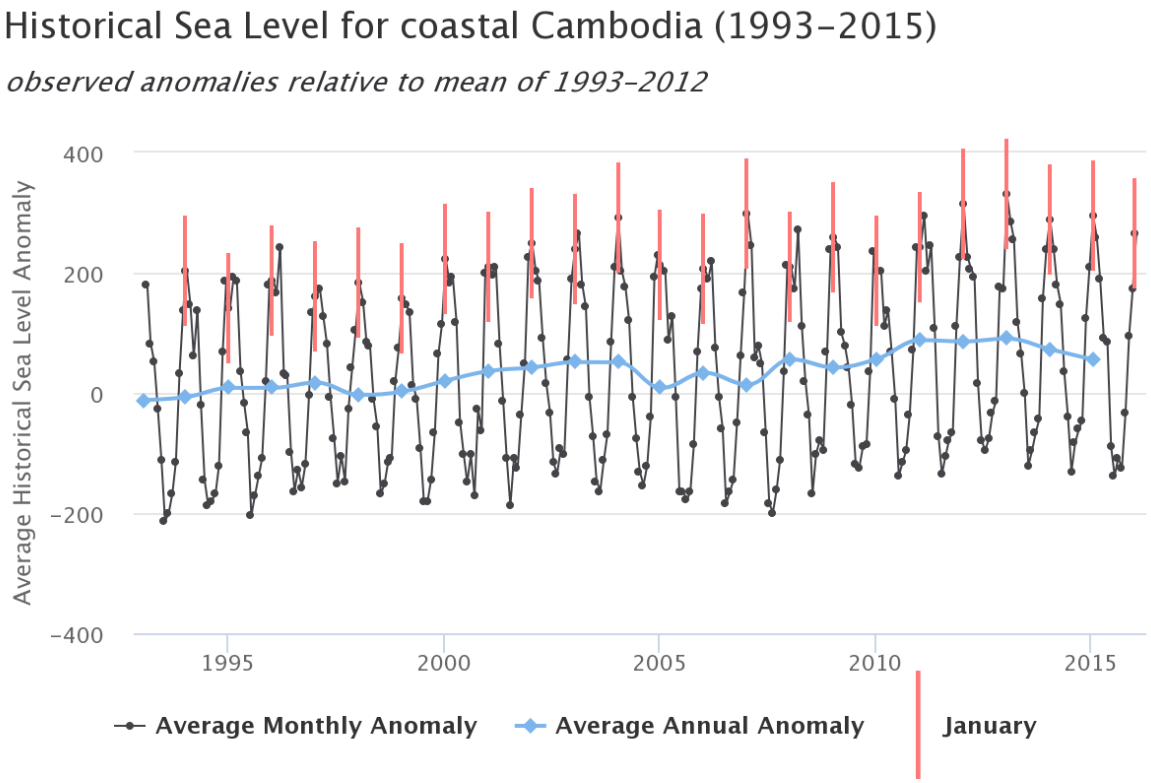


Figure 12: Historical sea level for coastal Cambodia (1993-2015)

3.2 Projected climate change up to 2050

3.2.1 Changes in temperatures

- Annual mean temperatures in Cambodia are projected to increase between 0.8 to 1.6ºC by 2050, relative to 2005.
- Annual mean temperatures in **Kampong Thom** are expected to increase under all models, with a median ranging between 0.7 and 1.6°C by 2050 relative to 2005 depending on the emission pathway.
- Annual mean temperatures in **Kampot** are expected to increase under all models, with a median ranging between 0.7 and 1.4°C by 2050 relative to 2005 depending on the emission pathway.

Mean Annual Temperature

SSP1-1.9 Ensemble median [range]: 28.12 [27.70 - 28.48] °C

SSP5-8.5 Ensemble median [range]: 28.99 [28.35 - 29.87] °C

Figure 13: Annual mean (Tas), maximum (Tmax) and minimum (Tmin) temperatures (ºC), total annual precipitation (Precip in mm), and number of days with daily precipitation greater than 50 mm (Pr>50mm) in Cambodia, Kampong Thom and Kampot for the year 2050 [65] [66]

		Baseline 2005	2050 SSP1-1.9	2050 SSP1-2.6	2050 SSP2-4.5	2050 SSP3-7.0	2050 SSP5-8.5
National average	**Tas**	**27.4**	**28.2 (27.2 - 28.9)**	**28.4 (27.6 - 29.2)**	**28.7 (27.9 - 29.5)**	**28.7 (27.7 - 29.5)**	**29.0 (28.0 - 29.9)**
Kampong Thom	Tas	27.6	28.4 (27.4 - 29.0)	28.6 (27.8 - 29.4)	28.9 (28.1 - 29.7)	28.9 (27.9 - 29.7)	29.2 (28.2 - 30.2)
Kampot	Tas	27.5	28.2 (27.5 - 28.7)	28.4 (27.8 - 28.9)	28.6 (28.1 - 29.2)	28.7 (28.0 - 29.3)	29.0 (28.2 - 29.6)
National average	**Tmax**	**31.9**	**32.7 (31.4 - 33.5)**	**32.9 (31.9 - 33.7)**	**33.1 (32.2 - 34.0)**	**33.1 32.0 - 34.1)**	**33.4 32.0 - 34.5)**
Kampong Thom	Tmax	32.1	32.8 (31.6 - 33.6)	33.1 (32.1 - 33.9)	33.3 (32.5 - 34.2)	33.3 (32.2 - 34.3)	33.6 (32.2 - 34.8)
Kampot	Tmax	30.4	31.1 (30.2 - 31.7)	31.3 (30.7- 31.9)	31.5 (31.0 - 32.1)	31.5 (30.8 - 32.2)	31.8 (30.9 - 32.5)
National average	**Tmin**	**22.9**	**23.8 (23.0 - 24.4)**	**23.9 (23.1 - 24.7)**	**24.2 (23.4 - 24.9)**	**24.2 23.3 - 25.0)**	**24.6 (23.8 - 25.4)**
Kampong Thom	Tmin	23.2	24.1 (23.2 - 24.6)	24.2 23.3 - 24.9)	24.5 (23.7 - 25.2)	24.5 (23.5 - 25.2)	24.8 (24.0 - 25.7)
Kampot	Tmin	24.4	25.2 (24.5 - 25.6)	25.3 (24.7 - 25.8)	25.5 (25.0 - 26.1)	25.5 (24.9 - 26.1)	25.8 (25.2 - 26.4)
National average	**Precip**	**1,983**	**1,851 (1,096 –2,583)**	**2,033 (1,331 –2,798)**	**2,049 (1,290 –2,768)**	**1922 (1308 - 2550**	**2,042 (1,326 – 2,790)**
Kampong Thom	Precip	1,985	1,814 (1,112–2,460)	2,018 (1,334–2,831)	2,056 (1,260–2,829)	1,928 (1282–2,513)	2,051 (1,317–2,801)
Kampot	Precip	2,473	2,373 (1,515–3,210)	2,589 (1,762–3,423)	2,544 (1871–3,283)	2,438 (1865–3,078)	2,564 (1,905–3,369)
National average	**pr>50mm**	**1**	**0.8**	**1**	**1.1**	**0.8**	**1.3**
Kampong Thom	pr>50mm	0.8	0.4	0.8	1	0.5	1
Kampot	pr>50mm	1.7	2.2	2	1.7	1.9	2.5

[65] World Bank. Climate Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-projections-expert

[66] Note to Figure 13: The values correspond to the median and in brackets the 10th and 90th percentiles (except for Pr>50mm) from CMIP6 model ensemble for individual warming scenarios.

Figure 14: Projected changes in climate to 2050 [67] [68]

		SSP1-1.9	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
National average	**Tas**	**0.8**	**1.0**	**1.2**	**1.2**	**1.6**
Kampong Thom	Tas	0.7	1.0	1.2	1.0	1.6
Kampot	Tas	0.7	0.8	1.1	1.4	1.4
National average	**Tmax**	**0.8**	**1.0**	**1.2**	**1.1**	**1.6**
Kampong Thom	Tmax	0.8	0.9	1.2	1.1	1.6
Kampot	Tmax	0.6	0.8	1.0	1.0	1.4
National average	**Tmin**	**0.9**	**1.0**	**1.2**	**1.2**	**1.6**
Kampong Thom	Tmin	0.9	1.0	1.2	1.2	1.7
Kampot	Tmin	0.7	0.8	1.1	1.0	1.4
National average	**Precip**	**-6.8**	**3.5**	**4.1**	**-0.7**	**1.7**
Kampong Thom	Precip	-8.9	3.8	4.2	-0.8	3.6
Kampot	Precip	-0.7	4.7	5.0	0.2	1.8
National average	**pr>50**	**-0.2**	**0.3**	**0.3**	**0.2**	**0.4**
Kampong Thom	pr>50	-0.3	0.4	0.3	0.2	0.3
Kampot	pr>50	0.4	0.0	0.0	-0.1	0.6

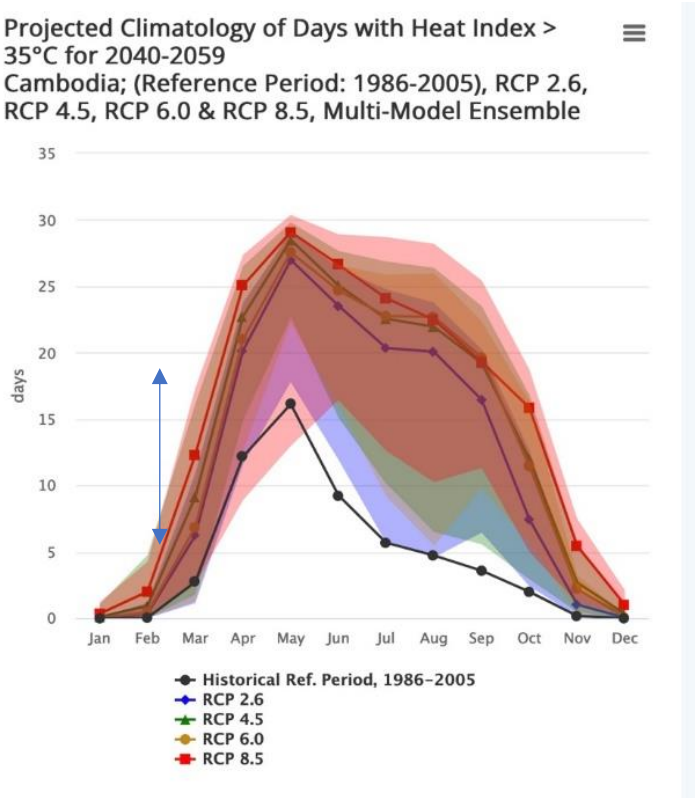


Figure 15: Projected climatology of days with heat index >35ºC for circa 2050

[67] World Bank. Climate Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-projections-expert

[68] Note to Figure 14: Relative change in temperature (ºC) and precipitation (%), and number of days with daily precipitation greater than 50 mm (days) in Cambodia, Kampong Thom and Kampot by 2050 (baseline 2005). The values correspond to the median from CMIP6 model ensemble for individual warming scenarios

3.2.2 Changes in precipitation

Annual Precipitation

SSP1-1.9 Ensemble median [range]: 1,851 [1,096 - 2,583] mm

SSP5-8.5 Ensemble median [range]: 2,042 [1,326 - 2,790] mm

- Climate projections show a reduction in precipitation in the season preceding the peak of the rainy period (March-May), which could indicate a delayed start of the rainy season in both provinces.
- Longer periods of drought may be expected across the country, especially during the early rainy season. March and April are the months with the highest increase in number of consecutive dry days in both locations, with an average of approximately one extra consecutive day without rain during these periods, and a potential of up to 10 extra days under worst case scenarios[69].

While the extent to which climate change will affect intra-annual precipitation remains unclear, higher variability between years is predicted by several models by 2050. In addition, the on-going precipitation regime projection reveals a trend towards a shorter rainy season, drier conditions in the months of April and May and wetter conditions in October and November[70], all of which have a strong potential to negatively impact food production and food security.

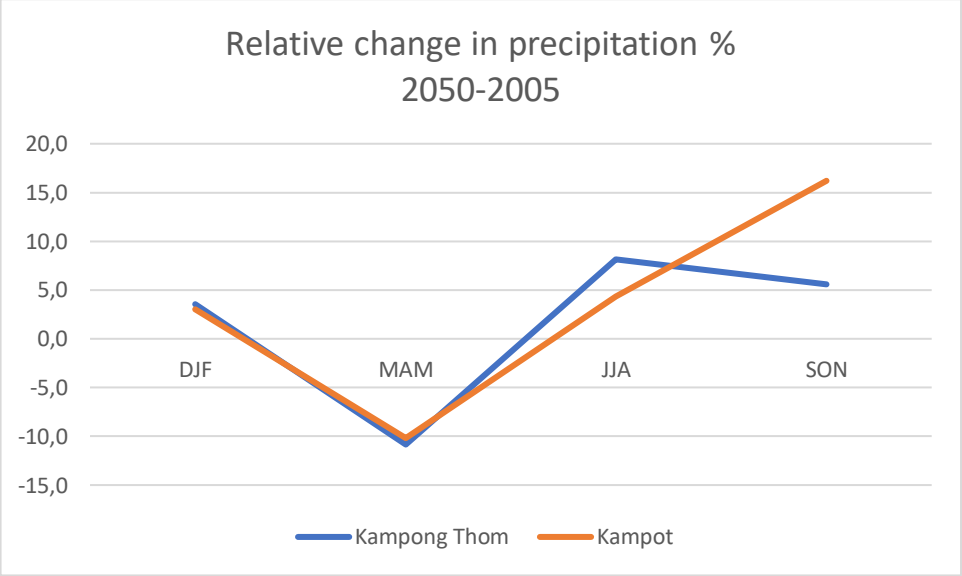


Figure 16: Relative Change in Precipitation 2005-2050

Provincial Predictions

- Predicting changes in rainfall for **Kampong Thom** is difficult, but the overall conclusion is that little change in annual average precipitation should be expected. As can be seen in Figure 16, the predicted change in average annual rainfall is far smaller (<50mm) than the inter-annual variability (>500mm). As with all of the country, the distribution of rainfall within the year may change, with more intense precipitation and drought episodes, a wetter wet season (June-August) and a drier dry season (March-May)[71].

[69] https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-projections .

[70] USAID. 2019. https://www.climatelinks.org/sites/default/files/asset/document/2019_USAID_Cambodia%20CRP.pdf

[71] RCG. 2013. Cambodia Climate Change Strategic Plan 2014 – 2023

- This means that communities in **Kampong Thom** are already coping with changes in yearly rainfall greater than the average changes predicted for 2050.
- However, the inter-annual variability range does appear to increase in some models, meaning some years may be even wetter and others even drier in the future.
- Under SSP-RCP trajectories, the maximum length of drought periods is projected to extend by 6-11 days (13-24%) depending on the scenario.

- Projections for annual average rainfall for **Kampot** are less conclusive, with different pathways and scenarios predicting quite different trajectories. The range in change in rainfall between the baseline and 2050 is –100 mm per year to +116 mm (or a –0.7% to +5% change)[72].
  - It is therefore difficult to draw any conclusions on any likely change in average annual precipitation to 2050.

3.2.3 Changes in extremes weather events

Heatwaves[73] are increasing in frequency and intensity, though projections are calculated for the region broadly rather than specifically for Cambodia.

What is known specifically for Cambodia, is that the total number of days per year (non-consecutive) with extreme temperatures (above 35°C) is likely to greatly increase towards 2050. The number of recorded days per year above 35°C was 65 days in 2013 and will increase to between 115 – 179 days by 2050, meaning almost a doubling of the number of hot days, even under the most conservative projections.

At 210 hot days per year, the projection for **Kampot** is a near threefold increase under the worst-case scenario. The World Bank stated that "There is sufficient existing data to infer that Cambodia also faces a transition to a state of permanent heat stress as a result of temperatures which regularly surpass levels safe for humans and biodiversity"[74].

The number of tropical nights above 26°C (at ~30 in 2013) is also set to increase dramatically under all scenarios in the CMIP6 model ensemble. For example, looking at SSP1-1.9 scenario, Cambodia can expect 57 hot nights (model ensemble range [13-101]) above 26°C by 2050, while under SSP5-8.5, this figure may increase to 121 hot nights (model ensemble range [44-183]). This shows a near doubling of hot nights per year under the lowest GHG emission scenario (SSP1-1.9) and a quadrupling of the number of hot nights under the highest (SSP5-8.5) for Cambodia.

In summary, while the length and intensity of heatwaves remains unclear, Cambodia, even under the most conservative of global warming scenarios, is very likely to experience many more hot days and nights.

Annual Maximum 5-day Rainfall (25-yr RL)

SSP1-1.9 Ensemble median [range]: 247.06 [143.23 - 476.79] mm

SSP5-8.5 Ensemble median [range]: 267.37 [130.37 - 472.37] mm

[72] World Bank. Climate Knowledge Portal. https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-projections-expert

[73] A heatwave is defined as a period of three or more days where the temperature is above the long-term 95th percentile.

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

3.2.4 Sea levels rise projections

By 2050, sea levels could rise between 0.16-0.30 m (Figure 17).

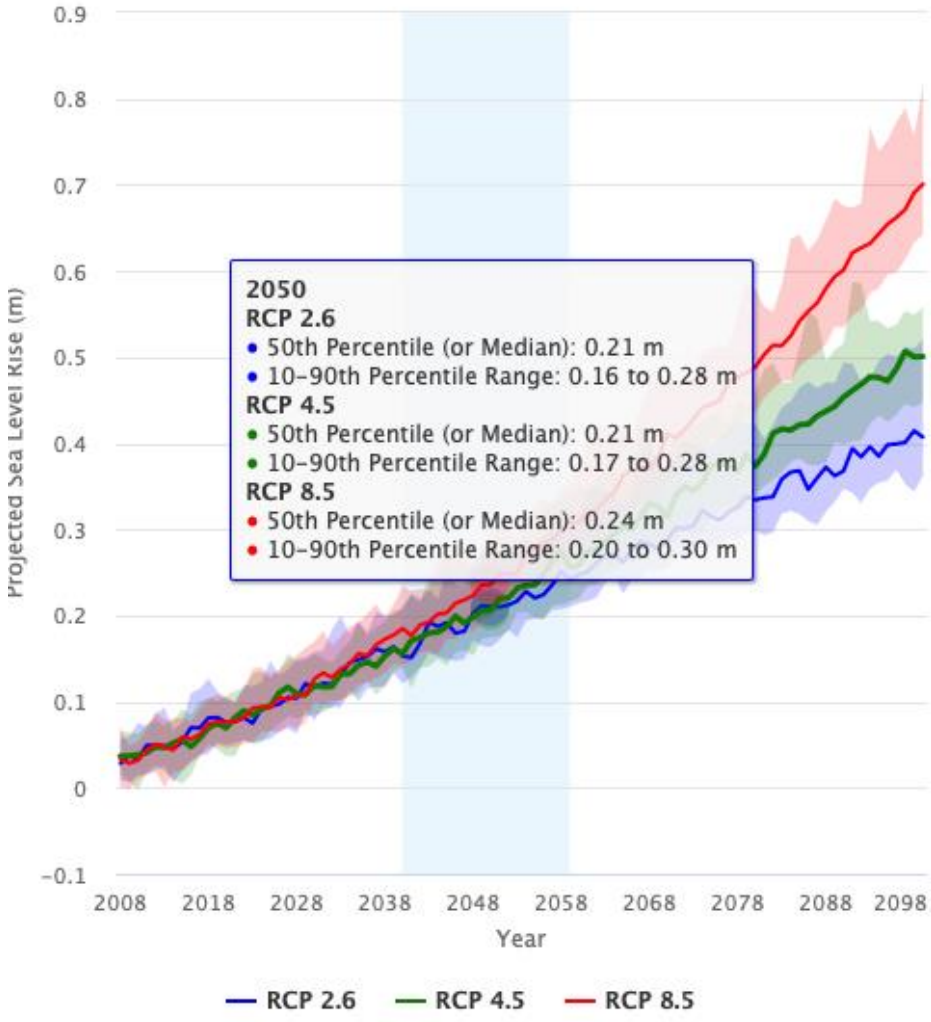


Figure 17: Projected Sea level rise of coastal Cambodia in 2050 relative to 1980

Baseline 2005	2022	SSP1-1.9	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
378.91	419.70	437.63	469.31	506.87	540.58	562.78

Figure 18: CO2 concentrations projections in 2050 in parts per million (ppm)

3.3 Climate change impacts on food security and nutrition (FSN)

3.3.1 Climate change impacts on food availability

Crop production

IPCC AR6 WGII Chapter 5: Summary of key impacts on crop production

- Recent warming trends have generally shortened the life cycle of **major crops**
- Climate variability is a major source of variation in crop production yield variability in **low input agriculture** has severe impacts on local food availability and livelihood
- **Above-ground annual crops** consumed as vegetables, fruits, or salad are essential for food security and nutrition: Above-ground vegetables are especially vulnerable to heat and drought stress during pollination and fruit set, resulting in negative impacts on yield and harvest quality
- **Below-ground vegetables** include starchy roots and tubers that form a regular diet in many parts of the tropics and sub-tropics. Warming and climate variability has altered the rate of tuber development
- These crops are considered stress tolerant but are more sensitive to drought than cereals. Impacts on water supply are critical as root crops are water-demanding for long periods, and highly sensitive to drought and heat events during tuber initiation
- In **fruit trees**, warming and climate variability have already affected fruit quality
- The impacts of climate change on **water availability** (rainfall and irrigation supply) are an emerging issue. Increased occurrence of drought combined with limited access to irrigation water is already a key constraint
- For instance, **rice and maize production in Viet Nam Mekong Delta (and by extension Cambodia)** has high exposure to multiple climate hazards such as flooding, sea-level rise, salinity intrusion, and drought

Climate impacts on important crops grown in Cambodia. Approximately 98% of rice, meat and pulses consumed within Cambodia is produced within the Kingdom[75], making the sustainability of internal food production of high importance. Further, as nearly 60% of Cambodian dietary energy supply comes from cereals, chiefly rice, its production is especially critical to national food security. Where climate change and atmospheric CO_2 concentrations impact the production, availability or nutrient content of rice and other essential crops and livestock, implications for food security may be severe.

≫ *Rice*

- The Cambodia National Climate Change Committee calculates that without implementation of adaptation policies and interventions, rice productivity will decrease by 10% for every 1ºC increase of temperature[76] [77], which may push rice farming to become non-viable for many farmers.
- Based on these projections, by 2050 rice yields may decrease by ~10% while incomes in the agricultural sector could drop 17% by 2050[78], both of which have the potential to strongly impact household

[75] FAOSTAT

[76] RGC. 2013. Cambodia Climate Change Strategic Plan 2014-2023. Phnom Penh, Cambodia.

[77] GEF 2018. FP076: Climate-Friendly Agribusiness Value Chains Sector Project Cambodia | Asian Development Bank (ADB) | Decision B.19/12

[78] Ministry of Economy and Finance and GSSD. 2019. Addressing Climate Change Impacts on Economic Growth in Cambodia. Phnom Penh, Cambodia.

food security and nutrition (access and availability), especially for the poorest households/ households without access to irrigation.

- Rice production is by far the most important agricultural activity in both **Kampong Thom** and **Kampot** and is likely to be strongly impacted by changes in precipitation (as highlighted by the CIAS 2019 report).
- Access and availability of sufficient, reliable water supply at the right time for irrigation of crops is already the major concern for farmers in **Kampong Thom**, with 2/3rd of farmers interviewed identifying drought and food insecurity as their most severe shock impacting households. In **Kampot** 2/5th of farmers see drought together with flooding as having an important influence on their households (animal disease as a shock in **Kampot** was highlighted by nearly ½ of farmers – an issue also likely to be worsened by climate change).
- Under higher atmospheric CO_2 conditions rice harvests are likely to be improved by a CO_2 fertilization effect, however this improvement is contingent on negative factors such as reduced access to water, declining soil health, increased impact of diseases and negative impacts of higher temperatures being overcome.

≫ *Soybean*

- The optimal soil temperature for germination and early seedling growth is 25–30°C. The optimal temperature for soybean growth is 20–30°C. Temperatures, while t of 35°C and above are considered to limit growth.
    - The number of hot days above 35°C are likely to double throughout the year, while during the main wet season (MWS) they may triple or quadruple.
    - This increase in the number of hot days is likely to reduce yields by affecting both germination and growth, and hence potentially reduce the production and availability of Cambodian grown soybeans.
- Soybean crops require between 500-1000mm rain during the growing period for optimal production. While they can survive on as little as 180mm depending on soil type, yields drop off rapidly below 500mm.
    - Drought during the growing period impacts soybean plant establishment and survival and ultimately affects yields.
    - Where climate change manifests in longer dry periods during the wet season, soybean production can expect to be negatively impacted.

≫ *Cassava*

- Cassava cultivation is well recognised as having strongly negative impacts on soil health and soil nutrient mining is a major issue in cassava cultivation. Additionally, traditional land preparation and harvesting techniques are well recognised as being extremely soil disturbing, leaving the soils highly prone to erosion and nutrient leaching. All these issues are likely to become more acute as extreme climate events, such as more intense rainstorms and drought, become more common.
- However, due to its ability to remain in the ground/ be harvested at a time of farmer's convenience, cultivating cassava provides farmers with a climate change and shock resilient crop, i.e. edible varieties

can be considered an emergency food when poor climate conditions have impacted production of other crops, such as rice that are more sensitive to extreme, acute climatic events.

- Increased cassava productivity is possible due to the CO2 fertilisation effect. Higher atmospheric CO2 concentrations have also been shown to increase water use efficiency (due to reduced stomatal opening requirements resulting in lower transpiration rates). Studies have shown that under elevated atmospheric CO2 conditions of 600ppm (a concentration predicted by several models to be reached by 2055-2070) cassava productivity could increase by 20-30%[79].
- Other studies have shown productivity will decrease, especially in tubers, and the cyanide content of edible leaves (important for protein supplementation in diets) will increase, making them inedible/ require increased processing[80].
- Cassava mosaic disease is already highly problematic in Cambodia; conditions such as drought or flooding weaken cassava crops and make them more susceptible to disease. Higher temperatures can generate conditions beneficial to CMD's vector insect's proliferation. The impacts of CC are therefore likely to negatively impact the ongoing fight against CMD**81** potentially counter balancing any gains from CO2 fertilisation,
- Overall, research suggests that while higher cassava yields and water use efficiency can be expected as atmospheric CO2 increases over the coming decades, these benefits will likely be offset by deleterious conditions such as increasing droughts and floods, declining soil health and greater spread of diseases exacerbated by climate change.

≫ *Cashew nut*

- The flowering, fruiting, insect pest incidence, yield and quality of cashew nut and kernels are vulnerable to climate change.
- Unseasonal rains and heavy dew during flowering and fruiting period affect the yield and quality of cashew nut.
- Cloudy conditions, high relative humidity and heavy dew create favourable conditions for outbreaks of insect pests and diseases.
- Drought conditions drastically reduce cashew nut production.

≫ *Lemon*

- Lemon farmers experience reductions in their yields due to the interplay of:
  - decreasing soil fertility because of unclosed nutrient circles,
  - high nutrient competition among plants,
  - low water holding capacities
  - mono-cropping practices negatively impact lemon production.
  - increased pest, disease, and fungus infections.
- Climate change effects such as higher temperatures, floods, or droughts can exacerbate the impact and likelihood of the above issues.

[79] Ruiz-Vera et al. 2021. High sink strength prevents photosynthetic down-regulation in cassava grown at elevated CO2 concentration. Journal of Experimental Botany, Volume 72, Issue 2, 2 February 2021, Pages 542–560, https://academic.oup.com/jxb/article/72/2/542/5921141?login=false

[80] Gleadow et al. 2009. Growth and nutritive value of cassava (Manihot esculenta Cranz.) are reduced when grown in elevated CO. Plant Biol (Stuttg) . 2009 Nov;11 Suppl 1:76-82. doi: 10.1111/j.1438-8677.2009.00238.x

[81] Jarvis, A., Ramirez-Villegas, J., Herrera Campo, B.V. et al. Is Cassava the Answer to African Climate Change Adaptation?. Tropical Plant Biol. 5, 9–29 (2012). https://doi.org/10.1007/s12042-012-9096-7

Example Popok commune Kampong Thom province

Popok commune is a relatively remote and can be used as a fair representation for remote rural communities throughout KPT. Cashew and other fruit trees, especially lemon, are important crops in Popok commune, Kampong Thom province.

Approximately 40% of cashew farmers in Popok practice cashew monocropping, while 60% of farmers have inter-cropped cashew nut with cassava and other cash crops such as soybeans, mung bean and maize. Approximately 22% of households in Popok grow lemon trees.

Cashew

Cashew, along with cassava and coffee, has been identified as an important crop in Cambodia by GIZ's "Strengthening the cli-mate resilience of agriculture in Cambodia and Viet Nam" project (2021- 2024) https://www.giz.de/en/worldwide/95504.html.

Cashew nut demand has been growing steadily over the last decade. The expansion of cashew nut production was the result of changing crop system prioritization by farmers based on market demand. Farmers perceive cashew nut as a profitable crop due to its high demand and price in the markets.

According to the local growers, farmers produce on average between 0.9 t/ha dry cashew nut. Cashew has strong potential to expand, create jobs and further improve incomes for farmers.

Climatic impacts on cashew in Popok

- Changing rainfall patterns and prolonged drought have caused lower cashew yields and quality.
- The insect pests and disease outbreaks worsen with higher temperatures and very wet conditions.
- The cultivation areas are sensitive to the flash flooding, which also contribute to soil erosion. The heavy rain occurs typically between August to October.

Lemon trees

Lemon trees are highly beneficial crops in Popok community. They are primarily considered as a market crop for providing additional household income, but can also contribute to important dietary diversity requirements, especially in terms of vitamins and micronutrients.

From an ecological perspective, lemon trees provide soil moisture and soil erosion benefits, and when planned properly in an agroforestry system, can increase productivity of other crops, including rice, as well as mitigate the impacts of flooding through providing soil stability benefits.

Climatic impacts on lemon in Popok

- Changing rainfall patterns and prolonged drought could affect lemon production. Insufficient water for irrigation was identified as negatively impacting the production of lemons, especially in the dry season.

Cultural practices

- Seed and variety – Most the seedling varieties are the local seed, whose fruit fall to the ground easily, is not resistance to insect pests and diseases and ripen unpredictably. Access the good cashew varieties is challenging.
- Decline soil fertility and increasing erosion as the result of monoculture, clearing and burning weeds and improper application of inorganic fertilizers impacts cashew productivity
- Limited knowledge of spacing, pruning propagation, grafting technique and disease prevention leads to low productivity and high reliance on pesticides.
- High application of pesticides is costly and may impact sustainability
- Women headed households suffer from limited information, technical and market knowledge, financial resources and labor.
- Farmers have cleared, slashed and burned the forest land for holding the cashew plantation expansion.
- Most of the farmers in the areas leave their cashew orchard with weed and without pruning, which causes the cashew growth slow. Farmers have grown cashew with improper rows, which caused difficulty for pruning the trees.

Home garden composition

The main crops grown in home garden[1]:

- **Leafy type**: kangkong, amaranth, ivy gourd, iceberg lettuce, Indian spinach, lettuce, arum leaf, jute leaf, Ceylon spinach
- **Cabbage type**: mustard green, swanton mustard, white petiole, Chinese cabbage, petsal (green petiole), common cabbage, cauliflower, Chinese kale, broccoli
- **Fruit/Tomato type:** green pepper, tomato, eggplant, pimento pepper, chili pepper, tabasco pepper, green papaya, bitter eggplant, okra
- **Cucumber/Gourd/Trellis type**: wax gourd, pumpkin, cucumber, angled loofah, bitter gourd, sponge gourd, bottle gourd, snake gourd, watermelon
- **Legumes/Bean type**: yard long bean, winged bean, hyacinth bean, mung bean, cowpea, snap bean, peanut, soybean
- **Onion type**: Chinese chives/onion stock, bunching onion, shallot, onion, garlic leek
- **Root type**: arrow root, taro root, cassava, sweet potato, radish, turnip, beet, Chinese radish, winged yam (white), winged yam (purple), potato yam, tiger paw yam
- **Edible Leaves/Flowers of trees**: sesbania javanica, sesbania grandiflora, ipil ipil, neem, drumsticks, sauropus androgynus
- **Spices and Herbs**: coleus, basil, coriander, ginger, turmeric, swarm leaf, lemon grass, japanese pepper mint, mint leave

While there is little to no specific information available on the climate change impacts to the specific home garden crops (except for soybean), negative impact from heat and drought can be expected for above-ground vegetables yield and quality (e.g., leafy and cucumber types), which are especially vulnerable to heat and drought stress during pollination and fruit set. Warming and climate variability has altered the rate of tuber development (root type). Root crops are more sensitive to drought than cereals., as they require important amount of water over long periods and are highly sensitive to drought and heat events during tuber initiation.

Figure 19: Projected crop yield changes under climate change conditions in 2050 in Cambodia

Projected crop yield changes of major crops under CC conditions in 2050 in Cambodia[82]	Empirical or anecdotal knowledge of resilient home garden-type species grown in Cambodia
Rice - 5.6 - 9.4% yield increase. While rice is vulnerable to damage from flooding, drought, higher temperatures and disease/pests under climate change, it is expected to overall benefit from eCO2 in the atmosphere towards 2050 Floating rice – elongated-stem rice growing with the flood waters around Tonle Sap. Traditional method of coping with high flood waters in Kampong Thom Soybean - 0.5-6.2% yield decrease	Sweet potato (drought resistant) and taro[83]
	Cassava (drought resistant and shock resistant due to its ability to be harvested throughout the year)
Soybean - 0.5 -6.2% yield decrease	Various tree species sesbania grandifolia, moringa, sauropus androgynous (edible, protein rich leaves), perennial, hardy and very drought resistant
	Pumpkin, bottle, wax and ivy[84] gourd – heat, humidity and drought tolerant[85], and able to remain on the vine until required.
	Kangkong – flood and drought tolerant
	Pea eggplant, banana, neem, acacia pennata[86]

[82] Data based on global gridded model projections from the ISIMIP fast-track ensemble – Rosenzweig et al. 2014.

[83] Fao 2020. Creating Enabling Environments For Nutrition Sensitive Food And Agriculture To Address Malnutrition.

[84] FAO 2020. CREATING ENABLING ENVIRONMENTS FOR NUTRITION SENSITIVE FOOD AND AGRICULTURE TO ADDRESS MALNUTRITION.

[85] FAO 2018. Rediscovering hidden treasures of neglected and underutilized species for Zero Hunger in Asia.

[86] Personal Communication. Lilian Beck.

CO_2 effects

CO_2 interactions with crops can be summarized as a) having a positive impact on the ability of the plant to photosynthesis due to the CO_2 fertilization effect, and b) reducing the stomatal conductance, meaning lower evapotranspiration potential (and a resulting reduced water requirement) that could increase drought tolerance in crops[87]. These processes are key factors in model-based predictions showing yield increases ranging between 5.4% (RCP26) and 9% (RCP85) towards 2050[88]. Improvements in evapotranspiration of C3 crops, including rice, due to stomatal conductance changes have been calculated to be ~5%, globally[89].

However, although yields may increase under higher atmospheric CO_2 concentrations, analyses on rice cultivars, in China and Japan have shown that due the CO_2 dilution effect, protein concentration declined by an average of 10% under elevated CO_2. Fe, Zn concentrations also declined (by 8% and 5%, respectfully) as did vitamins including B1 (-17%), B2 (-17%), B5 (-13%), and B9 (-30%), while Vitamin E increase[90] (see 3.4.1 below). With regards to food security and nutrition, these projected impacts would undermine the intake of micronutrients and vitamins that population in Cambodia is getting from rice-base diet. Research to develop cultivars adapted to elevated CO_2 concentrations and diversifying diets are two adaptation strategies addressing these impacts.

Aquaculture and fisheries

Climate change is expected to impact aquaculture and fisheries in a number of ways, including impacts to water levels and flood pulses (affecting migration, breeding and survival), habitat reductions and ocean acidification (impacting coral reefs and shellfish development). These changes are likely to impact breeding and nursery sites especially, meaning threats to fish populations (and therefore catch) can be expected.

Globally there is some evidence of reductions in nutrient content (fatty acids in molluscs) though overall there is *low confidence* in climate change affecting the nutritious value of seafood[91]. Increases in toxicity of seafood is a more pressing concern with higher mercury concentration and increases in cases of algal-produced toxins (ciguatera and *Vibrio)* being more likely under warmer conditions[92].

Ocean acidification due to seas absorbing atmospheric CO2 has strong potential to impact marine ecology and trophic interactions[93]. While it remains unclear exactly how various CO2 concentrations will affect marine productivity and therefore fish catches, it is likely that corals, shellfish and other calcifying marine organisms will be negatively impacted[94,95].

In Cambodia, consultations (led by FAO, MoE and MAFF) with fishing communities reliant on Community Fisheries and Community Protected Areas identified declines in fisheries resources, sea water intrusion, lack

[87] Toreti, A., Deryng, D., Tubiello, F.N. *et al.* Narrowing uncertainties in the effects of elevated CO_2 on crops. *Nat Food* **1,** 775–782 (2020). https://doi.org/10.1038/s43016-020-00195-4

[88] https://climate-impact-explorer.climateanalytics.org/impacts/?region=KHM&indicator=yield_rice_co2&scenario=rcp26&subregion=KH.KT&warmingLevel=3.0&temporalAveraging=annual&spatialWeighting=area&compareDimension=warmingLevel&compareValues=3.0%2C1.5&compareYear=2030&compareScenario=h_cpol

[89] Deryng, D., Elliott, J., Folberth, C., Mueller, C., Pugh, T., Boote, K., Conway, D., Ruane, A., Gerten, D., Jones, J., Khabarov, N., Olin, S., Schaphoff, S., Schmid, E., Yang, H., & Rosenzweig, C. (2016). Regional Disparities in the Beneficial Effects of Rising CO_2 Concentrations on Crop Water Productivity. *Nature Climate Change*, *6*, 786–790. https://doi.org/10.1038/nclimate2995

[90] Narrowing uncertainties in the effects of elevated CO2 on crops

[91] IPCC Report (Ch5)

[92] IPCC

[93] https://www.frontiersin.org/articles/10.3389/fmars.2020.543979/full

[94] https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract_id/10409

[95] https://link.springer.com/article/10.1007/s41208-019-00161-3

of freshwater (for domestic use and agriculture) and increasing frequencies of destructive storms as major issues affecting livelihoods of fishing communities[96].

A 2013 study by ICEM and DAI on aquaculture in Cambodia projected that:

- Increases in temperature and changes in rainfall patterns are likely to affect aquaculture as it becomes more difficult to prevent the loss of stock through flash flooding.
- Longer dry seasons may affect freshwater availability, especially if there is increased competition from other users, thereby constraining fish production.
- Storm intensity and frequency could affect coastal and reservoir aquaculture infrastructure and inland aquaculture farm flood security.
- Increased sea levels are likely to reduce the area available for aquaculture due to increased inland flooding"[97].

Figure 20: Climate Change impacts on fisheries in Cambodia by season[98]

Delayed onset of flood season	Change the trigger effect of flood season, with unknown response to fish migrations
Longer, drier dry seasons	Some species can survive for the dry season, as long as there are some viable fish refuges. It is not known how well they will be able to survive for longer, drier and potentially hotter periods Reduction of key habitats – for example, flooded forests Dry-season brood stock more exposed to fishing effort
Shorter, wetter rainy seasons	▪ Migration triggers affected ▪ Reduced season for breeding and spawning, as well as feeding ▪ Reduced opportunity for juveniles to reach suitable size and maturity to continue migration and life cycle
Sea Level Rise (SLR)	▪ Even a modest SLR of 20 cm would cause contour lines of water level in the Mekong delta to shift 25 km inland during the flood season and saltwater to move further upstream during the dry season ▪ Alter the fish species composition of fisheries but may not be detrimental of overall fisheries yield[99]

"The onset of the flood season acts as a trigger for migration, with fish moving along the main stems of the rivers or between the rivers and floodplains, where they migrate to breed, spawn and feed and then retreat as waters recede. While the amount of water in any given year is a contributory factor, the timing of the flood, combined with the number of peaks during the flood season and the area of land inundated, are also important factors. The area of land flooded provides important habitats for feeding, breeding and spawning, while the quality of the vegetation, such as flooded forests and wetlands, and the interconnectivity of the floodplain ecosystems also represent important factors in fishery production"[100]. (From CCPAP 2016-2020.MAFF).

[96] FAO GEF Project Document. Climate Adaptation and Resilience in Cambodia's Coastal Fishery Dependent Communities.

[97] MAFF Climate Change Priority Action Plan 2016-2022.

[98] MAFF CCPAP, 2016.

[99] ADB 2009.

[100] Baran, E., Kura, Y., Schwartz, N. (2009). Climate change and fisheries: vulnerability and adaptation in Cambodia.

Livestock

MAFF expects small- and medium-scale commercial livestock operations (with limited capacity to adapt to climate change) to be most strongly affected, however, high-performance breeds managed in high-density systems are also expected to be negatively affected.

Threats to the livestock sector include:

- Changes in temperature
  - Higher temperatures, and especially heatwaves, have strong impacts on livestock mortality
  - Increased temperatures result in higher livestock susceptibility to disease, and therefore morbidity
- Precipitation and drought,
  - Cambodian livestock farmers rely on rainwater for livestock grazing requirements (grass and feedstock) and drinking needs. Where precipitation is reduced in the long-term, or during years of extended or unseasonal drought, reduced productivity and increased mortality and morbidity can be expected
- Flooding and storms.
  - Extreme rainfall events and high winds/ storms are responsible for increased mortality across all livestock. Flooding can also impact feedstock and grazing requirements

Climate impact on feed crops like maize and cassava will have knock-on effects for livestock operations and production costs. In **Kampong Thom**, for example, increases in rainfall are expected to decrease cassava yields with potential implications for livestock feeding[101]. Where farmers are no longer able to grow or purchase sufficient food for their herds, herd sizes will decrease along with productivity. Availability and affordability of local meat products may be negatively impacted, with implications for FSN.

Climate change impacts on food storage and preservation

Food (and grain) storage and preservation in rural communities of Cambodia is often reliant on traditional methods that utilise clay or increasingly commonly plastic containers, raised upon wooden platforms and covered by palm thatched or corrugated zinc roofs. The conditions within these traditional setups are generally not ideal and led to heat damage (grain) and insect/pest infestation. Hotter and/ or more humid conditions are likely to increase the likelihood of pest damage. Drying of grain is important prior to storage to prevent fungal infestation, and erratic rains may impact this process. However, as innovation and adoption of technology advances towards 2050, these issues should be relatively easily overcome.

Insect production

Little is documented on insect farming in Cambodia. A 2018 paper[102] describing the trapping of - rather than farming- of insects mentions some activity in **Kampong Thom**. Insect trapping is highly impacted by seasonality of insect numbers, with significant drops during the hot, dry periods before the wet season starts in May (80kg per night in the rainy season reduces to 3kg in the dry season before increasing again on the onset of the rains). Given the predicted longer drier and hotter dry seasons towards 2050, insect farming will likely be negatively impacted by climate change. However, as the practice requires little or no land ownership and is

[101] ICEM: http://dss.icem.com.au/CambodiaDSS/.

[102] https://www.researchgate.net/publication/323402703_An_explorative_study_of_the_practice_of_light_trapping_and_the_informal_market_for_crickets_in_Cambodia

relatively risk free in terms of infrastructure/ crop damage from flooding and drought, insect collection may be considered an interesting, lucrative and nutrient-valuable alternative to traditional farming.

Forests

Forests are essential ecosystem service providers, supplying many of the prerequisites of agriculture and fisheries, including water replenishment, storage and flood regulation, soil health and climate stability. In terms of food availability, access and utilisation in Cambodia, they are important direct provision of food, especially in emergency contexts or times of low access to other foods (during drought or the while waiting for harvests).

Climate change is expected to negatively impact forests in a number of ways, but mainly due to increases in temperatures and dry periods resulting in more frequent forest fires. Additional climate change-driven pressure on agriculture (soil erosion, accelerated soil degradation, disease and reductions of water availability) will place more pressure on forests to provide alternative income sources, including for land use change from forests to tree plantations and for opening new lands for crops such as cassava, as previous plots become less productive more rapidly.

Cross cutting impacts to food productivity

≫ *Soil health and erosion*

- Accelerated degradation of soils is a likely consequence of climate change.
- Warmer temperatures are likely to increase the decomposition rate of organic materials in soils, meaning soil carbon levels and with it soil health will more rapidly diminish under conditions projected for Cambodia in 2050.
- Erratic rainfall that manifests as dry periods followed by more intense rainfall events has an increased capacity to wash away soil matter as well as nutrients within soils.

≫ *Irrigation*

- Reduced or delayed rainfall at crucial times, especially at the beginning of the rainy season (when rice crops require inundation and other crops require consistently available water for establishment of young plants) can lead to delayed planting and strongly impact resulting yields.
- Flooding damages irrigation channels and water storage infrastructure such as in stream check dams. More frequent or more extreme flooding is likely to threaten larger infrastructure and make the need to repair already impacted infrastructure more frequent. Continued need to repair infrastructure in high-risk areas, in addition to lower returns on labour and capital investments due to droughts, disease etc may result in abandonment of irrigation practices and potentially agriculture altogether.

≫ *Salinity*

- As sea levels rise, saltwater intrusion into coastal aquifers occurs. Cropping near coastlines is very likely to be affected by rising salt concentrations.
    - **Kampot:** salinity concentration increases extending further up the Mekong
- Where pumping of saline groundwater occurs for irrigation, the build-up of salt within soils can strongly impact an area's agricultural viability.

≫ *Insect pests*

Warmer temperatures are also associated with worsening pests, weeds and diseases.

According to the IPCC's WGII Sixth Assessment Report's Technical Summary, there is medium confidence that the occurrence of pests, weeds and disease will increase with global warming, and this increase will be amplified by climate-change induced extreme events (e.g., droughts, floods, heatwaves, and wildfires). It is expected that ecosystem health, food security, and human health in general will be negatively impacted.

"Changes in the rates of reproduction and distribution of weeds, insect pests, pathogens and disease vectors will increase biotic stress on crops, forests, livestock (medium evidence, high agreement). Pest and disease outbreaks will require greater use of control measures, increasing the cost of production, food safety impacts as well as the risk of biodiversity loss and ecosystem impacts"[103].

Further, the range of pests and diseases will likely increase while the stresses and disruptions to natural or agroecosystems (hot spells and drought) are likely to weaken ecosystems and crops' resistance to pests and diseases, making them more susceptible and likely less productive.

For Cambodia specifically, pests and disease are already a major issue. As mentioned earlier, in **Kampot** the number one issue raised by farmers is livestock and poultry disease, with nearly half of farmers citing its occurrence. High proliferation of weeds is also well recognised throughout the Kingdom as one of the major drivers of land use change and deforestation - as the labour/ financial costs of managing weed proliferation becomes untenable after just a few years of cropping, opening up new land for agriculture through swidden-type agriculture results in heavy losses of forested areas, and has done for many years.

3.3.2 Climate change impacts on food access

In total, agriculture (food and non-food production) contributes approximately 21% to national GDP[104]. Approximately 80% of Cambodia's territory is located within the Mekong and Tonle Sap basin (including the projects two target provinces), which, according to the climate change projections highlighted above, is likely to be increasingly impacted by higher temperatures and unpredictable rainfall. These worsening threats are likely to have increasingly negatively impacts on food production, especially for small scale, family farmers, who almost exclusively rely on rainfed agriculture for their food access and livelihoods. Rainfed agriculture contributes significantly to Cambodia's national economy, and more so for the rural majority of the population; impacts due to climate change are estimated to cost between US$ 100-170 million each year due to lack of adaptation capacity[105].

It is possible that climate change could worsen access to markets in some areas as flooding and storm damage intensify which impact on ability to transport agriculture products efficiently to the markets.

[103] Technical Summary IPCC WGII Sixth Assessment Report. 2021

[104] MAFF.2019. Agriculture Sector Development Plan 2019-2023. Phnom Penh, Cambodia.

[105] UNDRR (2019). Disaster Risk Reduction in Cambodia: Status Report 2019. Bangkok, Thailand, United Nations Office for Disaster Risk Reduction (UNDRR), Regional Office for Asia and the Pacific.

Sector	Source	Impact of Climate Change
Agriculture	Agriculture Public Expenditure Review (Mokoro 2010)	Increased annual losses by 2050 of 0.28% of GDP1
	USAID Mekong ARCC (USAID 2013)	Crop yields down by 3% to 6% by 2050
	ADB SE Asia study (ADB 2009)	Crop yields down by between 10% and 50% by 2100, depending on the CC scenario
	The Post Flood Early Recovery Needs Assessment (PFERNA) (RGC 2010, RGC 2014)	Losses of USD 152m in the 2013 flood and USD 56m in the 2009 typhoon.
	Cambodia CCFF (MoE 2015)	Losses of 1.14% of GDP by 2050[106]
	Analysis of crop yield and area trends	Losses of up to 1.6% of GDP by 2050[107]
Livestock	USAID Mekong ARCC study (USAID 2013)	Pig productivity declines by 5% for every 1oC above 30oC
	Research in S and SE Asia (Younas, Ishaq et al. 2014)	Heat stress reduces productivity by nearly 10%
Fisheries	USAID Mekong ARCC study (USAID 2013)	Probably negative, but the scale of impact is not yet clear
Forestry	USAID Mekong ARCC study (USAID 2013)	Decline in productivity, but the scale of the decline is not clear
	ADB SE Asia study (ADB 2009)	Decline in productivity, could be serious
Energy	Cambodia CCFF (MoE 2015)	Losses in cooling and distribution to rise by 2% of the value of energy generation
Sea level rise	DARA Climate Monitor (DARA and Climate Vulnerability Forum 2010)	USD 250m in 2010, not taking into account possible increases to 2030

Figure 21: Evidence on loss of output/ income in key sectors

[106] The figures presented in %GDP refer to the losses when agriculture has the current share of GDP. These will fall as agricultures share of total GDP falls.

[107] The figures presented in %GDP refer to the losses when agriculture has the current share of GDP. These will fall as agricultures share of total GDP falls.

3.3.3 Climate change impacts on food stability

Food stability is one of the four pillars of food security. To be food secure, a population, household or individual must have access to adequate food at all times and should not risk lose access to food as a consequence of sudden shocks or cyclical events (i.e., seasonal flooding). Instability occurs when there is inadequate access to food on a periodic basis, and is influenced by food production, household incomes, markets, and social entitlements. Where food instability occurs, the risk of the deterioration of nutritional status increases, especially of the most vulnerable groups. Adverse weather conditions and climate change, political instability, or economic factors (unemployment, rising food prices) can have strong impacts on food stability.

Focusing on Cambodia specifically, food stability is impacted by the seasonal nature of the dominant activity of rice farming. Due to rice farming's strongly cyclic nature, at certain times of the year, i.e., the lean season (August to November before the rice harvest occurs), families may run out of money to purchase food while production of food at the household level is commonly in short supply. During this time, households and communities that depend heavily on rice tend to rely on coping mechanisms such as formal or informal loans and off farm activities which may require seasonal rural to urban migration. In addition to farmers generally having less money during this time, the cost of rice is also highest. "The price of rice is highest immediately before the main wet season harvest which typically starts in November. The price drops when the main wet season harvest commences as rice supply increases, and gradually rises throughout the year"[108].

Seasonal flooding and untimely and prolonged droughts are responsible for Cambodia's inherent vulnerability to food instability, as yields and the timing of expected harvests are negatively impacted by unfavourable climate conditions.

As climate change is predicted to increase, the intensity of flooding events affects the timings of the onset of the rainy season and increase the likelihood and intensity of unseasonal droughts and extreme rainfall events (i.e., during harvest time), the stability of food production and farmers ability to sell and purchase food is likely to be negatively affected resulting in increasing instability of adequate food access, especially for rainfed rice production dependent communities.

Food instability associated with purchased, imported food can also be affected by climate change. Where climate change impacts production in one country, the knock-on effects can be an increase of cost or reduction in the availability in another, purchasing country. In Cambodia, nutritionally important products include meat, fruits and vegetables; these may be affected by various climate impacts that can reduce their availability or increase their price, thereby affecting food stability for consumers.

Impacts to rice production, while potentially significant, are unlikely to affect national availability of rice due to the quantities available and the political importance of ensuring rice is available to all citizens. There could however be stronger shock events towards 2050 that may create temporary emergencies that will require stronger social protection systems to ensure emergency rice is distributed effectively.

As most of the fruits and vegetables consumed in Cambodia are produced within the country and are reliant on rainfed production, any impacts to horticulture activities due to changes in precipitation regimes (longer, drier dry season, shorter wet season) could impact the availability of these products over the long term. Fruit trees ae likely less vulnerable due to their perennial nature, deeper roots/ drought tolerance. Yields however may decrease if conditions during pollination and flowering become less favourable.

[108] WFP 2010 Cambodia Food Market Analysis and Survey Report.

3.3.4 Climate change impacts on food utilisation & nutrition

Elevated atmospheric CO_2 concentrations

While higher CO_2 levels have the potential to increase rice yields, there is evidence to suggest that the nutritional quality of rice grown in higher atmospheric CO_2 concentrations will have lower protein value. Concentrations of some micro-nutrients, such as zinc, will also be lower.

In terms of nutritional value, an international study has found that higher levels of CO_2 are associated with a worsening nutrient profile for rice, with protein, iron and zinc content being significantly reduced[109]. On average, protein levels declined by about 10%, iron by 8% and zinc by 5% across the eighteen common cultivars used in the study when exposed to CO_2 concentration 200 ppm above ambient CO_2, or around 620 ppm. The CO_2 ppm concentration is in line with the CMIP6 SSP5 - 8.5 projection for 2050 (562.78 ppm) and therefore provides important evidence of the trend in nutritional value of rice as CO_2 concentrations continue to increase.

Focusing on rice, determining the likely benefits in terms of nutrition from higher yields under elevated atmospheric CO_2 (eCO2) is complicated. CO_2 fertilisation enables the plants to photosynthesise at increased rates, and therefore increase glucose (carbohydrate) production which in turn, under the right conditions, can result in higher rates of vegetative growth and grain production. However, the CO_2 effect is greatly reduced where nutrients such as nitrogen and phosphorus are limiting in soils and water availability is non-optimal, meaning that in order to capitalise on eCO_2 levels farmers will need to ensure their crops have improved access to water and soil nutrients – an especially important factor in the nutrient poor soils that dominate Cambodia. Further, apart from increased carbohydrate production (and therefore availability of carbohydrates to the consumer) it does not necessarily support an overall increase in proteins or micronutrients such as iron or zinc or B vitamins. For proteins, the decreased concentrations per g of rice are thought to result from nitrogen uptake by the plant not keeping up with the accelerated carbon-rich biomass production under eCO_2, resulting in more of carbohydrates and less of everything else – an effect called carbohydrate dilution[110].

The impact on other crops is still being understood, though some studies indicate that some changes to vitamins and micronutrient concentrations should be expected. Significant reductions in iron and zinc concentrations in leafy, stem and root vegetables and fruits, however concentrations of some antioxidants was found in to increase greatly in leafy vegetables.

Overall, the science suggests that while eCO_2 may increase yields under the right conditions, apart from improved carbohydrate concentrations, the nutritional quality of the produce will likely be reduced due to carbohydrate dilution. A 2007 study on protein reduction under eCO_2 (540–958ppm) for wheat, barley and rice found that the reduction in grain protein concentration was ~10–15% of the value at ambient CO_2[111]. In Cambodia this could impact the nutrition consumption profile of the entire population under the higher-end CO_2 emission scenarios predicted for 2050. This would mean that the population of Cambodia would need to rely more on other sources of protein for diets, such as meat and dairy, to ensure enough protein intake while at the same time increase saturated fat consumption.

Drinking water

Sustained periods of low rainfall can result in shortage of freshwater water supply and drought, leading in turn to shortages of drinking water and safe water for preparing/cooking food.

[109] Jing et al. 2016. https://pubmed.ncbi.nlm.nih.gov/26608560/.

[110] Toreti, A., Deryng, D., Tubiello, F.N. *et al.* Narrowing uncertainties in the effects of elevated CO_2 on crops. *Nat Food* **1,** 775–782 (2020). https://doi.org/10.1038/s43016-020-00195-4

[111] Taub, Daniel & MILLER, BRIAN & ALLEN, HOLLY. (2008). Effects of elevated CO2 on the protein concentration of food crops: a meta-analysis. Global Change Biology. 14. 565 - 575. 10.1111/j.1365-2486.2007.01511.x.

Mycotoxins[112]

Maize is generally the most at-risk cereal from mycotoxin contamination. However, according to ACIAR's 2015 Maize Production Guide, although some maize is grown in **Kampot** it is not produced extensively. **Kampong Thom** is not mentioned as a maize producing province. The risk of mycotoxin presence in rice is generally much lower than other cereals, though climate change is expected to impact all cereal-mycotoxin relationships. With rice being the dominant cereal throughout the country any climate related impact on mycotoxin contamination of rice would be important, though there is little information on the extent to which the predicted climate change scenarios would impact production or markets.

Climate Impacts Drivers (CID) and mechanism for food security impacts	Examples of effects on the target group Kampong Thom and Kampot
Increased heat and drought reduce crop and animal productivity and soil fertility and increase land degradation for some regions and crops.	Smallholders rely on agriculture for livelihoods. Food production systems that rely on rainfed agriculture and pastoral rangeland. Urban populations and the poor.
Extreme heat affects crop productivity. Combined with high humidity reduces agricultural labour capacity and animal productivity.	Agriculture rely on outdoor manual agricultural labour and experience high temperatures and humidity
Increasing temperatures and precipitation changes increase and shift crop and livestock pests and diseases	Cropping, livestock and fisheries (both inland and marine) will be stressed by increasing temperature and shifting rainfall patterns. Higher temperatures plus drought will likely lead to losses across the board for crops and livestock. Diseases and pests are expected to worsen. Increased flood damage is also predicted. Marine fisheries (Kampot) may be impacted by high temperature stresses to breeding and nursery areas. Inland fisheries (Kampong Thom) will likely be more heavily impacted by fluctuating river flows due to changing precipitation patterns compounded by damming operations.
Increasing temperatures and drought stress has led to higher post-harvest losses due to mycotoxins.	limited food safety surveillance. Important for maize, but less evidence on likely impacts on rice. Untimely rains during harvest periods could result in post-harvest damage
Rising ocean temperatures, marine heatwaves and ocean acidity reduces availability of fish in coastal communities.	Coastal communities in Kampot with high dependence on fisheries
Increased number and intensity of extreme events such as cyclones lead to reduced food production and distribution from crop damage, increased pest incidence and transportation disruption.	Nationwide
Increased atmospheric CO2 concentrations increase total plant biomass and plant sugar content, which can increase crops as well as pests and weeds. High CO2 also reduces transpiration during drought, which can increase plant drought resistance. Likely reductions in protein and micronutrient value of foods	Nationwide
Increased drought and flood events and increased pests and disease from rising temperatures lead to loss of agricultural income due to reduced yields, and higher costs of production inputs such as water. Reduced ability to purchase food leads to lower dietary diversity and consumption levels.	Low-income smallholder farmers in Kampong Thom and Kampot

[112] Mycotoxins are toxic chemical products produced by fungi that readily colonize crops. For further information, see https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8069105/ and https://www.sciencedirect.com/science/article/abs/pii/S0963996911003541

Increase in number and intensity of extreme weather events (e.g., droughts, floods) lead to increased food prices, which often leads to lower dietary diversity as well as lower consumption levels.	Low-income consumers. Women and girls.
Extreme events (e.g., floods) disrupt food storage and transport networks, reducing access and availability of food supplies.	Poor households living in flash flood and saline zones who rely on monocropped rice. Women and children may experience greater impacts from extreme events.
Increased temperatures reduce food safety caused by microorganisms, incl. increased mycotoxins in food and feed.	Limited food safety surveillance systems.
Climate change extreme events make fruits and vegetables relatively unaffordable compared with less-nutrient-dense foods.	Urban low-income households and rural households who purchase the majority of their food. Children with lower access to diverse food types as a result of climate impact drivers, e.g., drought.
Rising AT, ocean warming, and high CO_2 conditions increase risk of food poisoning and pollutant contamination of food through increased prevalence of pathogens (e.g., mycotoxins), HAB and increased contaminant bioaccumulation and threaten human health.	Current ability to reduce and monitor mycotoxin contamination is limited. Coastal areas of tropical countries with high dependence on fisheries
Increased atmospheric CO2 concentrations reduce nutritional quality of grains, some fruits and vegetables.	Low-income households who have limited access to range of diverse foods.
Rising ocean temperatures, marine heatwaves and ocean acidity reduce fish populations, which reduces consumption of fish high in iron, zinc, omega-3 fatty acids and vitamins in areas where fish populations decline.	Coastal population in Kampot who rely on fisheries.
Increased frequency and severity of extreme events (e.g., droughts and heatwaves) lead to greater instability of supply through production losses and disruption to food transport.	Low-income households in areas prone to floods. In Kampong Thom, many families reported not having a home garden due to flooding
Increased drought and flood events and increased pests and disease from rising temperatures lead to unstable incomes from agriculture and fisheries.	Small-scale producers (crops and livestock) and fishers
Climate change extreme events increase food prices due to climate shocks.	Urban low-income households and rural households who purchase the majority of their food. Women and children
Increased drought and flood events and increased pests and disease from rising temperatures cause widespread crop failure. Rising ocean temperatures, marine heatwaves and ocean acidity lead to dramatic decline in fisheries, contributing to migration and conflict.	Coastal communities in Kampot highly dependent on fisheries.

Figure 22: IPCC summary of climate impacts drivers on food security dimensions and relevance to Kampong Thom and Kampot

Climate change impacts in Kampot and Kampong Thom

Kampong Thom

- Inland fisheries in Kampong Thom play an important role in rural livelihoods and food security, especially for protein intake. As much of Kampong Thom's inland fisheries are in or around the Tonle Sap River basin, they are directly affected by seasonal patterns of floods and droughts, and so highly vulnerable to changing climate conditions. Temperature increases are also projected to impact fisheries through affecting fish metabolism, growth and distribution1.
- Additional but more indirect impacts of climate change include: increasing intensity of storms and extreme rainfall events presenting safety concerns for fisherfolk on the Tonle Sap (due to the need to use boats and the increasing danger due to stronger weather conditions); loss of habitat, particularly spawning areas/nurseries – as terrestrial agriculture becomes more stressed by climate change, pressure to open up new land in wetland and mangrove areas strengthens (with repercussions for fish populations).

Kampot

- During the 2016 droughts Kampot suffered from water scarcity that jeopardized food security, health and livelihoods. However, according to Climate Impact Explorer, rice production in Kampot Province is overall expected to benefit from increases in temperature between the expected range of 1.5°C and 3°C (as can be seen in the graph below). This means that towards 2050 rice yields can expect to benefit from the warmer temperatures (though only where sufficient water is available).
- Saltwater intrusion of agricultural land is considered a threat to food production all along the Cambodian coastline, including in Kampot. Compound threats from more intense storms/ cyclone events plus higher sea levels may result in increased risk of damage to crops and infrastructure. Salinization of river tributaries and aquifers may impact irrigation potential in areas close to the coastline and rivers. Similarly, access to potable water may be affected where salt lever become higher than permissible for drinking.
- In terms of impacts on food production from temperature and atmospheric CO2 increases, yields of both rice and soy are expected to increase slightly towards 2050, after which they either plateau or drop depending on which scenario is observed. Maize yields on the other hand are expected to drop rapidly under all potential scenarios.
- Sea fishing is a major livelihood activity in Kampot. Fisheries are expected to be negatively impacted by sea water temperature increases and acidification negatively impacting coral reefs and in turn fish stocks. Without protection, destruction/ clearance of mangrove forests (more than 40% reduction in area nationwide since 1997) may also be exacerbated by climate change as communities increase salt and charcoal production as agriculture become less productive, or agriculture further encroaches on unprotected areas, with negative implications for fish breeding.

3.4 Exposure to climate change

Cambodia is exposed to frequent climate related impacts across various sectors, including agriculture, fishery, forestry, energy, and infrastructure. This exposure is likely to get worse as global climate warming continues to influence regional weather patterns and drive increasingly higher temperatures towards the end of the century. The degree to which Cambodia is already impacted by floods, droughts, and storms places it at 14th in the world in terms of the proportion of the population and GDP at risk of being affected by climate related disasters[113].

Between 2011 and 2018, nearly one million households suffered from extreme weather of flood and storms is 902,941 households by flood, 7,676,206 ha by drought, and 49,000 households by storms. Climate hazards like these can destroy people's livelihoods, homes, and other property, reduce the ability of farmers to produce food, increase the spread of diseases and other health risks, lead to higher costs for family's businesses, and the government. It is seriously threatening Cambodia's people livelihoods and economy.

3.4.1 Exposure to extreme climatic events

Crop production in Cambodia, primarily rainfed, faces a range of climatic threats, chiefly droughts, floods, windstorms, heatwaves, as well as compounded heat and drought events in particular.

Extreme rainfall and floodings

Flooding is considered to be the principle natural hazard impacting Cambodia. Flooding is caused by two main processes: (1) increases in volume of the Mekong and Tonle Sap Rivers resulting in overflow and flooding of the surrounding area and (2) flooding resulting from extreme local rainfall[114]. While these processes are essential for the country's agricultural productivity, they also result in significant damage to crops and infrastructure throughout the provinces within the floodplain areas, amounting to losses of between US$ 100-170 million each year[115]. By 2050, more severe floods and droughts are expected to affect Cambodia's GDP by almost 10%.

Localised, intense rainfall impact locations throughout Cambodia (uplands, lowlands and coastal areas) wherever there is insufficient drainage or water intrusion capacity of the recipient landscape (i.e., capacity of the water to seep into the soils and aquifers or runoff efficiently without causing damage); deforestation and poor land management including unsustainable agriculture contribute strongly to local flooding and associated damage throughout the Kingdom.

Regional, upstream rainfall, as well as the influence of damming operations along the Mekong, present another, larger, slower and generally more protracted issue for communities that live along the Mekong and Tonle Sap river basins and flood plains. This flooding tends to be seasonal, but nevertheless can be unpredictable in its intensity and duration due to the large quantity of water influencing flooding depths, as well as the extensive rainfall catchment areas that influence the downstream waterflow and volume.

Increased intensity of rainfall during the monsoon seasons could significantly impact flood response management across the Mekong.

[113] According to the Global Climate Risk Index, Cambodia was ranked as the 14th most climate risk-prone country globally, https://www.germanwatch.org/en/19777

[114] Technical report on V&A assessment in specific sector, Centre for Agricultural and Environmental Studies (CAES) [Not published].

[115] Rinbo, 2009. The Expert Group Meeting on Innovative Strategies towards Flood Resilient Cities in Asia-Pacific Cambodia: Mainstreaming Flood and Drought Risk Mitigation in East Mekong Delta and Climate Risk and Adaption profile 2011.

Droughts

Drought is considered to be Cambodia's second major hazard. According to the National Committee for Disaster Management[116], Cambodia experienced episodes of extreme drought between 2001–2005 that affected nearly 2.5 million people and damaged more than 500,000 hectares (ha) of crop production. In 2004, a severe drought led to an 82 % loss of rice harvest[117]. In 2015/16, Cambodia experienced its strongest El Niño episode in 50 years, with a massive drought that negatively impacted 2.5 million people across 25 provinces through water shortages, land degradation, crop losses and livestock deaths[118]. More recently, droughts in 2018-2019 badly affected almost 100,000 ha of crop production. Very large decreases in rice farming productivity (up to 70%) could be expected without adaptation measures[119].

According to the Drought Initiative Cambodia report (2019), between 1996 and 2014, Kampot suffered 153 reported droughts, the second highest in Cambodia during that time-period[120]. **Kampong Thom** was one of the 10 provinces in Cambodia vulnerable to drought[121].

Though the total amount of rainfall per year is also not expected to change meaningfully by 2050, its distribution throughout the year may alter; Cambodia as a whole may experience an additional 6-9 days of continuous drought each year under worst case scenarios, with Kampot and Kampong Thom receiving 4.8 and 6.4 extra days respectfully[122]. Additionally, various reports, including the NDC Update 2020 state for example that "most of Cambodia's agricultural areas will be exposed to higher risks of drought" by 2050, and that under high emission scenarios the likelihood of drought conditions would increase, with concomitant reductions in the length of growing periods.

Windstorms

The country experiences considerable threats and impacts from typhoon events: between 2000-2019 almost 30,000 homes were damaged, and 113,000 ha of crops were destroyed.

Heatwaves

Growing number of hot days above 35ºC temperatures poses a threat to labourers, both in rural and urban locations, to work safely and effectively[123]. In addition, high temperature over several days can negatively impacts crop growth.

Compound events

The major compound events impacting food production, livelihoods and health are high temperatures/ heatwaves and drought.

[116] NCDM. N.d. The End User Manual of the Cambodia Disaster Loss and Damage Database (CamDi). Phnom Penh, Cambodia. http://camdi.ncdm.gov.kh/DesInventar/profiletab.jsp?countrycode=kh2&continue=y.

[117] UNDRR/ ADPC 2019. DRR in Cambodia. Status Report.

[118] UNDRR 2021. DDR Status Report, Cambodia

[119] GSSD 2017.

National Adaptation Plan Process in Cambodia. General Secretariat of National Council for Sustainable Development/Ministry of Environment, Kingdom of Cambodia, Phnom Penh.

[120] Drought Initiative Cambodia. 2019. https://www.unccd.int/our-work-impact/country-profiles/cambodia

[121] Drought Initiative Cambodia. 2019. https://www.unccd.int/our-work-impact/country-profiles/cambodia

[122] https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-projections

[123] World Bank/ ADB 2021. Climate Risk Country Profile Cambodia. https://www.adb.org/publications/climate-risk-country-profile-cambodia

As shown above, high temperatures are very likely to become far more common towards 2050 meaning chances of both high temperatures and drought occurring together will increase. Projections for changes in the occurrence of drought are less clear, with low confidence in projections across all models. It is however more likely than not that drought events during the dry season will become worse, and the wet season will become shorter.

There is some evidence of more erratic rainfall during the wet season, and the potential for prolonged unseasonal droughts towards 2050.

It is clear that where high temperature events lead to increased evapotranspiration rates in plants and an increased requirement of drinking water in livestock, the repercussions (of a concurrent deficit of water availability) can be disastrous in terms of increased mortality, crop losses and lower yields. These events are likely to be felt more acutely by farming families with limited access to pumped water, meaning that it is the more remote and poorer households that will feel the greatest impact of compounded drought and high temperatures circumstances.

A more intense lack of water and hotter temperatures may have important implications for dry season production of fruits and vegetables, the increased consumption of both is an important target for improving dietary diversity and nutritional deficits.

The resulting impact on rice productivity of compounded drought and heatwaves is predicted to be highly deleterious. Insufficient water and high temperatures can impact rice plant germination, sewing success, vegetative phases and grain filling. More common pest infestations due to higher temperatures, compounded by higher susceptibility due to the physiological stress that a lack of water places on plants, is likely to increase disease prevalence where drought and heatwaves coincide.

Drought and heatwaves area also strongly associated with forest fires that can impact agroforestry productivity, cashew farming for example, and also impact forests' capacity to deliver ecosystem services such as surface water flow rate reduction and increased infiltration to groundwater once the rains return. Drought and heatwaves also lead to increased weed proliferation as hardy, unwanted plant species thrive at the expense of crops (removing even more of the soil moisture), increasing costs and diverting labour away from more productive activities. Similarly, pest infestations are also associated with the high stress conditions brought about by simultaneous drought and high temperature episodes[124].

Higher temperatures have an impact on soil health and fertility. Decomposition of soil carbon is accelerated as temperatures increase, and in Cambodia, where sand soils dominate, and fertility is often low any increase in deterioration of soils is problematic. Intense rainfall, flooding and drought are compounding factors for soil health reduction, especially where land is tilled or denuded through deforestation.

An additional compounding factor that strongly impacts Cambodia's food production potential is upstream damming by neighbouring hydraulic nations. In 2019 the Mekong River fell to its lowest level in recent history, largely caused by damming. The reduction in volume of water in the Cambodian stretch of the river was both due to -and exacerbated by- the El Niño-induced low precipitation rates across the region (more water needed to be stored upstream, leading to less being available for release). The resulting lack of available water led to huge losses in rice, cassava, and livestock production in downstream Cambodia[125].

[124] CIAT FAO 2021. Climate Smart Agriculture Country Profile, Cambodia.

[125] CIAT FAO 2021. Climate Smart Agriculture Country Profile, Cambodia.

Hazard(s)	Climatic drivers	Reference(s)
Drought	Precipitation, evapotranspiration, historic evolution of soil moisture, temperature	35,77,78
Physiological heat	Temperature, atmospheric humidity, strongly dependent on diurnal cycle	56
Fire risk	Temperature, precipitation, relative humidity, wind, lightning	55,79
Storm risk	Wind speed, humidity, large scale atmospheric circulation	94,95
Coastal flood	River flow, precipitation, coastal water level, surge, wind speed	11,12,30
Flood risk at river confluences	Precipitation, water levels of contributing rivers, large-scale atmospheric circulation	31
Concurrent drought and heat	Temperature, precipitation, evapotranspiration, atmospheric humidity	7,35
Concurrent wind and precipitation extremes	Wind speed, precipitation, orography, large-scale atmospheric circulation	34
Concurrent heat and air pollution	Temperature, sulphur dioxide, NO_{XF} particulate matter (PM_{10})	6,76

Figure 23: Non-exhaustive list of documented climate-related hazards for which drivers are dependent and combinations of dependent hazards with potentially large impacts[126]

Sea level rise

Sea level rise threatens the country's low-lying areas, including settlements, beach resorts, seaports, coastal fisheries, and mangrove forests.

3.4.2 Exposure of farming and fishing activities

Under future climate conditions (2025 and 2050), most of Cambodia's agricultural areas will be exposed to higher drought risks. Based on data from the past 20 years, losses in production were mainly due to flooding (about 62%) and drought (about 36%). Most flooding occurs due to increased water levels in the Mekong River and Tonle Sap Lake between early July and early October.

A 2021 report by CIAT found that in Popok Commune (**Kampong Thom**) six out of ten hazards identified by the farmers involved drought directly, and the remaining four were associated with pest infestations that are induced or exacerbated by drought conditions[127].

[126] Zscheischler, J., Westra, S., van den Hurk, B.J.J.M. et al. Future climate risk from compound events. Nature Clim Change 8, 469–477 (2018). https://doi.org/10.1038/s41558-018-0156-3

[127] CIAT FAO 2021. Climate Smart Agriculture Country Profile, Cambodia.

In terms of impacts of climate related shocks on to farming households, such as flooding and drought, the Cambodia Inter-Censal Agriculture Survey 2019 (CIAS19) provides farmer survey-based information on impacts to households in **Kampong Thom** and **Kampot**.

As shown in the table below, drought and food insecurity is by far the most common severe shock affecting households in **Kampong Thom**, followed by insect damage (also likely exacerbated by higher temperatures and drought). In **Kampot**, livestock disease is the most reported severe shock, with flooding the next most reported, followed by drought and food insecurity and insect damage.

	# Households reporting severe shock in Kampong Thom	Percent of households reporting shock in Kampong Thom	# Households reporting severe shock in Kampot	Percent of households reporting shock in Kampot
Typhoon	6	13%	1	4%
Floods	3	5%	9	28%
Drought and food insecurity	30	65%	5	15%
Insects	16	34%	5	14%
Crop disease	5	11%	3	8%
livestock/poultry disease	4	8%	15	46%

Figure 24: Farmer reported impacts to agriculture production[128]

Climate events, such as the large-scale flooding in 2020 (and to a lesser extent in 2021) led to significant loss of crops and forced many of the most vulnerable households to reduce their food consumption, sell productive assets and contract debts. This year, over 113,000 people were affected by floods and over 87,000 ha of cropland areas were damaged.

Changes to Cambodia's climate have the ability to impact access and availability of fish and seafood in diets through disrupting productivity of natural and farmed stocks and through disrupting their capture and farming, i.e., infrastructure and fishing activities.

According to MAFF's 2016 Climate Change Priority Action Plan, delayed onset of the flooding season, droughts and longer drier dry seasons, shorter wetter rainy seasons and sea level rise are the main threats to capture fisheries.

[128] CIAS 2019

4 Social security situation & climate vulnerability

Take away points

- Farmers in Cambodia are exposed to significant risks and constraints that make the outcome of farming activities uncertain and often scarcely remunerating. Further challenges have recently arisen due to changes in climatic patterns and in dynamics of international trade, that have both exacerbated the unpredictability and the low profitability of agricultural activities.
- According to the German development bank KfW scoping study for supporting agricultural insurance (November 2018), rice, vegetable and high-value crop growers are expected to be the main potential users of insurance products in the future. Potential crop insurance products are likely to be indemnity (yield guarantee). Some of the major issues that may influence the development of agricultural insurance in Cambodia are: (1) Small size of the sector and lack of technical knowledge and expertise on both the public and private sectors side, (2) Inadequate insurance regulation, (3) Need for individually tailored and/or customisable insurance solutions for the diverse set of crops that are cultivated in Cambodia (but lack of local expertise to develop such solutions), and (4) Need for further processing of data on agricultural production and weather variables.
- Cambodia will require a diverse range of agricultural insurance products such as yield guarantee, weather and yield indexes, as well as Catastrophic risk mitigation-level programs for the national and provincial governments.
- Cambodia should consider:
  - Introducing a voluntary insurance program with certain mandatory requirements for the farmers to fulfil in order to be eligible for government assistance in case of severe or catastrophic weather events
  - Developing a separate catastrophic risk mitigation program to provide support to rural population, i.e., subsistence farmers
  - Supporting agricultural insurance schemes with a subsidy program
  - Encouraging financial institutions to bundle agricultural loans with insurance products
  - Facilitating the application of new technologies such as remote-sensing technologies and reanalysed weather data services
  - Facilitating provision of technical assistance to both insurance companies and government agencies

4.1 Social security situation

Cambodian economy averaged 7.7% real GDP growth over the last two decades, mainly driven by construction, tourism, and manufacturing for export sectors (garments, textiles and footwear) and domestic demand. This robust growth has translated into a higher income for the population and consequently decreased poverty rates from 53% in 2004 to 13.5% in 2014, respectively 12.9% in 2018[129,130]. However, due to the COVID-19 pandemic, since 2020, poverty has increased to an estimated rate of 17.8% of the population, according to

[129] (Where have all the poor gone? Cambodia Poverty Assessment 2013, April 2014)

[130] (Organisation for Economic Cooperation and Development, November 2017)

Asian Development Bank (ADB)[131]. Characterised as a least developed country, Cambodia has been eligible for graduation since 2021[132].

This economic performance allowed the government to initiate extensive policy reforms in the social protection area, aimed at reducing inequalities and better protecting people against various forms of risks. Consequently, a comprehensive National Social Protection Policy Framework (NSPPF) was elaborated for the decade 2016–2025.

Within the NSPPF, the social assistance policy is based on four types of interventions, each one targeting a specific domain:

1. Emergency responses
2. Human capital development
3. Vocational Training
4. Social Welfare of Vulnerable People (i.e., family package)

4.1.1 Emergency Responses

Under the responsibility of the National Committee for Disaster Management, the emergency response to natural disasters is delivered in three ways: (1) food supplies provided to low-income families in times of crisis; (2) a food security programme initiated by the Ministry of Economy and Finance (MEF) directed to poor and vulnerable citizens affected by the rise of food prices during a crisis; and (3) safe evaluation centres built in the most affected regions.

In November 2020, a Flood Response Plan was elaborated for the period November 2020 to April 2021, targeting 19 provinces and 800,000 persons affected by floods. A total of 388,000 people were identified as needing assistance, of which 237,000, representing 52,861 households, were declared eligible for receiving aid estimated at 9.43 million USD in total[133]. The major share of resources was planned for food security and nutrition (3.8 million USD) for immediate cash/ food assistance to affected households, to meet immediate food and nutrition needs during and after the crisis.

The Cambodia Climate Change Strategic Plan 2014-2023 is currently under implementation to prevent climate change. For 2019-2023, the objective is to mainstream climate change into national and sub-national programmes[134].

In May 2021, the National Committee for Disaster Management (NCDM) opened six new safe evacuation centres, with a total capacity of 2,000 up to 3,000 persons. The centres, built with the assistance of the Japanese government and the World Food Programme (WFP), provide housing facilities for displaced families during cyclones and floods; recently, the centres have been used as COVID-19 vaccination sites and quarantine sites[135].

[131] (Asian Development Bank, 2022)

[132] (United Nations Department of Economic and Social Affairs, 2021)

[133] (ReliefWeb, 2020)

[134] (OpenDevelopment Cambodia, 2015)

[135] (United Nations Cambodia, 2021)

4.1.2 Human Capital Development

Three main social assistance programmes are implemented in the following areas: Cash support for pregnant women and children under two years of age; a school feeding programme; and scholarships for primary and secondary education.

- **Cash support for pregnant women and children under two years of age**

This programme aims to provide financial support to pregnant women and children under two to receive adequate nutrition. The program beneficiaries are those holding health equity cards or priority access cards. It is implemented by an inter-ministerial group led by the Ministry of Social Affairs, Veteran and Youth (MoSVY) and coordinated by the National Social Protection Council (NSPC). In the first quarter of 2021, 37,233 pregnant women and 78,852 children under two years of age received medical check-ups under the programme. At the same time, the Royal Government of Cambodia has disbursed 6,657.32 million KHR to the beneficiaries by the end of November 2020.

To improve its efficiency, during the first quarter of 2021, an evaluation of the programmes was carried out, together with a data quality assessment and the development of real-time synchronisation and reporting dashboard in the management information system via the application programming interface. The scope of these evaluations and assessments was to prepare the programme for its integration into the family package.

- **School feeding programme**

The programme's direct objective is to improve the nutrition of students from low-income families to increase enrolment rates and reduce dropout rates in primary schools. Implemented through the inter-ministerial Prakas 90 from 23 January 2020, the government allocated 7,072.4 million KHR to the programme. The meals were prepared from local, community-based, agricultural products. In total, 205 schools were targeted for implementing the programme in six provinces, covering 52,130 students.

However, in March 2020, the schools were closed nationwide because of the COVID pandemic. The programme was converted by the Ministry of Education, Youth and Sport (MoEYS) into take-home rations of rice for cooks and students in poor households. By the end of 2020, four rounds of take-home rations were distributed to 51,222 students and 371 cooks. According to MoEYS, the programme has contributed to the school enrolment rate, but no statistics are available. On the other hand, since the programme consisted essentially of distributing rice to the students' resident, it is unclear how the impact on the enrolment rate was estimated.

- **Scholarship programme for primary and secondary students**

Introduced initially for the students in the primary schools, the programme provides annual scholarships in the amount of 60 USD to students belonging to low-income families. The selection of beneficiaries is done by a local committee. The annual scholarships are delivered in three tranches of 20 USD each in the school bank account, giving them directly to the students. In 2020, about 75,000 children in primary schools benefited from scholarships.

The programme was recently extended to the lower secondary level, where each student receives 90 USD per year, equally in three tranches. An assessment carried out by the World Bank concluded that the programme has a net positive impact on enrolment and reduces the dropout rate. Consequently, the Cambodian government intends to extend it to the upper secondary level, such that all the grades from 7 to 12 will benefit from the programme.

The good performance of the programme on schooling outcomes proves that this initiative is efficient in dealing with human capital development issues of social assistance. By extending it to cover both primary and

secondary levels, the education level will be positively impacted. However, there is also a need for extension in terms of coverage. The number of poor students receiving the scholarship is well below that of children living in poor households registered in the ID POOR system.

4.1.3 Vocational Training

Within this programme, the Ministry of Labour and Vocational Training (MoLVT) is conducting training programmes to raise the skills in various fields such as post-harvest techniques, women's entrepreneurship, and apprenticeship programmes together with enterprises. The NSPPF envisages introducing a cash transfer programme for technical training levels 1-3 for poor people and women in priority sectors.

4.1.4 Social Welfare of Vulnerable People

There have been concerns about the effectiveness of social assistance programmes under the human capital development component. The Cambodian government decided, therefore, to develop a comprehensive concept of the family package, which would integrate two of the above programmes (cash transfers to pregnant women and children under two, respectively, the scholarship program) into a single package which, in addition, will include two cash transfers programmes, one for disabled persons and the second elderly; thus, a total of four programmes will be unified into a single intervention. These last two programmes were planned by the NSPPF to be implemented in the previous phase (2020–2025). Concerning the cash transfers to poor persons with disabilities, the MoSVY started the identification of beneficiaries in eight provinces, but the process was put on hold due to the COVID-19 pandemic.

The MoSVY has been cooperating with the General Secretariat-National Social Protection Council (GS-NSPC) and other ministries to design family package's overall framework. The framework was submitted in ebruary 2021 to NSPC social assistance sub-committee. Based on the NSPC feedback, the MoSVY revised the framework, which was approved by the Chair of the NSPC Executive Committee on June 28.

The implementation of Family Package (FP) will be done gradually, in three steps:

1. By the end of 2022, the three programmes under the responsibility of MoSVY (cash transfer for pregnant women and children under two; Support to elderly; cash transfer for persons with disabilities) will be consolidated into one programme.
2. In 2023, the scholarship programme of MoEYS will be integrated into the family package.
3. All four programmes will be fully consolidated, and the family package framework will be fully operational in 2024.

This integrated approach of various human capital development programmes will reduce the administrative costs by unifying the delivery of benefits, streamline the services provided, and improve the identification of needy persons. At the same time, the unified family package puts the basis for the life cycle approach of social protection by including the entire age range in the provision of services. However, the "missing middle" (working-age population) is not explicitly present in the programme; it is supposed that this age category will be covered by the social security component.

The effective implementation of the family package needs careful attention from responsible authorities. The programme should not be perceived as a lump-sum aid to the family as a whole, but as a package of distinct benefits directed to specific categories of beneficiaries (children, disabled, elderly) and therefore each category will receive an explicit support to help in coping with his/ her vulnerability. Designed as such, the family package will represent a good opportunity for the transition from the exclusive support to ID-Poor households to a broader range that includes vulnerable persons.

In addition to the above programmes, the social assistance component includes two more mechanisms: The Health Equity Fund (HEF), respectively the Food Reserve Programme.

The HEF provides free health care services to poor families holding ID-Poor cards: user fee exemptions, expenditures for transport-related to seeking care and other hospitalisation expenditures. These benefits are defined by a minimum package of activities at health care centres and respectively by a complementary package of activities at referral hospitals. The HEF is already implemented in all public health facilities, and it is administrated by an autonomous entity under the Ministry of Health. Since its implementation, the HEF has proved to be successful in reaching the poor, although the quality of medical services needs further improvement. The HEF represents the best policy option for scaling up the interventions and achieve universal health coverage.

The Food Reserve Programme (FRP) of the National Committee for Disaster and Food Security Programmes of the MEF is designed to intervene for preventing food insecurity. With support from United Nation for Food and Agriculture Organization (FAO), programming framework has been put in place for the period 2019–2023 aimed at:

1. Enhancing agricultural productivity, diversification and commercialisation, and safe and nutrition-sensitive food systems for poverty reduction and food and nutrition security.
2. Equitable and sustainable management of natural resources, and increased capacity to monitor and report climate action.
3. Reduction of vulnerability, and improved resilience to climate change and shocks at national, community and household level.

Institutionally, the implementation of social assistance programmes is intended to be entrusted to a single authority. The Government will establish the NSPC to develop the social protection system and to ensure better harmonisation of the different strategies, policies, and other social protection activities as well as to ensure effective coordination of multi-sectoral issues. The NSPC is currently composed of high-ranking representatives from relevant ministries and institutions, including representatives of the Council for Agricultural and Rural Development (CARD), MEF, MoSVY, MoLVT, Ministry of Interior, Ministry of Health, Ministry of Planning, Ministry of Justice and Ministry of Commerce.

The main achievements as of 2021 in the two components (social assistance and social insurance) of the social protection sector are listed in the following table:

Figure 25: List of social protection programmes and main achievements

Programme	Main Achievements as of 2021
Social assistance	
Emergency response	
Food security programme	▪ Country Strategic Plan 2019–2023 in place, with WFP support. ▪ FAO Country Programming 2019–2023 underway ▪ Flood Response Plan elaborated (November 2020–April 2021) targeting 19 provinces and 800,000 persons affected by floods. 388,000 people were identified as needing assistance, of which 237,000, representing 52,861 households, were declared eligible for receiving aid estimated at 9.43 million USD, of which food security and nutrition 3.8 million USD and shelter 3 million USD). ▪ Cambodia Climate Change Strategic Plan 2014–2023 is currently under implementation. ▪ May 2021: the NCDM opened six safe evacuation centres, with a total capacity of 2,000 up to 3,000 persons, providing housing facilities for displaced families during cyclones and floods; the centres have been used as COVID-19 vaccination and quarantine sites.
Human capital development	
Supporting programs for pregnant and children under two	▪ To be expanded to children under five in 2022. ▪ As of June 2021: 159,650 pregnant women and children under two received conditional medical check-ups. ▪ As of June 2021: 40,082,656,000 KHR equivalent to 10,020,664 USD disbursed to beneficiaries.
School feeding programme	▪ 2020: 7,072.4 million KHR allocated to 205 schools in six provinces for 52,130 students. ▪ March 2020: the programme was converted into take-home rations in rice to students in poor households and cooks. ▪ End 2020: four rounds of take-home rations distributed to 51,222 students and 1,371 cooks. No data is available for 2021.
Scholarships for primary and secondary education	▪ School year 2019-2020: 193,541 children received scholarships in primary and secondary education (60 USD for primary and 90 USD for secondary). ▪ 2020: about 75,000 beneficiaries. No data is available for 2021.
Vocational training	
Short trainings organised for basic skills.	
It is envisaged to introduce a cash transfer for technical training levels 1-3 for poor people and women in priority sectors.	
Welfare for vulnerable persons	
Cash transfer program for people with disability	▪ New disability law drafted in 2021. ▪ A new programme identification process started (eight provinces) but stopped because of COVID-19. ▪ To be integrated in the family package.
Support program for elderly people	▪ To be integrated in the family package
Other social protection programmes	
Response to COVID-19 crisis	▪ Q1 2020: Establishment of a task force responsible for planning the financing of social assistance related to the fight against Covid-19. ▪ Q1 2020: Elaboration of national plan preparing for and responding to novel COVID-19 in Cambodia, updated in the beginning of 2021 with WHO support and aligned with WHO's 2019 Novel Coronavirus: Strategic preparedness and response plan. ▪ July 2020: MoEYS developed a sectorial response plan against COVID-19

	▪ April 2020: MoH started to implement the response measures to COVID-19 crisis within the project Environmental and Social Management Framework, as part of the Health Strategic Plan 2016–2020: Quality, effective and equitable health services.
Cash transfer program for poor and vulnerable households during Covid-19	▪ Since the start of programme (June 2020), the number of beneficiaries has increased from 2.15 million to 2.73 million in February 2021. Over the same period, the total budget of the programme passed from 23.64 million USD to 30.7 million USD. ▪ Around 700,000 households benefited from the programme by the end of Q1 2021. ▪ Cash transfers differentiated by region (urban, rural) and additional allowances granted for disabled, HIV infected, children under five and elderly.
Workers allowances	▪ Monthly allowance (between 15 and 40 USD) to workers on suspended contract. September 2020: 13,000 beneficiaries. ▪ March 2021: third round of allowances. ▪ Since the implementation of the programme until end of Q1: 330,000 workers have benefited from the package amounting to 6.84 million USD ▪ June 2021: new round of allowances (40 USD) for workers from garment/textile, footwear, travel accessory, bag, and tourism. Cash Relief Programmes for poor and vulnerable families extended until September 2021.
Post lockdown cash transfer program for household in difficulty/ with Covid-19 patient/ with death from Covid-19	▪ To be launched in June 2021 as a relief for those living in difficulties in the worse hit area.
Social security	
Pensions	Elaboration of sub-decree (32/March 4, 2021) on the adoption of social security pension for all persons specified by the labour law. The implementation of the scheme is going to be postponed until 2022. Pension is a very important element of social security for acceptable reason: managing pandemic's impacts on key sectors of the economy has priority during crisis.
Health insurance	▪ 11,458 private enterprises registered, employing 1,324,061 persons, of which 855,437 women. ▪ 38 public institutions are registered (399,721 employees, of which 116,927 women. ▪ In the HEF, 946 entities are registered, totalling 94,388 workers, of which 20,368 women: 52,482 commune/ Sangkat council members, village chiefs/ vice chiefs/ members; 1,183 athletes; 36,770 cyclo-riders, motor-taxi riders; 3,953 domestic workers, grocery sellers, etc. ▪ To achieve universal health care, a roadmap has been developed. ▪ More than 40% of Cambodians are covered under various social health protection schemes. However, there is an important distinction between legal coverage (people legally entitled to be covered) and effective coverage (people enrolled). ▪ Next priority: inclusion of informal workers in the HEF.
Occupational risks	11,826 private enterprises, employing 1.33 million persons (of which 859,208 women) have been registered with the social security and as of first quarter 2021, 11,826 enterprises, employing 1.33 million persons (of which 859,208 women) which is encouraging. In the beginning of 2021, the occupational risk scheme was also introduced in the public sector.
Allowance	▪ Birth allowances have been provided to the mothers; the progress is remarkable. ▪ In 2020, a total of 80,499 women (80,355 women from the formal sector and only 144 women from the informal sector). ▪ In the first quarter of 2021, a total of 239,387of such allowances were granted, the large majority (238,588) to women from the informal sector.

4.2 Vulnerability

According to several international climate change indices, Cambodia is one of the most vulnerable countries to the adverse impacts of climate change. The Global Climate Risk Index (1999–2018) placed Cambodia at 12th place among the most vulnerable countries globally. The World Risk Index (2019), calculated as a product of exposure and vulnerability, categorised Cambodia as among the 'very high' impacted countries.

Rising temperatures are likely to lead to increased frequency and intensity of extreme weather events in a fragile socio-economic context. The country's climate vulnerability results in loss and damage to human life, livelihoods, and the national economy, as well as the degradation of her natural resources. The country is particularly vulnerable to floods, droughts, windstorms, and seawater intrusion. According to a series of vulnerability assessments carried out in 2016, 17.5% of Cambodia's communes were 'highly' vulnerable (i.e. 288 communes) and 27.28% (449 communes) were 'quite' vulnerable to multiple climate change hazards.

4.2.1 Vulnerability of the food system

Vulnerability of the fish sector

A 2012 world fish centre study, titled assessing vulnerability to climate change and building adaptive capacity In Cambodia's fisheries sector[136] identified that:

- Saline water intrusion up the Mekong River delta has increased from approximately 20km inland to 50km inland since the end of the last century (~1km per year)
- Increasing intensity of storms and extreme rainfall events are highlighted as major safety concerns for fisherfolk on the Tonle Sap due to the need to use boats and the increasing danger due to heavier weather.
- Temperature increases are projected to impact fish metabolism, growth and distribution, while lower trophic levels could affect the food web[137].
- Climate change could generate anoxic conditions in the bottom layers of rivers and lakes while breeding cycles could be interrupted, which would influence fertility and extend the spawning season[138].
- These ecological impacts could change production and yield, species distribution, species diversity, migration patterns and instances of fish diseases.
- Climate change could favour some species over others, thereby changing the relative abundance of various species.
- Changing flood pulses could reduce key fish habitats such as flooded forests[139].
- Changes to hydrological flows could be amplified by an increasing number of hydropower dams[140] .
- Climate change is expected to reduce dry season flows in rivers and negatively impact water quality.

[136] World Fish Centre 2012. Assessing vulnerability to climate change and building adaptive capacity in Cambodia's fisheries sector. A report prepared for the Fisheries Administration project, "Building Capacity for Integrating Climate Change Adaptation in Fisheries Sector in Cambodia" Kaitlin Almack,

[137] Johnston, R., Hoanh, C. T., Lacombe, G., Noble, A., Smakhtin, V., Suhardiman, D., Kam, S.P., and Choo P.S. (2009).

Scoping Study on Natural Resources and Climate Change in Southeast Asia with a Focus on Agriculture.

International Water Management Institute, Colombo, Sri Lanka, and The WorldFish Center, Penang, Malaysia.

[138] V. Beznosov, A. Suzdaleva. Potential Changes in Aquatic Biota in the Period of Global Climate Warming. 2004. Environmental Science Water Resources.

[139] Ministry of Environment and UNDP. (2011). Building Resilience: The future of rural livelihoods in the face of climate change. Cambodia Human Development Report. UNDP, Phnom Penh, Cambodia.

[140] World Fish Center/SIDA. (2009). A scoping study: Natural Resources and Climate Change in South East Asia with a Focus on Agriculture--Fisheries Component. Environment (pp. 0-37).

- The degradation of forests and wetland ecosystems could make the agriculture and fisheries sectors more vulnerable to climatic variation.
- More than 80% of the fish traders and processors in the Lower Mekong Basin are women.

A concomitant threat to fisheries productivity and sustainability stems from planned increases in damming activities on the Mekong River. A study undertaken by IFREDI in 2013 identified potential reduction in fish yield of 30% by 2030, partly due to damming.[141] The report suggests that when population increases are factored in, the resulting reduction in fish and fish products would amount to 34% less availability than the baseline, with likely strong detrimental impacts on nutrition (especially for children and pregnant women) and income for rural populations. In general, it can be concluded that capture fisheries and aquaculture are highly vulnerable to climate change. This includes vulnerability to higher temperatures; changes in rainfall patterns; changes in hydrological regimes (water levels, duration of flooding, timing of flooding and damming activities); changes in run-off or sediment load/movement; and increased instances of extreme weather events (storms, floods and droughts)[142].

Vulnerability of the livestock sector

System	Impact	Adaptive Capacity	Vulnerability
Smallholder cattle/buffalo	Low	Low	Medium
Dairy/large commercial	Very High	High	High
Small commercial pig	High	Medium	High
Small commercial chicken	Very High	Low	Very High
Scavenging chicken	Low	Low	Medium
Field running layer duck	Very low	Low	Low

Figure 26: Vulnerability assessment of livestock to climate change threats [143]

Livestock-associated climate vulnerability stems from:

- Increased disease risk due to heat stress or changes in ranges of pathogens (temperature/ precipitation driven),
- Changes in fodder and forage availability and expense (as cereals and other fodder crop production is affected by climate change, i.e., flooding, unseasonal dry spells and drought and becomes less available and more expensive)
- Drinking water availability during prolonged drought and hot spells
- Animal mortality due to flooding, high temperatures and drought

[141] Food And Nutrition Security Vulnerability To Mainstream Hydropower Dam Development In Cambodia INLAND FISHERIES RESEARCH AND DEVELOPMENT INSTITUTE (IFREDI), Fisheries Administration, Ministry Of Agriculture, Forestry And Fisheries, November 2012

[142] Hap Navy, Truong Hoang Minh, and Robert Pomeroy. 2016. Impacts of Climate Change on Snakehead Fish Value Chains in the Lower Mekong Basin of Cambodia and Vietnam Marketing, Economic Risk Assessment, and Trade/Study/13MER03UC

[143] ICEM/DAI, 2013.

Coping with the impacts of these changes on agricultural systems will require concerted effort to adapt current practices to ones that are more suitable to the future predicted scenarios. Investment in agricultural technologies (seed varieties, water saving systems and practices (no-till and cover cropping) that reduce the negative impacts/ capitalise on the projected changes will be essential in order to ensure farming productivity is maintained.

According to the Estimating Minimum Expenditure Baskets and Expenditure Gaps in Cambodia (June 2020). Cambodia is highly vulnerable to climatic shocks, with floods and droughts occurring on a regular basis. These climatic events can have a direct impact on households' incomes, livelihoods, and, by extension, their food security and access to basic services. Furthermore, the actions taken by households to cope with shocks, such as reducing food consumption, withdrawing children from school, or selling productive assets, ultimately increase their vulnerability. This further undermines hard-won development gains and contributes to the transmission of poverty from one generation to the next.

Vulnerability of tree crop farming systems

Tree crops, including lemon are considered to be highly beneficial crops across Cambodia, including in Kampong Thom. They are primarily considered as a market crop for providing additional household income, but can also contribute to important dietary diversity requirements, especially in terms of vitamins and micronutrients.

From an ecological perspective fruit trees provide soil moisture and soil erosion benefits, and when planned properly in an agroforestry system, can increase productivity of other crops, including rice, as well as mitigate the impacts of flooding through providing soil stability benefits.

Mono-cropping practices are negatively impacting lemon production. Farmers experienced reduction in yields due to the interplay of:

- Lack of irrigation
- Decreasing soil fertility because of unclosed nutrient circles,
- High nutrient competition among plants,
- Low water holding capacities and
- Increased pest, disease and fungus infections.

Climate change effects such as heat, flood or drought increase the likelihood of the above issues.

Cashew trees, a large and expanding tree crop choice in Cambodia, may flower but not produce fruits due to heat stress. Lemon farming systems are highly vulnerable to economic shocks such as price fluctuations.

As tree crops in Cambodia are almost always planted in a monocrop system, farmers dependent on tree monocropping systems experience a two-folded risk profile due to 1) low profit due to low yields associated with monocrop-driven ecological factors and 2) the increased susceptibility to economic shocks to a lack of diversification.

4.2.2 Vulnerability of the target group

Cambodia's vulnerability is characterised by frequent flooding and irregular rainfall, coupled with an agrarian based economy, limited human and financial resources, insufficient physical infrastructure, and limited access to technologies. Socio-economic status, as well as location, access to resources and technology all influence Cambodia's ability to manage the impact of climate change. Different social groups experience climate vulnerability differently and women, children, the disabled, the elderly and other socially marginalised groups often feel the impacts of climate change disproportionately.

Climate change affects gender minorities disproportionately, including women and girls. The areas where women play a central role - food security, nutrition, energy, livelihoods, health, natural resource management, among others - are those most directly impacted by climate change. By exaggerating gender inequality, climate change also reinforces a structural root cause of violence against women and girls[144]. The main vulnerable of women to climate change are: limited voice in decision-making, limited capacity to diversity agriculture resources, few options to cope with disaster and extreme weather, income loses, workload and health problems, after disaster shocks, etc. The climate change spending addressing genders issues or gender focus on climate change related programs is 11% in 2018 and increased to 15% in 2019[145].

Projected heatwaves will negatively impact the most vulnerable populations, especially children and the elderly[146]. Higher temperatures and variable precipitation accelerate microbial growth, transmission and virulence, can lead to changes in the seasonal and geographic distribution of vector-borne and water-borne diseases[147]. The spatial pattern of malaria risk in Cambodia has been found to change as rainfall and temperature change in the future. The transmission risk tends to increase until 2050, and then decreases again in 2080[148]. High temperature and precipitation changes can also result in lower food production in the tropics as well as heat-related diseases.

The negative impacts of climate change on agricultural production can lead to breakdown of food systems, and vulnerable groups risk further deterioration into food and nutrition crises if exposed to extreme climate events. Adaptation strategies, for example additional time in sourcing water or pasture, can particularly affect women labour allocation, in turn influencing time available for childcare and feeding (e.g., breastfeeding exclusively, preparing healthy meals). Further strain on the workload of women and climate change related stress during pregnancy could contribute to low birth weight, leading to increases in risks of undernutrition and non-communicable diseases[149].

More than 4 million ha of lowland forest, especially those located in the northeast and southwest, which currently have a water deficit period of between four and six months, will become exposed to a water deficit period of between six and eight months or more. A decrease in forest cover may in turn have negative implications for the population, especially children, through micronutrient deficiencies12. Moreover, decreased forest cover, either from climate change or deforestation, increases the risk of landslides[150].

Rising sea levels are expected to impact coastal systems through inundation, flood and storm damage, loss of wetlands, erosion, saltwater intrusion, and rising water tables. Analysis of the impact of sea-level rises on coastal areas suggests that a total area of about 25,000 ha would be permanently inundated by a sea level rise of one metre, increasing to 38,000 ha at a sea level rise of two metres. Under a high emissions scenario, and without large investments in adaptation, an annual average of 30,700 people are projected to be affected by flooding due to sea level rises between 2070 and 2100[151]. Cambodia also faces inland river flood risks. It is

[144] Gender, Climate change, Health WHO: https://www.who.int/globalchange/GenderClimateChangeHealthfinal.pdf?ua=1

[145] The NGO forum on Cambodia: Cambodia's Citizens Climate Budget for 2018-2019

[146] WHO Climate and Health Profile Cambodia 2015: https://apps.who.int/iris/rest/bitstreams/1064308/retrieve

[147] Children's Environment and Health in East Asia and the Pacific: https://www.unicef.org/eap/reports/childrens-environment-and-health-east-asia-and-pacific

[148] NCSD (2016)

[149] Gender, Climate change, Health WHO: https://www.who.int/globalchange/GenderClimateChangeHealthfinal.pdf?ua=1; Gender statistics for key sectors in Cambodia: https://www.jica.go.jp/project/cambodia/011/news/general/ku57pq00001xwvts-att/20150308_01.pdf Gender statistics for key sectors in Cambodia: https://www.jica.go.jp/project/cambodia/011/news/general/ku57pq00001xwvts-att/20150308_01.pdf 12 Impacts of forests on children's diet in rural areas across 27 developing countries: https://advances.sciencemag.org/content/4/8/eaat2853?utm_source=TrendMD&utm_medium=cpc&utm_campaign=T rendMD_1

[150] Deforestation Effects on Rainfall-Induced Shallow Landslides: Remote Sensing and Physically-Based Modelling https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2019WR025233

[151] From WHO Climate and Health Profile Cambodia 2015: https://apps.who.int/iris/rest/bitstreams/1064308/retrieve

projected that by 2030 an additional 69,800 people may be at risk of river floods annually as a result of climate change, above the estimated 89,700 annually affected population in 2010.

According to the 2019 census and the commune level climate hazard index vulnerability map, approximately 22 700 people in Kampot province are already living in communes categorised as being highly vulnerable to climate change. They are:

Commune Code	Commune Name	Population
070708	Koun Satv	9 277
070613	Ruessei Srok Khang Kaeut	4 395
070203	Prey Tonle	2 546
070209	Tnoat Chong Srang	6 465
Total	-	**22 683**

Figure 27: Climate hazard vulnerability at commune level in Kampot[152]

Similarly, approximately 94 000 people in Kampong Thom province are already living in communes categorised as being highly vulnerable to climate change. They are:

Commune Code	Commune Name	Population
060608	Sochet	4 077
060609	Tum Ring	8 263
060501	Chhuk	10 688
060606	Ngan	9 682
060709	Ti Pou	10 792
060202	Damrei Slab	3 181
060203	Kampong Kou	6 494
060205	Nipech	3 009
060207	San Kor	14 248
060208	Tbaeng	13 102
060802	Chamna Kraom	10 526
Total	-	**94 062**

Figure 28: Farmer-reported impacts to agriculture production in Kampong Thom[153]

[152] CIAS, 2019.

[153] (Cambodia Inter-Censal Agriculture Survey , 2019)

5 Hotspots of climate risks and vulnerability

Summary - Key climate risks to food security and nutrition of the target group in the target region

Key points for Kampot

- As with the whole country, Kampot will likely become ~1°C hotter towards the middle of the century.
- Changes in rainfall regimes and averages are more difficult to predict, though it is likely that there will be more rain in some months towards the middle and end of the rainy season, and less at the beginning.
- Rice yields may be improved by higher temperatures, though this will be dependent on climate smart techniques/ strategies being implemented to deal with water shortages and soil health issues exacerbated by climate change related events such as drought and stronger storms.
- CO_2 fertilisation may benefit rice yields but have a deleterious effect on its nutritional value.
- Flooding and livestock disease are already the most common impacts on farmers. These will likely worsen towards middle of the century as temperatures rise and stronger extreme rainfall events become more common.
- Approximately 23,000 people in Kampot currently live in locations considered highly vulnerable to climate change.

Key points for Kampong Thom

- As with the whole country, Kampong Thom will likely become ~1°C hotter towards the middle of the century.
- Changes in rainfall regimes and averages are more difficult to predict, though it is likely that there will be more rain in some months towards the middle and end of the rainy season, and less at the beginning. Number days without rain may increase in March and April.
- Rice yields may be improved by higher temperatures, though this will depend on climate smart techniques/ strategies being implemented to deal with water shortages and soil health issues exacerbated by climate change related events such as drought and stronger storms.
- CO_2 fertilisation may benefit rice yields but have a deleterious effect on its nutritional value.
- Drought and related food insecurity are already the most common impacts on farmers. These will likely worsen towards the middle of the century as temperatures rise and stronger extreme rainfall events become more common longer or more frequent days-without-rain events occur, especially in the beginning of the wet season.
- Approximately 94,000 people in Kampong Thom currently live in locations considered to be highly vulnerable to climate change.

Figure 29: CRVA synthesis

Climate hazards and exposure	Impacts	Vulnerability	Key risks to FSN of target group	CRV hotspots
• Floods • Droughts • Windstorms • Compound heatwaves & droughts • Sea level rise • Rising CO_2 concentrations	• Rice yield decline due to higher temperatures • Increase crop and livestock water stress from higher temperatures and droughts • Onset of seasons less predictable impacting traditional rice production systems • Increase risks of pathogen, pests and diseases • Crop yield stimulation from elevated CO_2, but decrease in nutrient quality (strong evidence for rice) • Higher CO_2 increase competition with weeds, which are also stimulated • Reduction of coastal crop areas due to sea level rise • Higher temperatures reduce soil fertility, which is already low in Cambodia • Increase nitrate leaching due to higher temperatures and alternating heavy rain and drought events	• **Society** - Lack of food because of flooding and difficult to get health care. Worry about children getting sick or drowning. Some families migrate to earn money. Potential conflict over lack of water during drought periods. People travel long distances for water • **Food production –** higher temperatures and erratic water availability impacting all crops, including rice and vegetable production of small-scale farmers. Changes to wet season duration and timing impacting traditional cropping practices with traditional varieties and technology. Desertification and soil degradation in general impacting yields. Expansion of agricultural lands due to poor soils and unsustainable agricultural practices (and the resulting need to open new lands) driving deforestation and impacting biodiversity • **Health** - People have fever, coughs, diarrhoea, dengue, and malaria when flooding. When drought more itching and skin infections. • **Economy** – People have to spend money on food, health care (accessing health care and medicines), agriculture and feeding animals. Animals, rice, cassava, and charcoal are destroyed by flooding. • **Most Vulnerable** -Children are the most vulnerable as well as elders and pregnant women. There is a loss of work when there is flooding causing more loans to be taken out. There is a lack of drinking water. Migration continues as a coping strategy.	• Drought/flood/ pests/ desertification/ soil degradation etc impact food productivity and thereby the livelihoods of farmers • Decline in food production influences food access/ availability • Access to sufficient, clean water may impact WASH and thereby food utilisation • Decline in nutrient quality of crops, particularly protein and micronutrients • Decline in nutrient quality of seafood[154] • Increased food and nutrition insecurity due to decreased physical/economic access • Decline in dietary intakes of women due to tradition of women eating last & least • Poorer nutritional status of children below 2 years of age due to suboptimal infant and young child feeding practices & poor caring practices as mothers spend more time in fetching water in droughts and increased time spent on coping with situations of droughts or floods • Access to health services hampered during floods/droughts increasing chances of illnesses due to no immunization, infections (in floods especially), and poor management of illnesses leading to infection malnutrition cycle in children. • Hampered access to safe water and sanitation facilities	• Increase risks of damaging floods (flash floods) in Tonle Sap and Mekong River basins, flood plains, and upland areas (inc. Kampong Thom) • Loss of cropland areas in coastal areas and the Mekong Delta (inc. Kampot) • Fishing communities in both inland and coastal areas impacted by changing conditions (flood pulses, temperatures, mangrove and wetland degradation.

[154] Note scientific evidence remains limited.

6 Adaptation needs and options appraisal

Take away points

- Adaptation of food production systems include the following: use of climate-resilient cultivars and breeds (drought and heat stress resistant); sustainable intensification to increase yields of rice – dominant stapple crop in Cambodia; conservation agriculture (CA) techniques that minimise inputs and reduce environmental impacts such as nutrient leaching; improved water management in rice paddy and home gardens
- Diversification through development of mixed systems (rice-duck, rice-fish and agroforestry systems) can generate multiple ecological benefits and buffer climate shocks.
- Diversification of aquaculture species can help minimise economic losses from production shocks
- In Home gardens, root vegetables such as edible cassava pumpkin should be promoted as they are particularly resilient to climate variability and shocks
- Agriculture diversification to increase livestock and vegetables production is a key strategy to address both climate risks on food availability and underutilisation of and lack of access to diverse food, essential to a healthy nutritious diet.
- Implementing CA, System of Rice Intensification (SRI) and climate-smart-agriculture (CSA) type farming practices in general can provide the conditions needed to manage water, farmland and crop production sustainably and productively into the future. Special care should be taken to address inequity, such as unequal power relations in decision-making at the household level, to ensure WRA fully benefit from the implementation of these techniques and practices, and effectively reduce labour burden and increase purchase power.
- Adaptation targeting social resilience include Home Grown School Feeding (HGSF), Cash-based social assistance, Social Health Insurance (SHI) programme and a temporary, shock-specific cash transfer programme
- The Cambodian Government, and MAFF in particular, have developed a number of Priority Adaptation Actions for addressing the impacts of climate change on agricultural productivity. The Ministry of Women's Affairs have also identified Priority Adaptation Actions related to nutrition (Climate Change Priority Action Plan (CCPAP) 2016-2020 & Nationally Determined Contribution, 2020).

6.1 Adaptation options targeting food availability

Projections suggest that wet seasons will be shorter but with higher levels of rainfall, while the dry season will be longer and drier[155]. Cropping practices will need to adapt to cope with these changes.

The most likely and hard-hitting climate change impacts on crops are:

- Higher temperatures
- Longer and hotter heatwaves
- Shorter wet season
- Longer dry season
- More intense flooding
- More intense /longer droughts

[155] MAFF 2016. CCPAP

These likely future conditions are already well understood by the RGC and the international and national development community. The RGC has already developed a number of plans/ strategies that take the impact of these changes into consideration.

According to the RGC's Cambodia Climate Change Strategic Plan, The Second National Communication and MAFFs own CCPAP, nationally pressing adaptation needs include:

- **Climate-proofing rice production**
  - Droughts and floods are identified as major risks to rice
  - Low lying areas, including much of Kampot Province, especially coastal communities, will be at greater risk of flooding
- **Rubber (important for income rather than food production):** Reduction in productivity due to changes in precipitation (increases in some areas)
- **Cassava:** Reduction in productivity due to changes in precipitation (increases in some areas)
- **Soybean:** Decreased suitability due to increased precipitation, e.g., in Kampong Thom.
- **Livestock:** Threats include temperature changes, precipitation changes, changes in soil water availability, and changes in frequency and intensity of drought, flooding, and storms. The high and very high vulnerability livestock are:
  - Dairy – very high vulnerability to impacts of climate change
  - Pig – high vulnerability
  - Chicken – very high vulnerability
- **Fisheries and aquaculture:** In its CCPAP document, MAFF recognises Cambodia's fishery sector as being vulnerable to climate change - Increased temperatures, changes in rainfall and river flows, sea level rise, and increasing storm intensity will all affect fish biodiversity and productivity.
- **Forests:** Playing a key role in the provision and regulation of ecosystem services, forests play an essential role in water cycle regulation, slowing down surface runoff and assisting infiltration, and reducing flooding and flash flooding impacts on downstream infrastructure and crops. Forests help to replenish aquifers that provide water for irrigation and are themselves important sources of foods and emergency food for many rural populations.

Climate change predictions suggest that forests will be affected by changes in temperature, precipitation and shifts in seasons. Such changes directly and indirectly (e.g., fire) affect the existence and vitality of species and ecosystems and will increase the risks associated with pests.

In terms of adaptation to climate change in agriculture systems, improved water access and use efficiency, improved soil health and nutrient content, increased yield and income, and the provision of locally suited seeds and breeds have been identified as climate-smart-agriculture (CSA).

According to the IPCC AR6, CSA is an approach that aims to increase agricultural productivity, enhance food security, adapt to climate change and, where possible, reduce GHG emissions. Yet the IPCC also warns that CSA may not advantage women unless carefully designed participatory approaches are adopted, that can foster the adoption of gender-sensitive CSA technologies and practices. These includes, for example, direct seeding, green manuring and laser land levelling, which can have a significant role in reducing the gender gap in labor burden for women in agriculture[156].

[156] IPCC AR6 2022, Chapter 5: Food, fiber and other ecosystem products

The most promising interventions includes[157]:

- Access to improved climate-resilient and high yielding cultivars
- CA and diversified farming practices – crop rotation, cover cropping
- Agroforestry
- Investments in irrigation infrastructure and water saving technologies

Therefore, short season, locally suited cultivars, irrigation technologies and other agronomic interventions will need to be developed and deployed to allow farmers to capitalise on the slightly wetter but shorter wet season, and adapt to a longer, drier dry season.

Climate-resilient cultivars

Availability and use of improved and traditional cultivars proven to cope with inter-annual variability should be supported. Selecting heat tolerant varieties from the hundreds of farmer-accepted and trusted local cultivars could encourage better adoption of climate-resilient cultivars.

Higher temperatures, especially during crucial life stages of plants, and particularly if they coincide with drought spells, are likely to impact yields. Hardier, more resilient cultivars, or short-duration cultivars that can be planted earlier or later to avoid these shocks will be required to cope with climate change. Availability of these cultivars, effective and timely information and EWS as well as knowledge of which cultivars to choose in each location, each year, will be important to enable farmers to make the right decisions, and then implement them.

6.1.1 Focus on rice production systems

Being by far the most dominant and important crop for consumption and market, and with the largest footprint in terms of climate and environmental impact climate-smart rice production should be given particular attention in terms of climate proofing food production towards 2050.

Cambodia's "Updated NDC 2020" highlights interventions for climate proofing rice production. They aim to increase rice yield, reduce loss during post harvesting, and improve rice quality and safety through:

- Stress tolerant varieties
- Climate Smart Agriculture (CSA)
- Sustainable Rice Platform (SRP)
- Good Agricultural Practices (GAP)
- Organic Agriculture
- Integrated Soil and Nutrient Management (ISNM)
- Integrated Pest management (IPM)
- Water saving techniques
- System of Rice Intensification (SRI)
- Complex Rice System[158]
- Agroforestry
- On-farm seed conservation and selection techniques and postharvest technologies
- Sustainable landscape management (land levelling, Integrated micro watershed management)

[157] Savelli, A., Giles, J., Atieno, M., Leyte, J., Grosjean, G. 2020. Climate-Smart Agriculture in Cambodia. CSA Country Profiles for Asia Series. The Alliance Bioversity International and CIAT (The Alliance); Food and Agriculture Organisation of the United Nations (FAO), FAO, Rome, 54p.

[158] For example, mixed duck-rice system, a traditional mixed farming system in Asia, which is a low cost, environmentally friendly and labour-saving farming system and very suitable for small-scale and poor farmers. This system attracts interest for its agroecological benefits (e.g., organic fertiliser and pest control).

As mentioned above, promotion of the adoption of gender-sensitive CSA technologies and practices, including CA should be strongly considered by any policy maker or manager of agriculture production. CA already has a foothold in Cambodia.

In addition, integrated approaches such as rice-livestock systems, rice-fish systems and agroforestry provide agroecological benefits, diversify food sources and strengthen farmers' resilience to climate related shocks.

CA for Rice production (based on the CA Rice Curriculum MAFF/FAO 2020)

CA Principles:

- Minimum tillage and soil
- Permanent soil cover with crop residues and live mulches
- Crop rotation and intercropping

Case Example Rainfed lowland rice

(Appropriate for Kampong Thom and Kampot provinces)

CA activities associated with the three above principles:

1. ***Soil preparation (including stump removal and land levelling)***
2. ***Selection of cover crops and cover crop establishment***
    a. Establishment of the cover crop can be done either before or after harvest, meaning around Oct/Nov for medium cycle and Nov/Dec for late cycle regimes.
    b. A mix of cover crops is advisable, with stylo @6kg/ha, sunnhemp @20kg/ha, and pearl millet @12kg/ha having been shown to provide good results in Cambodia.
    c. Farmers should fence the field to avoid free roaming or discuss with livestock owners and agree on ways to protect the cover crops from free grazing.
3. **Rice variety selection** is based on the agroecosystems and water regimes of the plot. It could be short, medium, or long rice variety which will define the sowing date accordingly (see link below for detail of variety selection).
4. **Sowing operation** - Sowing of rice seedlings can be done directly into the soil within the cover crops (after cutting some for cattle) without the need to prepare the soil, however it may require no-till planting machinery. Effective rolling requires at least 2 passages to ensure the cover crops are killed.
5. **Soil fertility management** - The management of soil fertility is improved through implementing measures such as:
    a. No burning of rice straw. If wildfire cannot be prevented, it is advisable to shallow plow to incorporate the rice straw and stubble into the soil.
    b. Using mixed cover crops including leguminous species.
    c. Integrated weed management

Under poor soil conditions, farmers should consider applying mineral fertilizers in judicious quantities, and preferably within the hill during transplanting

6. **Integrated Pest and Weed Management**
7. **Harvest** – using hand or machinery appropriate for minimum soil disturbance

6.1.2 Focus on cassava and other root vegetables

Cassava and other root vegetables are inherently climate resilient due to their ability to remain in the ground once mature, regardless of weather conditions, and await harvest until the farmer is ready to collect them or the market ready to receive them. However, they are also associated with highly soil-disruptive harvesting practices, and commonly extract high quantities of nutrients from the soil without replenishment, leading to nutrient leaching and soil health reductions.

Best Practices for Rice CSA (from MAFF/ FAO CSA Rice Curriculum 2020)

- To cope with the challenges of climate change, rice producers must learn about techniques and evaluate and adopt technologies that allow them to adapt to both slow-onset climate change and increasing climate variability. In general, Cambodian rice farmers should be encouraged to adopt one of more of these following principles or "Best Practices of Rice CSA".
- Production of a climate responsive, multi-year seasonal calendar (SRP)
- To understand and implement appropriate spacing and transplanting techniques
- To undertake soil conservation practices, for example practicing minimum-till, cover cropping, mulching, intercropping and use of leguminous plants (~SRP)
- Promote increase knowledge of and access to a diverse set of rice variety seeds with a range of characteristics beneficial for strengthening farmers' resilience under varying conditions and appropriate seed selection and seed storing in airtight containers (FAO)
- To improve the adoption of land levelling, bund raising and other water management interventions (SRP) to the best of the farmer's abilities and resources
- Understand and implement appropriate Integrated Pest Management principles (SRP)
- Perform non-chemical soil fertility and pest/ weed control through adopting organic farming principles and technologies such as AWD, weed suppressing cover crops, manual removal.

Cassava in particular is also highly vulnerable to the Cassava Mosaic Virus disease that has been decimating the crop for over a decade in Cambodia and across the region.

According to the NDC, promoting cassava production systems and practices that are more resilient to climate change includes:

- Variety improvement program for Cassava Mosaic Virus Disease;
- Prevention of soil erosion and soil nutrient leaching;
- Appropriate waste management for cassava post-harvest processing

6.1.3 Focus on fisheries and aquaculture

Fish provide the vast majority of animal-based protein to Cambodian diets. However, according to the Updated NDC 2020 and FAO's CAMADAPT project, climate variability and climate change present a serious threat to fish catch and farming, are among the root causes of many of the challenges facing coastal populations. Further, climate variability/change is directly contributing to the destruction and modification of ecosystems, to salt-water intrusion, to storms (at-sea and on-land) and to water shortages, all of which can reduce the availability, accessibility and utilization of fish as food.

According to the NDC, promoting aquaculture production systems and practices that are more adaptive to climate change includes:

- Domesticate and produce both indigenous and exotic species that are more adaptable to climate change;
- Promote aquaculture in plastic ponds and composite ponds;
- Promote cage and pen culture in man-made reservoirs

Increase adaptation strengthen livelihoods and safeguard food and nutrition security of small-scale Fishermen

Adaptation options identified by CAMADAPT include:

- Species that are resilient in the context of climate change need to be selected.

- In order to improve water productivity, fish farming/small-scale aquaculture should be integrated into irrigation production systems, i.e., rice-field fisheries.
- If areas are no longer cultivable then small-scale producers can switch to aquaculture systems
- The capability of brackish water aquaculture should be improved with proper infrastructure design as well as land and water use policies
- Aquaculture should be diversified by finding and growing species that are more climate adaptable.
- There is also the possibility of reviving indigenous techniques of fish aggregation and floating beds.
- Indigenous species should be used, and culture technology improved to prevent overfishing and overfeeding.
- Species should be screened, and better-adapted species selected, or strains could be developed that are physiologically more tolerant to the changing environment
- There is a need for feeding practices that are more ecologically efficient and less polluting, and for disease treatment and prevention measures
- Aquaculture producers will have to avoid overfeeding and overstocking fish and to monitor water temperature.
- Technologies need to be adapted to suit the capability of diverse groups of people including the poor

Post-harvest adaptation options for fisheries

- Insurance schemes could be introduced.
- Investment in better infrastructure could be increased and a disaster response plan developed.
- Traditional post-harvest methods that are more resilient could be promoted; i.e., local materials, traditionally smoking fish

6.1.4 Focus on livestock

Livestock provides food of animal origin to the Cambodian diet important for proteins, fats and oils. Overall consumption of fats and oils is far below the recommended level, as highlighted in section 2.2, with animal origin products (meats, dairy, …etc.) providing just 13 g per day. For protein, although the recommended daily level is being met, livestock contributes very little, with fish and seafood supplying the vast majority of animal origin protein. There is a clear scope to increase the contribution of livestock products to improve and diversify the Cambodian diet.

According to the NDC, promoting livestock production systems and practices that are more adaptive to climate change includes:

Promote animal production and animal health - Improvement of animal breeding technology in Cambodia through artificial insemination which can adapt to climate change.

Promote animal production and animal health improvement in Cambodia through animal breeding technology which can adapt to climate change

- Animal improvement: feed fodder, cooling systems and deworming,
- Vaccine programmes

Promotion of research capacities on animal genetic, animal breeding, and animal feed is strengthened to adapt to climate change

- Strengthened research skills and Improved breeding technologies;
- Improved vaccination
- Animal Breeding and Feeding (Animal improvement technique, Fodder Programme),
- Cooling systems, de-worming and vaccine programmes,
- Animal disease surveillance

6.1.5 Adaption in home gardens and vegetable production

As mentioned above, water, soil health, improved, locally adapted cultivars/breeds and access to improved income generation opportunities have been identified by farmers as the most pressing needs for adapting to climate change. As with all crops, this has contributed to the low productivity of vegetables throughout the kingdom and is likely a large reason for the low consumption of vegetables by the Cambodian people.

The Cambodian diet currently includes just 1/3 of the recommended 300-400 g of vegetables per day, meaning there is an important and urgent need to increase production, availability and ultimately consumption. If legumes are included, the situation is worse with just ~1/6 of the required intake being met. This lack of vegetables and legumes in diets has important ramifications for dietary diversity, micronutrient, fibre and protein intake.

A number of suitable crops for improving home gardens capacity to adapt to climate change have been identified for Cambodia:

- **Kangkong** is noted as being particularly resilient to inundation and therefore flooding, as well as requiring little watering, i.e., it is drought resistant.
- **Sweet potato, sesbania grandifolia and sauropus androgynous** are also considered drought resistant.
- Due to their ability to remain on the stalk, **pumpkin, bottle and wax gourd** can be harvested over a long period, which provides a degree of resilience to adverse weather affects that can impact other more harvest-time specific fruits and vegetables.
- Growing edible **cassava, sweet potato and other root vegetables** is advantageous in that their harvest time is far more flexible/ less influenced by seasonal or unseasonal weather condition. They can remain in the ground until required, providing an emergency supply of carbohydrates during or after stress events.

FAO's 2019 regional study on Future Smart Foods and under-utilised food crop species identified a number of vegetable crops that are considered to be nutritious, climate resilient and economically viable, as well as locally available (in each country). The table below showcases these species for Cambodia as well as regional species that could have relevance to Cambodia's climate change future (that are already known to exist in Cambodia but are underutilised).

Figure 30: Adaptive capacity potential of specific crops grown in home gardens

Location	Name	Soils/ climate change adaptation/ social benefits	Health/ dietary benefits
Cambodia	Wild Vigna	Drought tolerant	High in protein, sulphur amino acid, resistant starch and presence of trypsin inhibitors for cancer prevention
Cambodia	Sweet potato	Generates income in minority group communities	High in energy, carbohydrates, vitamin A, B6, C and magnesium
Cambodia	Peanut	Mostly grown in upland area	Rich in energy, fat, carbohydrate, protein, manganese
Cambodia	Ivy gourd	Fast growing; flavour enhancement of local staple foods	Rich in vitamins and minerals
Cambodia India	Drumstick	Fast growing, drought resistant tree	Rich source of carbohydrates, fats, protein and vitamins. Rich in calcium, potassium, vitamin C. Powerful anti -inflammatory and antioxidant properties
Bangladesh Cambodia Lao PDR Vietnam	Taro	Wet/ flooded Generates income in minority group communities Resilient to many diseases & pests	Antioxidants, Vitamins A, B6, C, E Rich in carbohydrates and calcium Protein
Bangladesh	Foxtail millet	Marginal soils	Blood sugar
Bangladesh Vietnam	Mung bean	Drought tolerant. Short growing cycle Nitrogen fixing- improves soils	High in proteins and minerals
Bangladesh Vietnam	Pumpkin	Heat and humidity tolerant	Protein, vitamins, calcium, iron, antioxidants
Bangladesh	Snake gourd	Tolerant of saline environments	Protein, vitamins, minerals, fibre
Bhutan	Soybeans	Good Potential for value added product development	High protein ratio and rich in essential foliate and dietary fibre
Bhutan	Banana	Flood resistant	Rich in essential minerals especially potassium and vitamin B6
Bhutan	Moringa	Fast growing and drought resistant	A significant source of vitamins and manganese, iron and protein
Lao PDR	Greater yam	Grows in wet and dry land and in poor soils	A good source of calcium, magnesium, phosphate and sodium
Lao PDR	Fancy yam	Disease resistant; grows in wet and dry regions	Rich in carbohydrates and calcium
Lao PDR	Rice bean	Easily adapts to various weather conditions; provides soil retention to prevent and mitigate erosion	High in protein
Lao PDR	Cowpea	Adapts to various soil types and conditions	Rich in proteins, calories, minerals, amino acids and vitamins
Lao PDR	Sword bean	Grows in arid regions and helps to improve soil fertility	A good source of protein and vitamins
Nepal	Grass Pea	Grows on poor soil	High in proteins
India	Jackfruit	Grows well under adverse climate and soil conditions	High value in calcium, carbohydrates, potassium and protein

As described above each of these crops has nutritional value as well as characteristics that make it appropriate for cultivation under future, likely harsher conditions.

However, access to sufficient water throughout the growing period is a common challenge for home gardens- and often a barrier to adoption of horticulture activities. As temperatures increase and drought becomes either

longer, more common or untimely (stronger drought spells during the wet season, for example) households will find it more difficult to store sufficient water to ensure home gardens remain productive.

This stress on vegetable production has the potential to lead to reduced adoption rates and even abandonment as production viability drops. Ensuring farmers have both **access to crops that are resilient** as well **exposure to an enabling environment** that ensures availability of innovative and affordable water solutions will be paramount to successful home garden productivity into the future.

As climate change is likely to bring longer drier dry seasons, production during this period will become more difficult. Dry season vegetable growing is often undertaken in order to limit disease, weed and pest burdens, however the trade-off of having limited water for irrigation is already high, and may become unfeasible under future scenarios.

Access to markets, knowledge of market dynamics and business skill of growers all present major additional barriers for households that already practice, or wish to begin practicing, home gardening, and is an area that needs to be strongly focused on in conjunction with any agricultural productivity increasing activities

In addition to selecting specific crops that are less vulnerable to climate change, choosing cropping methods and systems that are more resilient to high temperatures, inundation, storms, drought and disease is key.

Mixed cropping, cover cropping, polyculture, agroforestry and permaculture have strong bio-physical, nutritious and economic attributes that make them particularly important for small scale farming for FSN in the future. For medium to large scale farming, CA, already being researched and adopted in Cambodia, provides one of the most future-climate promising and current-climate proven methods of increasing productivity while simultaneously integrating climate adaptation and mitigation within its production system.

6.1.6 Focus on vegetable production

Cambodia's "Updated NDC 2020" highlights horticulture as a priority sector for adaptation and provides a number of adaptation options for consideration:

Development of horticulture and other food crops for increase production, improved quality safety; harvesting and post harvesting technique and agrobusiness enhancement

Increase horticulture production and productivity and profit in horticulture production value chains through using tress tolerant varieties and CSA practices and increasing resilience to climate change.

Fostering local chemical free produced vegetable value chains by improving sustainable water management practices, promoting diversification to increase food security, access to healthy food and diversified income opportunities resilient to climate change.

- Stress tolerant varieties
- Climate Smart Agriculture (CSA)
- Conservation Agriculture (CA)
- Good Agricultural Practices (GAP)
- Integrated Soil and Nutrient Management (ISNM)
- Integrated Pest Management (IPM)
- Participatory Guarantee Systems (PGS)
- Organic agriculture
- Water saving techniques
- Post-harvest technologies
- Stress tolerant species and varieties
- Intercropping
- Agroforestry
- Crop rotation, mixed cropping /companion planting
- Integrated farming system approach

Figure 31: Overview of current and planned policies and initiatives targeting climate change relevant to adaptation issues identified above

Food group	Crop/ animal	Policy inclusions/ Priority Adaptation Action (PAA) for Government? (NDC, MAFF)		Climate change adaptation Interventions/ case studies available technical material
Cereals	Rice	NDC Yes. PAA#2 Development of Rice crops for increased production, improved quality-safety; harvesting and post harvesting technique and agro-business enhancement. MAFF Yes. Example: Action Fiche #1 This action is designed to promote adoption by rural households of sustainable farming system approach which helps generate more income through crop diversification and intensification. (1) Promoting integrated farming system (model farming) with 1,000 communes in selected 23 provinces (Each commune should attract 10 households making a total of 11,000 households (farmer promoters); (2) Promote and scaling up existing crop options tolerant to flood and drought and pest and disease suitable to AEZ and climate hazard; (3) Develop technical package for selected crops resilient to climate hazard; (4) Enhance crop establishment through micro-engineering: planting method, water saving techniques, laser land levelling, farm infrastructure to store water, enhance IMP into farming practice; (5) Enhance seed drill for upland crop AEZ; and (6) Collect and conserve plant genetic resource horticulture and subsidiary crop.		Stress tolerant varieties, Climate Smart Agriculture (CSA), Sustainable Rice Platform (SRP), Good Agricultural Practices (GAP), Organic Agriculture, ISNM, Integrated Pest Management (IPM), Water Saving Techniques, System of Rice Intensification (SRI), Complex Rice System (for example duck-rice farming), Agroforestry, On-farm seed conservation and selection techniques and post-harvest technologies, Sustainable landscape management (land levelling, Integrated micro-watershed management.
	Maize, sorghum, wheat	NDC No. No specific mention MAFF Yes: Action Fiche #1 Promoting and up-scaling climate-smart farming systems that increase resilience to climate change and extreme weather events	In rainfed lowlands of Cambodia, mono cropping of rice is a common practice. This practice is generally at risk of climate variability that causes extreme events such as flood and/ or drought which in turn lower crop yield, and in severe case totally damage the crop. Enhanced farmers adoption of integrated farming system approach where conditions are favourable would help strengthen rural farming communities the capacity to mitigate the impact of extreme events and adapt to climate change by increasing income. Crop diversification and/or intensification could also help improve nutrition of rural HH.	No
Tubers	Cassava	PAA#6 Building climate change resilience on cassava production and processing MAFF Yes: Action Fiche#2 Promote post-harvest technology for cereal crop and tuber crop, and conduct the research and transfer appropriate post-harvest technology	1. Variety improvement program for Cassava Mosaic Virus Disease; 2. Prevention of soil erosion and soil nutrient leaching; 3. Appropriate waste management for cassava processing developed From National Cassava Policy (2021): 1.1.18. Identify areas affected by climate change and analyse root causes and impacts on cassava farms MAFF 1.1.19. Develop a climate change adaptation plan for cassava farms in affected areas MAFF, MoE 1.1.20. Build infrastructures to minimize negative impacts resulting from climate change. MAFF	FAO/MAFF Conservation Agriculture Module (Cassava crop with four-mix seed cover crop) FAO CMD Guidelines - healthy planting materials ASEAN/ GIZ 2015 - Use of Healthy Planting Materials; Contour Intercropping https://asean-crn.org/cambodia-national-study-promotion-of-climate-resilience-in-rice-and-cassava/

				National Cassava Policy (UNDP/ Gov) Climate Change
	Potato	No		
Vege-tables	All	Yes. PAA#3 Development of horticulture and other food crops for increased production, improved quality/safety; harvesting and post harvesting technique and agro-business enhancement MAFF Yes: Action Fiche #1 (vi) Collect and conserve plant genetic resource horticulture and subsidiary crop. Action Fiche#3 Develop crop variety suitable to AEZ resilient to climate change (including coastal zone) This action is designed to strengthen scientific research capacity to develop improved crop varieties and enhance adoption by farmers in the identified key agro-ecological zones (AEZ) including coastal zone of Cambodia (1) Strengthening existing research on new crop variety tolerance to biotic and abiotic stresses (caused by climate shift, new disease and plants imported). (2) Enhancing scientific and technology development and appropriate adaption and mitigation for agricultural sector (technical training for staffs and officials). (3) Developing adaptation/DRR strategies for farming community in climate prone provinces (both research and scaling up), ex. ACIAR ACCA project (Australian CCA in Svay Rieng and can be replicated in another province. (4) Conducting research on impact of climate change on quality of cereal, horticulture and crop products in post-harvest and process at CARDI research centres. (5) Developing research capacity on biotechnology for agricultural crops and plant breeding (GDA and CARDI). (6) Conducting research on GHG emission from agricultural sector.	Stress tolerant varieties, Climate Smart Agriculture (CSA), Conservation Agriculture (CA), Good Agricultural Practices (GAP), ISNM, Integrated Pest Management (IPM), Participatory Guarantee Systems (PGS), Organic Agriculture, Water saving techniques, post-harvests technologies and stress tolerant species and varieties, intercropping, agro-forestry, crop rotation, mixed cropping /companion planting, integrated farming system approach	FAO/MAFF - Agroforestry Module FAO/MAFF drip irrigation guidelines USAID - Feed the Future/ Harvest, East- West Seed - drip irrigation training materials
Fruits	Lemon and fruit trees in general	No - not mentioned as a priority area in NDC, nor in MAFF climate change plan (CCPAP)	No specific fruit tree -climate change plans, strategies or goals from gov	FAO/MAFF - Agroforestry Module FAO/MAFF LNP Lemon Guidance FAO/MAFF Conservation Agriculture Module and guidelines

Dairy	Milk, cheese etc	No - however the CCPAP identifies dairy as the most vulnerable livestock sector		none
Protein foods	Livestock	NDC Yes. PAA#11, 12, 13 MAFF CCPAP Yes. Action Fiche #1 Promoting resilience in animal production and CCA (technical package) Action Fiche #3 Promoting and enhancing technology development on the improvement of animal breed, animal feed, and animal health for CCA and DRR.	Strengthened climate-resilient animal breed through modern technology Strengthened research skills and Improved breeding technologies; improved vaccination. Animal Breeding and Feeding (AI technique, Fodder Programme), Cooling systems, deworming and vaccine programmes, Animal disease surveillance) Animal Health and Production cooperatives establishment and technical guidelines for animal health and production set up, Integration with farming systems based on animal production is expanded	From MAFF's CCPAP 2018: · Establish the technical guideline for cattle, buffaloes, pig and poultry on smallholder and commercial scales · Establish demonstration farms for cattle, buffaloes, pig and poultry husbandry · Expand the integrated farming system based on animal production · Improve use of current resources e.g., crop residues, natural pasture. · Increase forage cultivation and its utilization · Technology transfer e.g., seeds, cultivation practices, preservation. · Reduce grazing pressure on protected areas, reducing contact and risk of disease due to unpredictable events: CC · Promoting One Health approach (Contextualizing animal health in relation to social, environmental and public health).
	Chicken/ eggs	No specific mention of chicken though vaccine initiatives under PAA#12 may include chicken MAFF CCPAP: Same as livestock	Animal Breeding and Feeding (AI technique, Fodder Programme), cooling systems, de-worming and vaccine programmes, Animal disease surveillance)	FAO/MAFF - Climate Smart Agriculture Chicken Raising Module
	Fish	Yes. PAA#14 and #15 Fishery management and aquaculture development: Promoting aquaculture production systems and practices that are more adaptive to climate change Promoting climate resilience in the fisheries sector MAFF CCPAP: Action Fiche #1: Promoting aquaculture production systems and practices that are more adaptive to climate change and extreme weather events.	"Develop aquaculture system increase production, enhance livelihoods related to food and nutrition security, reduce fishing pressure on fisheries resources" (1) Domesticate and produce both indigenous and exotic species that are more adaptable to climate change; (2) Promote aquaculture in plastic ponds and composite ponds; (3) Promote cage and pen culture in man-made reservoirs (1)Dredging and rehabilitation of fish refuges and critical habitats; (2) Protection of flooded and mangrove forests as the spawning, nursing and feeding habitats for fish and other aquatic animal	FAO Capfish - climate resilience guidelines for capture fish sector Climate Adaptation and Resilience in Cambodia's Coastal Fishery Dependent Communities https://www.thegef.org/projects-operations/projects/9201 The “Climate Adaptation and Resilience in Cambodia’s Coastal Fishery Dependent Communities” project, or “CamAdapt”, will contribute to addressing these challenges by

		Action Fiche #2: Promoting community fisheries, resilient capacity and climate resilience of wild fishery resources Action Fiche #3 Enhancing the climate resilience in fishery sector (ECRF) Action Fiche#4 Enhancing fish and fisheries products in the entire value chain in response to climate change and disaster impacts. Action Fiche#5 Strengthening capacities for risk prevention and reduction, effective emergency preparedness and response at all levels; enhancing fisheries related early warning system, and integrating DRR and CCA measures into recovery and rehabilitation initiatives in the fisheries sector	CCPAP: 10,000 aquaculture is developed and become aquaculture promoters 100,000,000 fingering are produced every year from fish stations both inland and coastal and small holder seed producers. 10% of aquaculture production increased every year % reduction of illegal fishing natural fishery and endangered species. Reduce illegal fish and fishery products imported from neighbouring country (with uncontrolled quality).	implementing appropriate adaptation measures, and enhancing the exiting initiatives related to fisheries and coastal management. CamAdapt will support the coastal fishery-dependent communities in their effort to adapt to climate change through strengthening coastal ecosystems and adapting their livelihoods. ADB Coastal fisheries programme: in development
	Legumes (soy, peanuts, beans etc)	Partially - Only mung bean mentioned in PAA#8 MAFF CCPAP: No specific mention	Mung-bean grown within short duration variety (less than 55 days from planting till first harvesting) and irrigated with small amounts of water;	FAO/MAFF - Agroforestry Module (general legume inclusion) FAO/MAFF Conservation Agriculture Module (general legume inclusion)
	Nuts (cashew)	Partially in PAA#4 - Development of Industry crops for increase in production, improved quality safety; harvesting and post harvesting technique and agro-business enhancement MAFF CCPAP: No specific mention	Increase industry crop productivity and profit in the production value chains through stress-tolerant varieties and CSA practices and increasing resilience to climate change. Diversification will also contribute to increase in income (Land equivalent ratio) and diversification of economic opportunities of farmers to adapt to climate change. Increase in income through improvement in processing technologies.	FAO/MAFF - Agroforestry Module FAO/MAFF Conservation Agriculture Module and guidelines
Cross cutting interventions	Small business management, women's involvement, soil health maintenance, seed improvements, water	Yes. PAA#5 - Improvement of support services and capacity building to crop production resilient to climate change by promoting research, trials and up-scaling climate smart farming systems that increase resilience to climate change and extreme weather events. MAFF CCPAP: Cross cutting Actions. Action Fiche #3 Institutional mainstreaming CCA and DRR by building capacity and scaling up community resilience. Action Fiche#3 Promote marginalized groups and women participation to CCA and mitigation strategy.	Crop production manuals (e.g. SRP, GAP, Post-harvest technologies/tools, Agricultural Organic Standards, irrigation facilities, saving water technologies/tools, green houses) and Irrigation facilities and agricultural machinery tools/ equipment), Climate Smart Agriculture (CSA), Agroforestry, Integrated Soil and Nutrient management (ISNM), Integrated Pest Management (IPM), Botanical pesticide production, organic fertilizer, Conservation Agriculture (CA), water saving techniques (rain-water harvesting, drip irrigation etc.) and postharvest and processing To respond to these constraints, the key activities include: (1) Up scaling capacity building and farmer field schools on integrated farming for DRR and CCA (25 Post-harvest trainings, and 11 training modules), (2) Conduct training by using Training Materials on climate change and DRR to train central and provincial government staffers and target farmers around 200 farmer cooperatives (on crops, livestock, aquaculture, small	FAO/MAFF Gender Module and associated trainings Case Study examples FAO/MAFF CSA Rice Module (land levelling, water efficiency etc) FAO/MAFF Conservation Agriculture Module

	saving etc	Action Fiche #5 Enhance knowledge management related to CCA and promote innovation that is needed based.	and medium scale rubber plantation), (3) conduct (ten) trainings on REDD+ to FA staffers at national and sub-national. Piloting climate-smart villages by introducing: Agroforestry (maize, soybean, and other crops sandwiched between rows of multi-purpose trees that stabilize and enrich the soil). Testing climate-smart services, such as tailored weather forecasts to plan planting, harvesting and other activities on the farm. Technical advises and weather forecasts services will be delivered by mobile phones and phones will be used to enable farmers to buy index-based insurance that gives them	

Figure 32: Overview of adaptation interventions

Initiative	Source	Actors	Timescale/ Implementation status	Target group	Adaptation options (see IPCC adaptation options)	Adaptation category	Climate hazards	Link to FSN	Adaptation costs
Agriculture focused									
Life and Nature Project	GEF	GEF/ADB /MAFF	4/5 years (Completed)	Rural remote small holders and climate vulnerable groups, strong women focus. Some nutrition focus.	• No till, reduced tillage or conservation agriculture • Integrated pest and weed management • Adjustment of planting dates/ counter season crop production	Sustainable intensification/ climate smart agriculture/ Agronomic on-farm management	All	Improved access to nutritious foods and incomes through livelihood improvement/ diversification	5m USD
					• Organic management • Community seed/feed/fodder banks • Integrated water management/water conservation and efficiency • Agroecological approaches • Agricultural diversification on-farm biodiversity (i.e. intercropping) • Mixed systems: crops, trees, silvopastoral, fisheries, aquaculture, agroforestry • substitution/change plant or animal type • Improved soil management (reduced soil erosion, salinization, compaction) • On-farm Improved irrigation efficiency and use/ drip irrigation	Nature-based adaptation or ecosystem-based adaptation			
					• Diversification of livelihoods (economic diversification either on-farm or employment in local community) • Farmer-to-farmer training, farmer field schools • Reduced deforestation and forest degradation	Social, Economic & institutional			

					• Community forest management				
CAMADAPT	GEF-LDCF	FAO	4 years (in progress)	The project aims to help coastal fishing communities and protected areas in the Cambodia's main four coastal provinces – Kampot, Kep, Koh Kong and Preah Sihanouk to improve their livelihoods by increasing their adaptive capacity to climate change, while improving the marine ecosystem and biodiversity.	• Climate services: Improving weather forecasting and early warning systems • Community-based adaptation (including disaster risk management)	Cross-sectoral	Temperature increases, Sea-level rise, changes in seasons.	Sustainable fish stocks and livelihoods - important for direct access to protein, and incomes to purchase foods	4.35m USD
CAPFISH	GEF	FAO-MAFF	60 months (in progress)	The sustainability of Cambodian fisheries (based on one of the world's most diverse population of fish species) is severely challenged by a series of internal, external and global threats: illegal fishing, uncontrolled and excessive fishing capacity, poor valorization of the resource, hydropower development, habitat destruction, agriculture intensification and climate change. The intervention provides support to marine and inland fisheries management, conservation, control and surveillance, in the form of capacity development to central and subnational administrations as well as concerned communities (Committees responsible	• Community-based adaptation (including disaster risk management) • Water management - regional level • Community-based adaptation (including disaster risk management) • Local governance and conflict resolutions schemes • National & international adaptation planning, coordination, policy & governance/ integrated approaches at multiple scales	Cross-sectoral	Temperature increases, Sea-level rise, changes in seasons.	The fisheries sector makes a large contribution to the food security and livelihoods of Cambodian people and accounts for 76% of households' animal protein intake and the second most consumed food after rice. Average fish consumption is 52.4 kg per person per year and one of the highest in the world. Fish is the most available and cheapest form of animal protein in the country that no other domestic source of food can replace. As a sector with a low entry barrier. Fishing is also an important safety net for vulnerable households.	4,35m USD

				for the management of Community fish Refuges and Community Fisheries) and their networks, ensuring access to members of ethnic minorities particularly women and children.					
IBIS Rice	IBIS Rice	Wildlife Conservation Society	10+ years (ongoing)	1,500 rural farming households	Conservation focused organic farming producing premium jasmine rice for market	• Reduced deforestation and forest degradation • Reforestation and forest restoration • Afforestation and land rehabilitation • Reduced impact logging • Community forest management	Forest	• Value of rice increases with premium brand certification - improved livelihoods income generation • The project has significantly improved livelihoods while reducing deforestation by 75% in the areas where farmers live and cultivate.	
						• Organic management	Crops-Mixed-Livestock-Aquaculture-Forestry-Fisheries		
						• Certification and labelling programs	Cross-sectoral		
Scaling up Forecast based Financing/Early Warning Early Action (FbF/EWEA) and Shock Responsive Social Protection (SRSP) with innovative use of climate risk information for	ECHO	WFP FAO	2 years (completed)	Regional project to scale up Forecast-based Financing (FbF) or Early Warning Early Action (EWEA) and shock responsive social protection (SRSP) in the ASEAN countries to become new approaches in the implementation of the ASEAN Agreement for Disaster Management and Emergency Response.	Climate services: Improving weather forecasting and early warning systems	Cross-sectoral	All	Household income, livelihoods, resilience building	0.041m USD

disaster resilience in ASEAN									
Cambodia: Irrigated Agriculture Improvement Project	ADB	ADB	2019-2021 (completed)	Impact of the project will be inclusive economic growth through agriculture and irrigation attained. Outcome will be water and agriculture productivity in the project areas enhanced. The project will deliver two outputs to achieve the desired outcome and impact including (i) Efficiency and climate resilience of irrigation systems enhanced; and (ii) Water resource management improved.	• Integrated water management /water conservation and efficiency • On-farm Improved irrigation efficiency land use/ drip irrigation	Crops-Mixed-Livestock-Aquaculture-Fisheries	Drought, temperature increase	Enhancing agriculture productivity and promoting diversification of productivity = increased access to diverse foods	2.5m USD
Social Protection Focused									
Cambodia Food Reserve System (CRFS)	MoFinance	MoI, MoF, MAFF	Since 2008 (ongoing)	The Cambodia Food Reserve System (CFRS) responds to vulnerable people and farmers affected by disaster or emergency and mostly in need of food and/ or seed for rehabilitation of rice, vegetable and other crops land in the Kingdom of Cambodia.	Improving access to community services, social assistance, social insurance, social safety nets for vulnerable groups	Cross-sectoral	All	• Provide immediate and essential emergency food support needed by people affected by disaster or emergency; and • Provide immediate quality seed support to the farmers who require seed to ensure the rehabilitation of damaged crop production areas due to disaster or emergency.	The Food Scholarship Program was launched in 2004 and a piloted Home-Grown School Feeding Program began in 2014, as well as a school lunch program in 2017. Since 2019, Cambodia has gradually built the Home-Grown School Feeding Program into a national program funded by the national budget.
Emergency Food Assistance Project	ADB https://www.a	ADB/ RGC	2008-2016 (completed)	Food-insecure households in 10 food-insecure and vulnerable	Improving access to community services, social assistance,	Cross-sectoral	All	• compensatory consumption support,	24.5m USD

	db.org/documents/cambodia-emergency-food-assistance-project			provinces.*Linked with Cambodia Food Reserve System (CRFS) above. These results were achieved through activities such as producing and promoting quality seeds, introducing livestock and aquaculture to diversify the production and consumption base, implementing a food-for-work program that involved rehabilitation of small tertiary irrigation canals and village roads, and developing disaster preparedness, such as crop contingency planning and establishing the Cambodia Food Reserve System (CFRS).	social insurance, social safety nets for vulnerable groups			including activities such as the distribution of free rice and food to the most vulnerable households, the provision of food to school-feeding programs, and the establishment of a food-for-work program • Productivity enhancement support, which encompassed the provision of seed and fertilizer to small and marginal farmers; and • Capacity development for emergency response to the food crisis, which included the development of a system of emergency food security reserves and rapid responses.	
Cash for Work Program for Rural Development and Livelihood Enhancement Project (CFWRDLEP)	MEF	MEF, MRD, MOWRAM and EDC	2020-2021	Little information on beneficiaries. Themes include: Component 1-rural road construction under cash for work program Component 2- quaternary canals construction under cash for works program; Component 3-providing	On-farm Improved irrigation efficiency and use/ drip irrigation Improving access to community services, social assistance, social insurance, social safety nets for vulnerable groups	Crops-Mixed-Livestock-Aquaculture-Fisheries Cross-sectoral	Drought, heat-wave, all	Unknown - likely to reduce under nutrition through delivery of cash and irrigation to vulnerable groups	unknown

				low-cost electricity for supporting irrigation system					
Traditional School Feeding Programme **Home Grown School Feeding (HGSF) Program**	WFP	MoEYS, WFP	2020-2024 (ongoing)	Based on human capital development objective that includes the consideration of nutrition for pregnant women and children, access to adequate food for children from the poorest and most vulnerable families facing food insecurity, the need to help these citizens reduce their hunger in the short term and provide additional nutrition, encourage enrolment in schooling, reduce absentee rates, participate in positive learning activities, reduce dropout rates and increase primary school graduation rates.	Improving access to community services, social assistance, social insurance, social safety nets for vulnerable groups	Cross-sectoral	Unknown	The Food Scholarship Program was launched in 2004 and a piloted Home-Grown School Feeding Program began in 2014, as well as a school lunch program in 2017. Since 2019, Cambodia has gradually built the Home-Grown School Feeding Program into a national program funded by the national budget.	unknow

6.2 Adaptation options targeting food utilisation and nutrition

Future climate conditions and changes in atmospheric CO_2 will impact food utilisation and nutrition in Cambodia. In terms of adaptation to climate change in the agriculture sector, water availability and water use efficiency, improved soil health, increased yields and improved income opportunities, and the provision of locally suited seeds and breeds, have been identified as CSA-related areas where farmers feel they need the greatest support. Access to improved–climate resilient and high yielding–crop varieties, diversified farming practices–crop rotation, cover cropping, conservation agriculture–and investments in irrigation infrastructure and water saving technologies have been singled out as the most promising interventions[159].

A stronger focus on diversifying food production away from the prevailing dominant cultivation of rice is likely a positive step in terms of increasing access to a diverse diet and building food and nutrition security in Cambodia. Encouraging the cultivation of alternative crops, such as legumes within mixed cropping modalities that provide both human and soil health benefits, should be strongly considered.

Where substitution/reduction of the production and consumption of rice for more nutritious foods **is not a viable option**, identifying and making available rice cultivars that are higher in protein and other nutrients, and that thrive at higher CO_2 levels and in warmer, shorter wet season conditions will be paramount to ensuring nutrient security towards 2050.

Where substitution/ reduction of rice production and consumption **is a viable option** (which given rice's ingrained position within Cambodia's social and political culture may be difficult) consumption of more nutritious alternatives should be encouraged. With reference to Cambodia's shortfalls in terms of dietary diversity identified in Section 3, increases in fruit, vegetable and legume consumption should be specifically prioritised, Cambodia already imports significant quantities of fruits and vegetables to meet demand (despite consumption being low). To satisfy this demand internally, and to take advantage of prospective future increased demand for more nutritious food vegetables, increased attention towards diversified food production in home gardens, at the smallholder level and at medium to large scale should be prioritised by agriculture policy makers and support agencies. Climate Smart Agriculture methodologies and technologies that promote mixed farming, rotation cropping, cover cropping and other forms of polyculture with edible legumes should be given specific attention.

CO_2 impact on rice – as described above, higher atmospheric concentration of CO_2 are expected to be felt most strongly in terms of higher yields and increases in carbohydrate production (CO_2 fertilisation) but will likely result in reduced protein concentrations in food rice for consumption (the carbohydrate dilution effect). A 10% reduction in protein concentrations per gram of rice can be expected. Currently Cambodian's receive approximately 32 g, or nearly half of their daily protein intake from consumption of rice, meaning a 10pc reduction in rice protein concentration due to elevated CO_2 may result in a 3 g (or near 5%) reduction in total daily protein intake for the average Cambodian consumer, under business and usual conditions.

However, with appropriate planning (see paragraph below), overall rice yields will likely increase under the higher atmospheric CO_2 concentrations predicted for 2050. This means more rice may be available for consumption or sale. If rice farmers are then able to sell higher quantities of rice (due to increased yields from CO_2 fertilisation) and purchase more, higher protein foods, the reduction may also be averted for this demographic, however rice purchasers may not be able to do so. If the increased availability (and/ or lower cost/kg) of rice results in rice being consumed at a higher volume (10% more rice per day) without a reduced intake of other nutritious foods (i.e., people eat more overall) the reduced protein concentration issue may be averted, though the increase in associated carbohydrate intake would likely create other problems, for example

[159] Savelli, A., Giles, J., Atieno, M., Leyte, J., Grosjean, G. 2020. Climate-Smart Agriculture in Cambodia. CSA Country Profiles for Asia Series. The Alliance Bioversity International and CIAT (The Alliance); Food and Agriculture Organisation of the United Nations (FAO), FAO, Rome, 54p.

increased rates of obesity. Specific attention will need to be paid to the impact of less nutritious, cheaper rice on low income/ poor households that will likely increase their rice intake at the expense of more nutritious dietary items.

In order to capitalise on higher yield opportunities under elevated CO_2 conditions, sufficient soil nutrients and water are required during crop growing periods. While C3 plants such as rice will become more water efficient under higher CO_2 concentrations, higher temperatures, longer droughts and reduced water infiltration due to climate change may make water less available. In general soils will likely become less healthy (as higher temperatures increase rates of soil carbon decomposition and increased flooding and heavy rain events increase erosion and runoff) soil nutrient availability may decrease. To adapt to these changes, rice farming will need to adopt better soil and water management practices. As described previously, implementing CA, SRI and CSA-type farming practices in general can provide the conditions needed to manage water, farmland and crop production sustainably and productively into the future. Special care should be taken to address inequity, such as unequal power relations in decision-making at the household level, to ensure WRA fully benefit from the implementation of these techniques and practices, and effectively reduce labour burden and increase purchase power.

6.3 Adaptation options targeting social resilience to climate risks

A substantial proportion of Cambodia's population is highly vulnerable to climate induced shocks. Climate shocks have a direct impact on household incomes, livelihoods, food security and access to social services in Cambodia[160]. Poor households are among the most vulnerable, and shocks can push these households further into poverty. Meanwhile a large portion of the population lives close to the poverty line (the second and third quintile of the population having on average only 20 USD/month/capita income) and shocks are shown to regularly push these 'near poor and vulnerable' households back into poverty[161]. Without the means to effectively cope, actions taken by households in the face of these shocks (such as reducing food consumption, withdrawing children from school, or selling productive assets) undermine future prospects and ultimately increase their vulnerability. The impact of recurrent shocks presents a threat to Cambodia's sustainable development, and to national efforts to reduce poverty. Increasing efforts to build resilience to and mitigate impacts of these shocks on the most vulnerable is a priority for the Royal Government of Cambodia.

The social protection sector in Cambodia is highly dynamic and rapidly evolving, with significant changes in the past few years that are building an enabling environment for resilience to shock responses. This includes developing the national social protection policy framework (NSPPF) 2016-25, establishing the institutional framework, rolling out cash-based social assistance, expanding the Identification of Poor Households (IDPoor) programme, and transitioning to digital cash delivery systems. The COVID-19 crisis highlighted the critical importance of social protection, particularly cash transfers, in helping people to cope with shocks. The National Social Protection Council's (NSPC) experience in implementing the national Cash Transfer Program for Poor and Vulnerable Households during COVID-19 (CT-COVID) firmly demonstrated that the social protection system in the country, though still in the early years of growth and expansion, does indeed offer great potential as a system through which the needs of those affected by shocks can be met, providing a valuable mechanism that complements existing government efforts for disaster response. Additionally, responses to the large-scale flooding in October 2020 highlighted the relevance of a Shock Responsive Social Protection (SRSP) framework for enhancing coordination of emergency assistance to affected households. During the October 2020

[160] For example, in the NCDM/HRF Rapid Assessment to flash floods in Oct 2020, the two main concerns of affected households were lack of food and loss of livelihoods

[161] Studies highlight that a shock contributing to reduction in average household income by just 20% would nearly double the national poverty rate (OECD (2017) Social Protection System Review of Cambodia, OECD Development Pathways). As many as two million people were estimated to have fallen below the poverty line owing to the 2008-9 food and fuel crises (Jalilian et al (2009) Global Financial Crisis Discussion Series Paper 4: Cambodia, ODI)

flood event, humanitarian actors and coordination platforms such as the Cambodia Humanitarian Response Forum (HRF) were interested to align emergency cash assistance programmes with and complement the government's CT-COVID programme in flood affected areas. Going forward, the use of social protection systems for shock response can help to facilitate more harmonised and unified ways of working between government social protection actors, such as NSPC, MoSAVY, MoP, etc., government disaster management actors such as NCDM, and partner organisations leading on emergency response at times of shock. Social protection that reaches those in need and that can be scaled up rapidly to mitigate impacts of shocks that occur has potential to contribute to significant savings for the RGC over time, as it cushions the impact of shocks on those that are vulnerable and builds resilience. SRSP is an important complement to wider RGC efforts to reduce vulnerability and enhance the long-term resilience of households, for sustainable development and poverty reduction.

The design and implementation features of routine social protection programmes to adaptation options aimed at building social resilience and to ensure their continued accessibility and effectiveness at times of shock:

- **Home grown school feeding (HGSF)**. Transition from school meals to take home rations. This was done in response to the COVID-19 pandemic. Would help maintain the relevance of food assistance and to ensure food needs of children continue to be met in event of school closures. Food is one of the critical basic needs of those that are vulnerable to shocks. HGSF is operational in some of the localities most prone to shock.
- **Cash-based social assistance:** waiving enforcement of conditionalities; waiving the automated time-bound (3 year) exit of households from IDPoor; and waiving the automated exit from programmes due to child age, at times of shock. Ensures continuity of routine cash transfers and any top-ups at times of critical need (prevents households being penalised for non-adherence to conditionalities at times when services are inaccessible either physically or economically; means programmes that use IDPoor status or child age in the eligibility criteria will not exit beneficiaries during this period).
- **Social health insurance (SHI) programme:** Reduce or fully waive members' contributions for a period following a shock and a grace period during which members cannot be suspended. Will prevent defaulting and exclusion of members and the event employers were unable to pay their contribution, enabling them to continue to access social health insurance (SHI) at times of shock.
- **A temporary, shock-specific cash transfer programme, delivered by government, through social assistance systems and processes**. (1) Cash provides a way to meet diverse needs. (2) builds on the well-functioning existing institutions, digital systems and administrative processes of the cash-based social assistance programmes, for speed and cost efficiency. Done in COVID-19. (3) Is a way to reach those that are not currently beneficiaries of routine social protection and who are vulnerable to shocks, but in a clearly communicated, separate and temporary programme. Exit is easier to communicate. This option can be designed to include either, or both, of those who DO meet the targeting criteria of routine social assistance programmes but who are currently excluded; and those who DO NOT fit these criteria and who are thus excluded. (4) If IDPoor is transitioned to a more comprehensive social registry, then with the rollout of OD IDPoor, this provides a starting point to identify the 'near poor' that live close to the poverty line and that are vulnerable to becoming poor when a shock hits. Other easy to verify demographic vulnerability criteria that are captured in IDPoor, and nature of livelihoods, could also be used for targeting this programme. (5) NSSF beneficiaries can also be included. As NSSF coverage expands, this will mean that the NSSF registry contains more of the informal sector (many of whom are near poor, and therefore vulnerable to falling into poverty when a shock hits), who can be rapidly identified. Certain NSSF members in specific affected industries can be automatically included for assistance under this programme ('no regrets' style response). Or they can be assessed by OD IDPoor.

Figure 33: Overview of social assistance programs

Category	Programme/Scheme	Type and value of transfer	Eligibility	Coverage	Ministry/Agency
1. Social assistance programs for emergency response					
Emergency	Emergency Food Assistance Project	Food	Food insecure households: IDPoor 1 and 2 affected by food price crisis	Beneficiaries: 500 000 Provinces: 10 Districts: 33 Communes: 100	Ministry of Economy and Finance (MEF)
	Food Reserve System	Food	Food insecure households affected by natural disasters	Nationwide	MoEF/ National Committee for Disaster Management
	Social interventions for emergency and relief	Food	Households affected by natural disaster and other vulnerabilities	Provinces: 2 Beneficiaries: approximately 15 000	Ministry of Social Affairs, Veterans and Youth Rehabilitation (MoSVY)
	Cash-for-work programme	Cash; on average USD 5 per workday	Food insecure households affected by natural disasters	The first phase of the programme (ended in 2012), created 2 million workdays; sustaining temporary jobs in a three-year cycle	MEF
	Reducing the vulnerability of rural Cambodian livelihoods through enhanced sub-national climate change planning and execution of priority actions	Cash	Poor households	Provinces: 2 Beneficiaries: close to 15 000, about 4 000 of whom are poor/ vulnerable women	MoE/Secretariat of the National Committee for Democratic Development, (NCDD-S)
Human development	Cash transfer for poor families with pregnant mothers/children under five years (U5)	Cash	Pregnant women and U5 children	Women: 2 145 Children: 1 200	NCDD-S/ Council of Agricultural and Rural Development (CARD)
	NOURISH Mother/Child nutrition cash transfer incentive for health service utilization	Cash	Pregnant women and U2 children	Provinces: 3 Beneficiaries: 300 000	Save the Children District/municipality/ commune
	School food programme	Food	All students in selected schools in rural/ remote areas with food insecurity	Provinces: 9 Schools: 1 219 Students: 300 000	Ministry of Education, Youth and Sport (MoEYS)
	Primary school take-home rations	Food	Students in grades 4-6 IDPoor 1 and 2	Provinces: 3 Schools: 765 Students: 6 200	MoEYS
	Home-grown school feeding	Food-for-work/ cash-for-work program		Schools: 59	MoEYS

			All students in grades 1-6 in selected schools in rural/remote areas with food insecurity	Students: 13,000	
	Primary school scholarships	Cash; USD 60 per year	Students in grades 4-6 in schools in rural/remote areas IDPoor 1 and 2	Nationwide Schools: 2 934 Students: 79 004 (planned), 77 605 (actual)	MoEYS
	Primary school scholarships	Cash; USD 60 per year	Students in grades 4-6 in schools in rural/remote areas IDPoor 1 and 2	Students: 26 000 (Different areas than the RGC primary school scholarships)	MoEYS
	Lower secondary scholarships	Cash; USD 60 per year	Students in grades 7-9 from poor households	Schools: 809 (out of 1 600) Students: 70 574	MoEYS
	Upper Secondary Scholarship	Cash; USD 90 per year	Students in grades 10-12 from poor households (currently covering only grade 10)	Schools: 120 Students: 3 600	MoEYS
Social Health protection	Health Equity Fund(s)	Fee subsidy	Members of poor households with IDPoor cards	Nationwide Recipients: 2.9 million	Ministry of Health (MoH)
	Community-based health insurance	Insurance benefit	Poor and near poverty	Operating Districts (ODs): 21 Members: 117 726	MoH/ Non-governmental organizations (NGOs)
	Voucher for reproductive health scheme	Health service	Women and children from poor families	Provinces: 5 Ods: 23 Cases: 68 276	MoH
Vulnerable groups	Social welfare for the elderly	-	Elderly (65+ years)	Provinces: 11 Associations: 358	MoSVY
	Social welfare for families living with disabilities	-	People with disabilities who are poor, elderly or have no supporting families	Beneficiaries: 300 000 (almost 100% coverage)	MoSVY
	Disability allowance	Cash; USD 5 per month	People with disabilities who are poor, elderly or have no supporting families, verified by local authorities	Nominally nationwide	MoSVY
	Social welfare for vulnerable children and orphans	Social service; USD 1.25 per day per child	Vulnerable children and children living in residential care institutions	Nationwide Institutions: 253 Children: 11 017 (to include only the RGC)	MoSVY/ NGOs

2. Social protection program for labour market policy and employment					
Labour policy and employment	Second chance or informal technical vocational education and training (TVET)	Training; USD* 28 for one week, USD 100 for one year	Young dropouts from poor households, referred by local and school authority	Nationwide, which includes 36 training institutions, 12 NGO-run training centres, 750 private providers, and 100 000 expected participants	Ministry of Labour and Vocational Training (MoLVT)
3. Social Insurance schemes					
Old-age pension	National Social Security Fund for Civil Servants (NSSF-C)/ National Fund for Veterans (NFV)	Cash; the minimum benefit is 60% of the final basic salary and allowances (excluding position allowance). The maximum benefit is 80% of final salary for 30 years of service	Lifetime pension payable after 20 years of service (minimum) at the normal retirement age of 55	NSSF-C recipients: about 180 000 civil servants and their dependents	MoSVY
		The pension amount is subject to a minimum amount, depending on the salary grade. Retirement allowance is equal to eight months of total final salary	NSSF-C: civil servants, excluding police and armed forces		
			NFV: war veterans, police and armed forces	NFV recipients: about 87 500 war veterans, police and armed forces and their dependents	
Invalidity	NSSF-C and NFV	Cash; the minimum benefit is 50% of final salary and allowances (not including position allowance). The maximum benefit is 65% of final salary for 30 years of service	Lifetime pension payable after 20 years of service (minimum)	NSSF-C recipients: about 180 000 civil servants and their dependents	MoSVY
		The pension amount is subject to a minimum amount, depending on the salary grade. For less than 20 years of service, a lump sum benefit is payable equal to four to ten months of total final salary		NFV recipients: about 87 500 war veterans, police and armed forces and their dependents	
		Invalidity allowance is payable equal to six months of total final salary			
	NSSF (EII)			Enterprises: 7 796	

		Cash; a contribution of 3% from employees and 0.8% from employers	Employees of business enterprises with at least eight employees	Employees: 1.1 million	MoSVY
Health Insurance	NSSF-C and NFV	Insurance benefit	NSSF-C: civil servants, excluding police and armed forces	NSSF-C recipients: about 180 000 civil servants and their dependents	MoSVY
			NFV: war veterans, police and armed forces	NFV: about 87,500 war veterans, police and armed forces and their dependents	
	NSSF	Insurance benefit; a proposed contribution of 50% from employees and 50% from employers	Employees of business enterprises with at least eight employees	Enterprises: 11	MoSVY
		A contribution rate of 2.4% of insurable earning for medical care and 1.4% for sickness cash benefits and maternity cash benefits		Employees: 7 956 (as of 2015)	

4. Other social protection programs by NSSF-C and NFV	
Benefit type	**Benefit details**
Sickness cash benefit	Full salary, including allowances for up to three consecutive months of illness and 90% of salary thereafter for up to 12 months, depending on years of service
Maternity benefits	Maternity leave for 90 days at full salary and cash allowance of KHR* 600 000 per child or miscarriage
Marriage allowance	A cash allowance payable at first marriage
Work injury benefits	Medical care, cash benefit at full salary during treatment and convalescence, and permanent invalidity benefits for permanent disability
Death benefits in case of death on mission	Cash allowance of six months of total final salary of the deceased Funeral allowance
	Survivor pension payable to widow at KHR 6 000 per month and KHR 5 000 per month for each child under 16 years
Death benefits in case of civilian death	Funeral allowance of 12 months of pension of the deceased
	Survivor pension payable to widow at KHR 6 000 per month and KHR 5 000 per month for each child under 16 years

Figure 34: Overview of social protection programs

Source	Destination	Description	Sector	Amount (US$)	Funding status
Government of Japan	UN Children's Fund	COVID-19 response (SM200105)	COVID-19	966579	Paid Contribution
USA Government	UN Children's Fund	COVID-19 response (SM200097)	COVID-19	1143619	Paid Contribution
Government of Denmark	UN Children's Fund	COVID-19 response - Cambodia (SM1899100775)	COVID-19	428	Paid Contribution
US Fund for UNICEF	UN Children's Fund	COVID-19 response - Cambodia (KM200023)	COVID-19	3625	Paid Contribution
Government of China	UN Children's Fund	Response to the COVID-19 pandemic - Cambodia (SM200312)	COVID-19	800	Paid Contribution
Government of Japan	UN Office for Project Services	Emergency procurement of critical medical equipment to support the Royal Government of Cambodia for enhancing their response to the Coronavirus outbreak	COVID-19	6320167	Paid Contribution
Government of Denmark	ACT Alliance / Danchurch Aid	COVID-19 Response	Health	16083	Commitment
UN COVID-19 Response and Recovery Fund	UN Children's Fund	COVID-19 response - Cambodia (SM200464)	COVID-19	200	Paid Contribution
UN COVID-19 Response and Recovery Fund	WHO	Strengthened National Preparedness, Response and Resilience to COVID19 in Cambodia	COVID-19	100	Commitment
Government of Australia	IOM	Mekong Region: Responding to Cross Mobility Challenges at Points of Entry (PoE) During COVID-19 Outbreak - Cambodia	COVID-19	258964	Commitment
UN COVID-19 Response and Recovery Fund	IOM	Strengthened National Preparedness, Response and Resilience to COVID19 in Cambodia	COVID-19	500	Commitment
UN COVID-19 Response and Recovery Fund	UN Population Fund	Strengthened National Preparedness, Response and Resilience to COVID19 in Cambodia		200	Paid Contribution
UN Children's Fund	UN Population Fund	Rapid Assessment on Social and health Impact of the Covid-19 on returning Migrant Workers to Cambodia		20	Paid Contribution
Government of Japan	Government of Cambodia	Provision of medical equipment to address COVID-19	COVID-19	18559762	Commitment
IOM	UN Population Fund	COVID-19 Funding		5	Paid Contribution
Government of Ireland	UN Children's Fund	Cambodia: COVID-19 response in the areas of nutrition and WASH in Cambodia (SM200572)	WASH	294118	Paid Contribution
EC Humanitarian Aid and Civil Protection Dept.	Save the Children	Emergency response to flood affected households in Battambang province, Cambodia (ECHO/DRF/BUD/2020/91021)		470035	Commitment
Government of Korea Republic	IOM	Strengthen COVID-19 Response to Returning Migrants in Cambodia		300	Commitment
COVID-19 Humanitarian Thematic Fund	UN Children's Fund	COVID-19 response - Cambodia (SM189910)		428	Paid Contribution
TOTAL				**28035933**	

6.4 Case Study on the Vegetables Value Chain

6.4.1 Overview of vegetable production in Cambodia

Some of the main vegetable and fruit products produced and consumed in Cambodia are:

- Cassava is a popular cash crop across much of Cambodia. Cassava, along with cashew and coffee, has been identified as an important crop in Cambodia by GIZ's "Strengthening the climate resilience of agriculture in Cambodia and Viet Nam" project (2021- 2024)[162]. It is produced predominantly for sale into the starch industry, as such much of the production is of non-edible, starch rich varieties. However, a significant quantity of edible cassava is grown for direct consumption and for market.
- Lemon production is an attractive, low labour livelihood activity with high potential for increasing household incomes and providing micro-nutrients for a more balanced, diverse diet.
- Soybean in Cambodia is mainly grown for export. Most of the Cambodian soybean crop is exported to Vietnam or Thailand[1]. It is however also used extensively for consumption and can provide important and affordable proteins for Cambodian diets. Soybean has been identified as an important CA crop and can be grown in a polyculture system with maize and other crops, in rotation with millet and sorghum, used as a mulch and as a nitrogen fixing legume. In Popok, **Kampong Thom**, soybean is used by farmers to intercrop with cashew nut.

Cambodia's vegetable industry is erratic and characterized by seasonal gluts. Frequent supply shortages are compensated for with cheap products from neighbouring countries, predominantly Vietnam. Demand for vegetable products tends to grow very rapidly with urbanization and increased income. The import from neighbouring countries such as Vietnam (60%) and Thailand (20%) are still significantly high more than 80%. Only 20% of the crop is grown during the wet season from May to November, mainly due to the difficulties with pests, diseases and floods. Prices of some vegetables can double during this period. Vegetable production is highly labour intensive. On average, about 424 labour days are needed to cultivate and market vegetable crop production from one hectare, compared to only 78 days per hectare for cereal crops such as rice and maize.

Diversity of vegetables (fruit and leafy) are demanded by consumers; such growth provides major opportunities for farmers to diversify their production and increase their incomes. Such opportunities may be especially valuable for women, who are the primary producers and marketers of vegetable produce throughout Cambodia. Finally, from the farming through retailing, vegetable production employs about twice as much labour as cereals per hectare of production; small farmers, rural laborers, and the urban poor stand to gain extremely from these employment opportunities. Vegetable production plays an important role in poverty alleviation through employment generation, improving the feeding behaviour of the people, and creating new opportunities for poor farmers.

In Cambodia, two main seasons can be distinguished: the dry season from November to May and the rainy season from May to October. In the early dry season, vegetables are easy to grow and give high yield because of favourable cropping conditions: the good climate, wet soil, lack of pests, and easy access to water sources. But at the end of the dry season, when water is no more available, the yields decrease, especially for temperate vegetables like tomato, cabbage and Chinese cabbage which require a lot a water. In the rainy season, vegetables are difficult to grow and give low yield, the climate is warmer, the ponds and lakes suffer from water shortage and some areas are flooded. During the rainy season, some vegetables such as tomato, cabbage and

[162] https://www.giz.de/en/worldwide/95504.html

Chinese cabbage, cannot grow to meet the market needs. At this time (as well as in the late dry season), the imported vegetable quantity increases and comes in addition to local production.

The vegetable cropping systems can be roughly divided into two types:

- Vegetable production in the home gardening or near the houses, on non-flooded land, that can take place both in rainy and in dry season.
- Vegetable production in the lowland, taking place in the beginning of the dry season (rice being cultivated in the lowland in the rainy season).

In Cambodia, there is a clear differentiation of the sources of vegetables according to the type of vegetables, some vegetables are nearly entirely imported (tomato, cabbage, onion, Chinese cabbage) while some other are entirely local (including leafy vegetables such as lettuce, spinach, cucumber, yard long bean).

There are two categories of producers: (1) Producers bringing their personal vegetables only and selling them wholesale to collectors, wholesalers, retailers at the market (they represent 15% of producers present in the market); and (2) Producers bringing their personal vegetables and buying vegetables from other farmers to the market, in this case they act as collectors: they represent 85% of producers selling in the market.

6.4.2 Key Issues in the vegetables value chain

- Low productivity – growth in vegetable outputs has been due entirely to increased land planted areas – either new land released by irrigation or switching from other crops rather than increase in efficiency. There is in needs by doing better or effectively, not doing more. In some locations, low productivity is recognized to be core competitiveness problem underpinning in the whole sector.
- Inadequate inputs and vegetable varieties; (1) prevailing varieties are old and not suitable for demanding markets. Varieties of vegetables such as tomatoes, cabbages and other vegetable seeds should be produce locally adjusted to the market's needs, (2) agricultural inputs, we identified the problems of seed prices and quality, but problems with availability and supply assortment are also not negligible. In addition to seeds, farmers find problems in sourcing fertilizers, seedlings and protection products, (3) problems with plant protection related to effectiveness, i.e., the quality of plant protection products and the availability and price of and level of knowledge about these products.
- Inadequate growing techniques. Improving competitiveness in vegetable exports requires changes in the production system, including the implementation of new techniques and machinery, irrespective of the types applied. Other necessary elements here are the extension of the vegetable season not only by using new cultivars, but also by means of various techniques of implementation (hotbeds, greenhouse and plastic mulches, etc.
- High costs of on-farm investments and the credit needed - Examples of widely needed investments may include irrigation systems, mulch foil, rotating tills, insect, pest and disease protection, calibrators, packaging machines and cold storage units. The loan arrangements offered by financial institutions feature high interest rates and unfavourable conditions.
- The structure of different value chains – linking farmers to ultimate consumer market limited farmers' access to appropriate information and concentrates power in key traders and other intermediaries.
    - Physical infrastructure is highly variable in its quality. Together with weak transportation and high wastage rates for perishables this acts as a disincentive to improve practice.
    - Some market structures (such as seed supply industry) are anti-competitive.

- Unreliable and low levels of seeds quality undermine farmer confidence.
- Financial services are often unfavourable for vegetable investment.
- Low levels of co-operation between small-scale farmers acts as a barrier to planning and investment.

- Weak private sector capacity and weak knowledge and information. The importance of knowledge and information in enhancing productivity prompted question related to market system providing a solution to weak knowledge and information; knowledge and information services not addressing the wider productivity problem in the vegetable sector. Addressing this issue require understanding of: Underlying systematic constraints impinging on the supply and demand for information, and Sources of information were commonly being used by farmers, their perceptions of these and the wider experience of development agencies in engaging farmers
- Lack of cool warehouses and storage; (a) An extension of the production season is also constrained by a shortage of adequate storage opportunities. Because of the lack of proper storage, some locally grown, and traditionally produced vegetables must still be imported out of season as fresh goods, and (b) With proper storage, products such as cabbage lettuce, onions, and many others can be kept and sold with insignificant quality changes throughout the year. Also, storage inadequacy and the lack of storage space represent major constraints which would preferably be solved by additional and adequate storage capacities, although in these cases, financial shortcomings arise.

6.4.3 Adaptation priorities for vegetables value chain

The current effort to adapt to climate change may not be enough to stop losses in GDP. The impact of climate change on Cambodia's economy (loss in projected GDP growth from climate change) is -0.4% in 2020, -2.5% in 2020, -6% in 2040, and -9.8% in 2050. The trend in climate change spending as a share of GDP is 1.4% in 2015, 1% in 2016, 1.8% in 2017 and 2018, and 2% in 2019. Most climate change spending is road improvement, livelihood of climate change vulnerable and irrigation in 2019. The expenditure for climate change benefits by the SNA was just 2.1% of the total expenditure on climate change in 2019. As a trend in this relative term, this 2.1% of the total climate change expenditure in 2018, which as a significant drop from 2.7% in 2017 and 2.8% in 2015.

Notably, recent research[163] indicates that without climate change, the real GDP will grow at an average of 6.9% per year from 2017 to 2050, achieving Upper Middle-Income Country (UMIC) status in 2035. With climate change, the headline projections use the mid-climate change scenario and a mid-adaptation scenario that is equivalent to current levels of adaptation. Climate change reduces average GDP growth to 6.6% and absolute GDP by 0.4% in 2020, 2.5% in 2030, and 9.8% in 2050. As a result, the UMIC status may be delayed by one year. Accordingly, Cambodia has begun developing her National Adaptation Plan (NAP). The NAP process builds on work carried out as part of the National Adaptation Plan of Action (NAPA), the Second National Communication (SNC) and the CCSAP, among others. The NAP identifies climate change impacts, vulnerability, and adaptation actions for Cambodia.

According to the Master Plan for Crop Production in Cambodia to 2030, the prioritization of the first 10 crops includes cereals (rice and maize), tubers (cassava), fruit trees (mango, banana, cashew nut), spices (pepper), and pulses (mung bean). Individual vegetables (e.g., tomato, cucumber, lettuce) are not among the first 10 crops, mainly because of their small value as percentage of GDP and low potential for export. However, if all vegetables were taken as a composite value chain, their importance in the scoring would certainly be bigger,

[163] NCSD (2016)

and they would be part of the first ten most important crops. The prioritized value chains are rice, maize, cassava, mung bean, mango, cashew nuts, pepper, and vegetables. The key issues in the priority value chains as following:

- **At the production level**: (1) limited access to quality seed, (2) dependence on rainfed agriculture, (3) limited knowledge of crop practices to increase productivity, improve climate resilience, respond to pests and diseases, and conserve natural resources (soil fertility, water), (4) access to mechanization services to lower dependence of increasingly scarce agricultural labour, (5) lack of mutually beneficial linkages with other value chain actors, (6) small farm size not providing sufficient income for economic viability, (7) Still relatively weak organizational capacity of farmer groups and farmer cooperatives in consolidating and planning joint efforts to benefit large numbers of smallholder farmers, (8) lack of risk reduction mechanisms available to farmers (e.g., crop insurance, early warning systems).
- **At the postharvest level:** (1) lack of a warehouse receipt system allowing farmers to collateralize their stock and benefit from access to finance and seasonal price variability, (2) lack of access to providers of drying and storage services at the village level, (3) high cost of electricity.
- **At the trade and marketing level**: (1) logistics cost, (2) Access to affordable multi-modal transportation (containers, truck, railways, vessel), (3) quality assurance, (4) branding, and (5) agricultural statistics and market information.

7 Policy Recommendations

7.1 Summary

Take away points

- The resilience of food production systems in Cambodia and the achievement of sustainable intensification of food production under both current and future climate conditions depend on the successful promotion and adoption of climate adaptation strategies targeting the following priority areas: 1) water resources, 2) soil health, and 3) crop yields and income.
- Implementation through integrated social protection and payment for ecosystem services mechanisms can help target poorer households.
- Home gardens play a central role for food security and nutrition of the target group. Increasing their resilience and development through the adoption of technologies and conservation practices that improve soil health and water management is a priority. Capacity building activity is another priority action.
- School feeding program and cash support are essential mechanisms for ensuring food security and nutrition of children of vulnerable households, WRA and smallholding households, and are effective schemes to address acute food and/or income shortages during climate shocks.
- Four specific priorities for improving food security and nutrition status of the target group include healthy diets for all (targeting food availability, access and utilisation), empowerment of youth, women and the vulnerable, resilient and sustainable livelihoods, and just, inclusive and participative governance for a more inclusive food system.

7.2 Priority for improving the resilience of food production systems and fostering sustainable intensification

The resilience of food production systems in Cambodia and the achievement of sustainable intensification of food production under both current and future climate conditions depend on the successful promotion and adoption of climate adaptation strategies targeting the following priority areas: 1) water resources, 2) soil health, and 3) crop yields and income.

- Priority for addressing **agricultural water needs** under a hotter, less predictable climate with a shorter wet season and a longer, drier dry season:
    - Improvement in water use efficiency and storage at the individual, smallholder production and home garden level;
    - Integration of water storage and irrigation infrastructure with aquaculture production;
    - Improvement in water infiltration capacity at the community/ landscape level (protection and expansion of ecosystem service providing natural resources, such as forests and responsible agricultural landscapes) and creation of infrastructure such as check dams;
    - Identification and adoption of nutrient rich, drought resilient/short season crop cultivars and breeds appropriate to local conditions and market preferences
- Priority for addressing **soil health deterioration** under increasing climatic pressure (higher temperatures, more intense droughts and extreme rain events):

- Use of cover crops and similar mixed cropping techniques including agroforestry that increase organic nutrient availability to soils while simultaneously providing protection to soil through physically shielding the soil from direct sunlight and rain damage
- Implementing no-till or minimal till production techniques for major crops, including rice, maize and cassava.
- Increasing usage of organic fertilizers, including nitrogen fixing legumes species and mulching to ensure soil carbon and water content is maintained at a level beneficial to sustained cropping – reduce need for opening new lands and resulting deforestation
- Strengthening protection for ecosystem service providers, such as forests and wetlands, with particular focus on reducing encroachment by farmers, deforestation and opening of new lands/ land-use change from natural forests to farmland

- Priority for addressing **declining yields and incomes** due to increased changing climate trends (higher temperatures, longer dry season, shorter wetter wet season) and climate variability (less predictable)
  - Identification and development of an enabling environment for the adoption of higher yielding, more nutrient dense and future-climate resilient seeds and breeds
  - Strengthening EWS to enable farmers to make informed choices on cropping decisions about when and what to plant, how much to invest, and whether to prioritize off-farm activity to generate additional income
  - Increase investments in agriculture extension, trainings and technologies to support farmers in understanding and adopting CSA methodologies

These interventions can potentially be implemented under integrated social protection and payment for ecosystem services mechanisms where vulnerable households and communities benefit from both construction and output of the activities.

Specifically for vegetable production in home gardens:

- **Focus on water and soil management:** As mentioned in Section 6, home garden producers are ideally suited to, and already practice, diversified mixed cropping. Given this baseline, the role of agricultural policy makers and extension agents is to fortify the currently already diversified but vulnerable practices and identify new, context appropriate more resilient practices and technologies that focus on water and soil management.
- **Capacity building:** Fostering knowledge exchange between expert farmers and extension agents and supporting increased access to appropriate technologies and markets that assist home garden producers to increase productivity, access diverse, nutritious seeds/ cultivars/ breeds (with an increased focus on legumes) and strengthen income generation under more challenging climate conditions will be essential.

7.3 Priority for the integration of social protection into resilient food production schemes:

- Cash For Work, including payment for ecosystem services and landscape management through paid work (such as planting trees, land levelling, check dam construction) for members of vulnerable communities

- Home-grown school feeding programmes (school meals integrated local production of vegetables/eggs targeted for resilience/ climate change adaptation training and CSA technology exchange

As highlighted above, existing plans and strategies support these policy recommendations:

Cambodia's Climate Change Strategic Plan (CCCSP; 2014-2023)

The CCCSP was formulated to address the various dimensions of climate change impacts and identify responses across an array of sectors including the economy, health, food security, energy, and environment. The strategy consists of strategic objectives to improve resilience; reduce GHG emissions; support knowledge and awareness, social protection and institutional strengthening in climate change related sectors.

The CCCSP is supported by sectoral Climate Priority Action Plans (CPAPs) produced by relevant line ministries, including MAFF.

MAFF's Climate Change Priorities Action Plan (CCPAP)

The Ministry of Agriculture Forestry and Fisheries' Climate Change Priorities Action Plan 2016-2020 (CCPAP) was designed to guide MAFF in delivering on agriculture sector actions to meet its own targets within the ASDP, its national commitments to Cambodia Climate Change Strategic Plan (CCCSP), as well as Cambodia's international commitments to the UNFCC, SDGs and Sendai Framework.

Agriculture Strategic Development Plan (ASDP; 2019-2023)

The ASDP is MAFF's primary planning tool. It is produced every five years as the main component of its strategy to continuously improve agricultural development, intensification and innovation. Both the 2014-2018 and 2019-2023 ASDP are comprised of five main strategic actions:

1. Improvement of agricultural production, intensification and agri-commercialization
2. Improve animal production and animal health
3. Sustainable fishery resources management
4. Sustainable forest and wildlife resources management, and
5. Institutional strengthening, efficiency supporting service and human resource development.

Cambodia's Nationally Determined Contributions (NDC; 2015 and 2020)

Periodic submission of NDCs to the UNFCCC is an obligation for all signatories to the Paris Agreement. NDCs integrate information from all climate-relevant sectors, with the aim of providing a comprehensive report of national efforts to prevent dangerous anthropogenic interference with the global climate system, and at the same time contribute to poverty reduction and promote economic growth efforts[1].

7.4 Priority for improving food security and nutrition status of the target group in the target region

Stakeholders at national, sub-national and community levels across sectors muss work together to create multiplier effects for poverty reduction, ending malnutrition and hunger, and protecting our environment. Most importantly, engaging and including the voices of consumers and producers as well as the most vulnerable, including youth, women, indigenous peoples and ethnic minorities, will be key to shape the food system of tomorrow, for a healthier population, planet, equitable economy and prosperity. Four specific priorities for improving food security and nutrition status include the following:

1. **Healthy diets for all:**
   - Healthy diets are to be made more available and accessible through enhanced agricultural productivity and diversification, agroindustry, research and development, food safety, food fortification, value addition, wider commercialization, and infrastructure improvements in local markets;
   - Food will be made more accessible through the expansion of social assistance to vulnerable individuals and households including its cash transfer, homegrown school feeding, and use of fortified foods for in-kind distribution schemes;
   - The expansion of 1,000 days health counselling and services for mothers and children under 2 years of age, with a focus on promoting exclusive breastfeeding and improving infant and young child feeding and mother's dietary diversity;
   - Operationalize the National Roadmap for Prevention and Treatment of Child Wasting;
   - Ensure access to clean drinking water, sanitation and good hygiene practices;
   - Create food environments where consumers can make healthy food choices through regulation of food marketing (including breast-milk substitutes) and promotion of national dietary guidelines and standards.
2. **Empowerment of youth, women and the vulnerable:**
   - Engage youth, particularly young women, in leadership roles and provide opportunities for youth, women and the vulnerable to be routinely engaged in policy dialogue and decision-making;
   - Promote digitalization, research and development, innovation, and support for the vulnerable, youth and women's SMEs; and
   - Strengthen vocational training programs, formal and non-formal education, and youth and women associations to meet the demands of a developing food system and the country's development.
3. **Resilient and sustainable livelihoods:**
   - Expand shock responsive social protection to include vulnerable families and strengthen resilience and maintain food reserves;
   - Apply One-Health principles, including traceability along the value chain; and
   - Steer food systems development in the direction of green growth by enabling the potential of the private sector in digitalization, green financing, agroecological transformations, gender-sensitive implementation of CSA, resource efficiency, reducing waste and food losses, renewable energy uses, and improving green infrastructure including irrigation and rural roads.
4. **Just, inclusive and participative governance for a more inclusive food system:**
   - Open the door for multi-stakeholder and multi-sectoral dialogue, coordination, and collaboration to make planning and implementation processes more just, inclusive and participatory. These processes will be promoted at national, sub-national and community levels, and include collaboration between the Royal Government of Cambodia, development partners, the private sector, academia and civil society.

8 Annex

8.1 Climate information and early warning systems (EWS) in Cambodia

Climate data consist of observational data, historical reconstruction data derived from proxies or reanalyses and climate model projections derived from global and regional climate models [General Circulation Models (GCMs) and regional climate models (RCMs), respectively][164]. Climate datasets typically include a combination of data on earth surface mean and extreme temperatures, precipitation, cloud cover, direct (short-wave) and indirect (long-wave) solar radiation, atmospheric pressure and wind at various temporal-scale (i.e., hourly, daily, monthly).

Climate change projections are computed based on scenarios of future greenhouse gas emissions and mitigation efforts. The latest Intergovernmental Panel on Climate Change (IPCC) scenarios were developed within the sixth modelling intercomparison project (CMIP6) and include a core set of five scenarios spanning strong-mitigation and carbon storage efforts, delayed actions, and business as usual emissions (SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5).

Information on climate risks for agriculture and food systems consist of climate risk indicators derived from climate data and climate impacts data, which the later are produced with agricultural and hydrological modelling tools. Since climate is a key drivers of crop production, crop yield models have been widely developed and applied to assess climate change impacts on the supply dimension of food security. Water resources and use for agriculture is another focus of impact modelling tool for food systems. In addition, agroeconomic models simulate commodity trades and are used to project net food demand and consumption under socio-economic conditions. They sometime also include crop production projection that account for climate change.

This section reviews existing climate change information in Cambodia and a classification of the most appropriate products.

8.1.1 Climate observation and historical climate data

- Climate observation network

Climate observation data include on-site measurement and satellite imagery. In Cambodia, the Mekong River Commission data portal[165] provides a good overview of the climate observation network. It includes a total of 759 monitoring stations operating across the country.

- Reanalyses data products

Reanalyses are modelled historical climate data sets that complement observation data. These are useful in data scarce regions. Historical climate data provide information on past climatic trends and provide baseline information to assess present and future climate change. Reanalyses are used as a baseline for future climate projections, to quantify the relative change in climate at a given time-horizon. A key source of uncertainty in reanalysis data is precipitation.

The Asian Precipitation-Highly Resolved Observational Data Integration Towards Evaluation of the water resources (APHRODITE) reanalysis product has focused on improving representation of the Asian monsoon, and thus appears the most suited for the South-East Asian region[166]. This dataset is a daily gridded precipitation

[164] (Chen et al, 2021)

[165] (Mekong River Commission, n.d.)

[166] (Iqbal, et al., 2021)

dataset covering a period of more than 50 years and was created by collecting and analysing rain-gauge observation data across Asia through the activities of the APHRODITE project[167].

Another widely used historical climate dataset is the CRU dataset, which is used in the World Bank Climate Portal.

8.1.2 Early warning systems

The need for strengthening the capacity for collection, analysis, modelling and interpretation of climate data and information dissemination, including seasonal forecasting for adaptation and community early-warning facilities for disaster risk management is recognised in Cambodia's Climate Change Strategic Plan 2013-2023. Strengthening EWS and climate information dissemination are also expressed as Priority Adaptation Actions in Cambodia's Nationally Determined Contribution submission to the UNFCCC. For example, it states the intent to "Establish a national climate and flood warning system, including a service centre and flood emergency response plans"[168].

Cambodia's Ministry of Water Resources and Meteorology (MOWRAM) is the lead government body responsible for EWS in Cambodia. MOWRAM, together with various donors and meteorological agencies, have undertaken a number of initiatives to develop EWS for Cambodia and the wider Mekong River basin region. These rely on satellite observations of atmospheric and vegetation conditions and on-site gauge systems that monitor ground-water tables. Hazard indicators are developed, and populations receive warnings though diffusion channels.

Since 2015, the United Nations Development Programme (UNDP) has been heavily involved with building MOWRAM's capacity to capture and analyse data and provide effective early warning information to at-risk communities. As well as repairing old and installing new recording stations, UNDP trained a total of 54 staff from MOWRAM, including meteorologists, hydrologists, technicians, and provincial staff as well as key meteorologists and hydrologists to accurately forecast and model weather using the collected data. This has supported a shift from three-day to ten-day, sub-seasonal, and seasonal weather forecasting in Cambodia and allows communities to prepare for disasters and to adapt to the changing climate[169]. However, it is unclear where this system is based or what it is called (unable to find through internet search).

MAFF are responsible for EWS focusing on agriculture, fisheries and livestock, though little data is available on progress in achieving improvements.

According to the 2020 updated NDC "National end-to-end Early Warning Systems with focus on effective dissemination to populations at risk" is also an adaptation action under the responsibility of NCDM.

In Cambodia, the following EWS exist:

- SERVIR-Mekong

  Works in partnership with regional organisations (predominantly the Asian Disaster Preparedness Centre), to help the five countries in the Lower Mekong Region, including Cambodia, use information provided by Earth observing satellites and geospatial technologies to manage climate risks.

- ESW1294

  Uses a network of smart sensors (water gauges/ meteorological readings) that utilise mobile phone networks to inform local citizens in advance of natural hazards occurring in Cambodia. When an event

[167] (APHRODITE's Water Resources, n.d.)

[168] (Cambodia's Updated Nationally Determined Cotribution, 2020)

[169] (Changing the Face of Early Warning in Cambodia, 2020)

such as flooding is detected or predicted, a voice recording is sent to the mobile phones of registered users in the areas at risk. It is overseen by the various Provincial Centres for Disaster Management.

- CREWS (just launched, 2021-2025)

  Aims to enhance capacities of national and regional stakeholders and institutions to provide hydrometeorological, early action, and response services that will ensure that vulnerable populations in Cambodia and Lao PDR are reached by risk informed EWS. The project is structured around strengthening disaster risk knowledge; detection, monitoring, analysis and forecasting; warning dissemination and communication; and preparedness and response capabilities.

8.1.3 Climate model projections available

- Coupled Model Intercomparison Project (CMIP): CMIP6 and CMIP5

Climate change projections are produced by GCM and Earth System Models (ESM). Climate projections vary widely across modelling techniques, and a robust assessment of climate projections would typically include results from an ensemble of multiple models. The CMIP is a framework for comparing the projections and performance of GCMs and ESMs; and provides the main data source for model ensemble projections of climate change at global scale. Whilst CMIP6 is the latest phase of CMIP and results from this phase are increasingly available, many climate projection assessments still rely on results from CMIP5 (the previous phase).

Model performance evaluation is an integral part of CMIP, and efforts have been made in evaluating the performance of global climate models for South-East Asia and even Cambodia. Simulating precipitation patterns over Southeast Asia has been a critical weakness. For example, results from CMIP5 tended to overestimate mean precipitation[170]. Regional performance evaluation is complex, and models are evaluated against multiple criteria. An evaluation of the best CMIP5 models for the lower Mekong basin showed that different models performed better depending on the criteria used for the evaluation[171]. Models participating in CMIP6 have a higher resolution and provides an improvement for regional application. A recent evaluation of CMIP6 rainfall projections over mainland Southeast Asia indicated that three models (MRI-ESM2-0, EC-Earth3 and EC-Earth3-Veg) among the 34 that participated in CMIP6 would be best suited for regional climate change analysis over Southeast Asia[172].

- CORDEX SEA

Climate projections from CMIP remains, however, too coarse for regional application. The COordinated Regional climate Downscaling EXperiment (CORDEX) is an international initiative similar to CMIP but aimed at producing high resolution climate projection data by downscaling GCMs data using RCMs. CORDEX SEA (Southeast Asia) produces high resolution data for the Southeast Asia region and is therefore particularly valuable for assessing climate change risks in Cambodia.

Available data from CORDEX SEA includes, at the moment, downscaled climate data from eleven GCM from CMIP5. Downscaled data from CMIP6 are not yet available.

- Climate scenarios

CMIP6 scenarios consist of an updated set of scenarios since CMIP5 based on the Shared Socio-economic Pathways (SSPs). They include sustainable pathways (SSP1-2.6), middle-of-the road (SSP2-4.5), regional

[170] (Tang, Hu, & Duan, 2021)

[171] (Ruan, Yao, Wang, & Liu, 2018)

[172] (Iqbal, et al., 2021)

rivalry (SSP3-7.0), fossil-fuel-rich development (SSP5-8.5) and a 1.5ºC Paris agreement goal scenario (SSP1-1.9).

With regards to the time-horizon relevant to the project (up to 2050), the resulting global mean temperature increases relative to pre-industrial level in the near-term (~2030s) range between 1.5ºC (SPP1-1.9, SPP1-2.6, SPP2-4.5, SPP3-7.0) to 1.6ºC (SPP5-8.5). Similarly, the global mean temperature increases in the medium-term (~2050s) range between 1.6ºC (SSP1-1.9), 1.7ºC (SPP1-2.6), 2ºC (SPP2-4.5), 2.1ºC (SPP3-7.0) and 2.4ºC (SSP5-8.5).

8.1.4 Climate impacts on food systems

The Intersectoral Impact Modelling Intercomparison Project (ISIMIP) has produced coarse climate impact data (0.5ºx0.5º resolution) across sectors, including agriculture[173]. For agriculture, data on projected climate impacts on crop yield for rice, wheat, soybean, and maize have been produced. Most recently, Hasegawa et al., have compiled peer-reviewed studies on climate impacts on crops, which include four independent studies for rice production Cambodia[174]. These studies comprise global scale modelling approaches (i.e., gridded crop models such as the ones participating in ISIMIP) and a local modelling approach based on the General Large-Area Model for annual crops (GLAM)-Rice crop model. The GLAM-Rice model is based on the GLAM[175, 176].

Data are limited regarding climate impacts on food crops, as research efforts have focused on important commodity crops, such as rice, but not so much on other food crops relevant to nutrition security, such as legumes, fruits, and vegetables. It is to be noted that climate indictors can also be used to assess systematic risks on agriculture (e.g., number of days above heat thresholds). Figure 35 provides an overview of climate data for Cambodia.

[173] (The Inter-Sectoral Impact Model Intercomparison Project, n.d.)

[174] (Hasegawa, et al., 2021)

[175] (Kim, Park, Chun, & Li, 2018)

[176] (Chun, et al., 2016)

Figure 35: Overview of climate data for Cambodia

Dataset	Type	Variables	Spatial coverage	Resolution	Temporal horizon	Projection Scenarios	Reference
CMIP6	Climate projections	Temperatures, precipitation (ensemble mean, anomaly)	Global (downscaled to Cambodia)	1ºx1º (~100km)	2020-2099	SSP1-1.9 SSP1-2.6 SSP2-4.5 SSP3-7 SSP5-8.5	World Bank Climate knowledge portal https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-projections
CMIP5	Climate projections	Temperatures, precipitation (ensemble mean, anomaly)	Global (downscaled to Cambodia)	1ºx1º (~100km)	2020-2099	RCP2.6 RCP4.5 RCP6 RCP8.5	World Bank Climate knowledge portal https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-projections
CORDEX-SEA	Climate projections	Temperatures, precipitation (ensemble mean, anomaly)	Regional, downscaled from CMIP5	0.25ºx0.25º (~25km)	2020-2099	RCP2.6 RCP4.5 RCP6 RCP8.5	Not easily accessible http://www.ukm.my/seaclid-cordex
CRU	Observed climatology, daily time-series	Temperatures, precipitation (climatology)	Global (downscaled to Cambodia)	0.5ºx0.5º (~50km)	1901-2020	n.a.	World Bank Climate knowledge portal https://climateknowledgeportal.worldbank.org/country/cambodia/climate-data-projections
ISIMIP phase 1	Climate impacts	Yield (maize, wheat, soy, rice), economic damage, freshwater, extremes	Global (downscaled to Cambodia and provinces)	0.5ºx0.5º (~50km)	2020-2099	RCP2.6 RCP4.5 RCP6 RCP8.5	Climate Analytics Impact Explorer tool: http://climate-impact-explorer.climateanalytics.org
Hasegawa et al., 2022	Climate impacts	Agriculture yield (maize, wheat, soy, rice)	Global, Cambodia, Southeast Asia	Site-based and gridded (5'x5'; 0.5ºx0.5º)	2025-2030 and 2050-2080	RCP2.6 RCP4.5 RCP6 RCP8.5	https://www.nature.com/articles/s41597-022-01150-7#Sec10
APHRODITE	Observed climatology, daily time-series	Temperature, precipitation	Monsoon Asia Area	0.5ºx5º (50km), 0.25ºx0.25º (25km) and 5'x5' (5km)	1995-2015	n.a.	APHRODITE: Asian Precipitation - Highly-Resolved Observational Data Integration Towards Evaluation Of Water Resources http://aphrodite.st.hirosaki-u.ac.jp/index.html
SERVIR-MEKONG	Climate impacts	Climate variables and indices derived from CMIP5	Countries along Mekong-river basin	0.5ºx5º (50km)	2099	RCP4.5 RCP8.5	ADPC/SERVIR-Mekong, NASA Jet Propulsion Laboratory (JPL) https://mdcw-servir.adpc.net/climate-studies/

Dataset	Type	Variables	Spatial coverage	Resolution	Temporal horizon	Projection Scenarios	Reference
SERVIR-MEKONG	Early warning information	Drought indices	Countries along Mekong-river basin	0.5ºx5º (50km)	Outlook 2 months	n.a.	ADPC/SERVIR-Mekong, NASA Jet Propulsion Laboratory (JPL) https://mdcw-servir.adpc.net/home/
ESW1294	Early warning system	Floods- Groundwater levels	Camb. KrongSiemrean (Kampong Thom) Kampong Kraeng (Kampot)	Side-based (19 active sensors)	Daily	n.a.	Early Warning System (EWS) 1294 http://ews1294.com/en/home/
CREWS	Early warning system	Indices on floods, droughts, landslides and severe weather	Lower Mekong countries				Not yet available; project launched in 2021 ADB, World Bank, UNDDR https://public.wmo.int/en/projects/reinforcing-capacities-of-meteorological-and-hydrological-services-and-enhancing-early

8.2 Definitions

Based on the IPCC AR6 WGII glossary

- Vulnerability

  The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. See also Exposure, Hazard and Risk

- Exposure

  The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.

- Hazard

  The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. See also Impacts and Risk

- Risk

  The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species.

  In the context of climate change impacts, risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards. Hazards, exposure and vulnerability may each be subject to uncertainty in terms of magnitude and likelihood of occurrence, and each may change over time and space due to socio-economic changes and human decision-making.

  In the context of climate change responses, risks result from the potential for such responses not achieving the intended objective(s), or from potential trade-offs with, or negative side-effects on, other societal objectives, such as the Sustainable Development Goals (SDGs). Risks can arise for example from uncertainty in implementation, effectiveness or outcomes of climate policy, climate-related investments, technology development or adoption, and system transitions. See also Hazard and Impacts

- Risk assessment

  The qualitative and/or quantitative scientific estimation of risks. See also Risk management and Risk perception

- Impacts

  The consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather / climate events), exposure, and vulnerability. Impacts generally refer to effects on lives, livelihoods, health and wellbeing, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure. Impacts may be referred to as consequences or outcomes and can be adverse or beneficial. See also Adaptation, Exposure, Loss and Damage and losses and damages, Vulnerability and Risk

- Food security

  A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. The four pillars of food security are availability, access, utilization and stability. The nutritional dimension is integral to the concept of food security {FAO, 2018/ 2009 #6619}.

  Availability

  Physical availability of food. Food availability addresses the supply side of food security and is determined by the levels of food production, stocks and net trade.

  Access

  Economic and/ or physical access to food. Economic access is determined by disposable income, food prices and the provision of and access to social support. Physical access is determined by the availability and quality of land and other infrastructure, property rights or the functioning of markets.

  Utilisation

  The way in which the body uses the various nutrients in food. Individuals achieve sufficient energy and nutrient intake through good care and feeding practices, food preparation, diet diversity and intrahousehold distribution of food. Combined with biological utilization of the food consumed, energy and nutrient intake determine the nutrition status of individuals.

  Stability

  The stability of the other three dimensions over time. Even if individuals' food intake is adequate today, they are still considered food-insecure if periodically they have inadequate access to food, risking deterioration of their nutrition status. Adverse weather conditions, political instability or economic factors (unemployment, rising food prices) may have an impact on individuals' food security status.

- Food system

  All the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the output of these activities, including socio-economic and environmental outcomes (HLPE, 2017). [Note: Whilst there is a global food system (encompassing the totality of global production and consumption), each location's food system is unique, being defined by that place's mix of food produced locally, nationally, regionally or globally.]

- Malnutrition

  Deficiencies, excesses, or imbalances in a person's intake of energy and/or nutrients. The term malnutrition addresses three broad groups of conditions: undernutrition, which includes wasting (low weight-for-height), stunting (low height-for-age) and underweight (low weight-for-age); micronutrient-related malnutrition, which includes micronutrient deficiencies (a lack of important vitamins and minerals) or micronutrient excess; and overweight, obesity and diet-related noncommunicable diseases (such as heart disease, stroke, diabetes and some cancers) (WHO, 2018). Micronutrient deficiencies are sometimes termed 'hidden hunger' to emphasise that people can be malnourished in the sense of deficient without being deficient in calories. Hidden hunger can apply even where people are obese.

- Early warning systems (EWS)

  The set of technical and institutional capacities to forecast, predict, and communicate timely and meaningful warning information to enable individuals, communities, managed ecosystems, and organisations threatened by a hazard to prepare to act promptly and appropriately to reduce the possibility of harm or loss. Dependent upon context, EWS may draw upon scientific and/or indigenous knowledge, and other knowledge types. EWS are also considered for ecological applications, e.g., conservation, where the organisation itself is not threatened by hazard but the ecosystem under conservation is (e.g., coral bleaching alerts), in agriculture (e.g., warnings of heavy rainfall, drought, ground frost, and hailstorms) and in fisheries (e.g., warnings of storm, storm surge, and tsunamis) (UNISDR 2009; IPCC, 2012a).

8.3 Overview of adaptation options identified in IPCC AR6

Adaptation category	Adaptation option	Focus
	Climate-smart facilities (e.g., deeper ponds, water storage)	Aquaculture
	Investment in protection infrastructure	Aquaculture
	Greater investments in stronger equipment (i.e., cage and mooring systems)	Aquaculture
	Farmed stocks adjusted to the new productive capacity	Aquaculture Systems
	Change production cycle or aquaculture system type	Aquaculture Systems
	Collective water storage and management schemes (WUEs)	Aquaculture Systems
	Dietary changes + food environments (including food waste)	Consumption and nutrition
Sustainable intensification/ climate smart agriculture / Agronomic on-farm management	No till, reduced tillage or conservation agriculture	Crop-based systems
	Precision fertilizer management	Crop-based systems
	Integrated pest and weed management	Crop-based systems
	Adjustment of planting dates / counter season crop production	Crop-based systems
	Reduced grassland conversion to cropland	Crop-based systems
Nature-based adaptation or ecosystem-based adaptation	Organic management	Crop-Mixed-Livestock
	Community seed/feed/fodder banks	Crops-Mixed-Livestock
	Integrated water management /water conservation and efficiency	Crops-Mixed-Livestock-Aquaculture-Fisheries
	Conventional breeding (cultivar or species improvement, assisted evolution in fisheries)	Crops-Mixed-Livestock-Aquaculture-Forestry-Fisheries
	Biotech and bioengineering	Crops-Mixed-Livestock-Aquaculture-Forestry-Fisheries
	Agroecological approaches	Crops-Mixed-Livestock-Aquaculture-Forestry-Fisheries
	Agricultural diversification on-farm biodiversity (i.e., intercropping)	Crops-Mixed-Livestock-Aquaculture-Forestry-Fisheries
	Mixed systems: crops, trees, silvopastoral, fisheries, aquaculture, agroforestry	Crops-Mixed-Livestock-Aquaculture-Forestry-Fisheries

Adaptation category	Adaptation option	Focus
	Shifting location of crop production, grazing; relocation of aquatic species	Crops-Mixed-Livestock-Aquaculture-Forestry-Fisheries
	substitution/change plant or animal type	Crops-Mixed-Livestock-Aquaculture-Forestry-Fisheries
	Improved soil management (reduced soil erosion, salinisation, compaction)	Crops-Mixed-Livestock-Forestry
	Increased organic carbon content e.g., bio-char, residues	Crops-Mixed-Livestock-Forestry
	Certification and labelling programs	Cross-sectoral
	On-farm Improved irrigation efficiency and use / drip irrigation	Cross-sectoral
Social, Economic & institutional	Migration (for off-farm employment; either seasonal or permanent)	Cross-sectoral
	Diversification of livelihoods (economic diversification either on-farm or employment in local community)	Cross-sectoral
	Climate services: Improving weather forecasting and early warning systems	Cross-sectoral
	Increase incentive to consume and farm non-feed species	Cross-sectoral
	Transparency of food chains and external costs	Cross-sectoral
	Shortening supply chains, direct sales, circular economies, regional & local food systems strengthening	Cross-sectoral
	Farmer cooperatives, collective marketing	Cross-sectoral
	Insurance products: weather index, aquaculture etc.	Cross-sectoral
	Farmer-to-farmer training, farmer field schools	Cross-sectoral
	Water management - regional level	Cross-sectoral [or one sector]
	Community-based adaptation (including disaster risk management)	Cross-sectoral [or one sector]
	Local governance and conflict resolutions schemes	Cross-sectoral [or one sector]
	National & international adaptation planning, coordination, policy & governance / integrated approaches at multiple scales	Cross-sectoral [or one sector]
	Improving access to community services, social assistance, social insurance, social safety nets for vulnerable groups	Cross-sectoral [or one sector]
	Inclusive governance approaches to address inequities e.g., gender, Indigenous peoples, rights-based approaches	Cross-sectoral [or one sector]

Adaptation category	Adaptation option	Focus
	Relocation of farming facilities	Cross-sectoral [or one sector]
	Soft engineering responses and buffers	Fisheries (Oceans and inland)
	Reduced deforestation and forest degradation	Forest
	Reforestation and forest restoration	Forest
	Afforestation and land rehabilitation	Forest
	Reduced-impact logging	Forest
	Community forest management	Forest
	Livestock fattening	Livestock-Mixed
	Livestock seasonal feed supplementation	Livestock-Mixed
	Improved animal health and parasites control	Livestock-Mixed
	Livestock thermal stress control	Livestock-Mixed
	Livestock methane inhibitors	Livestock-Mixed
	Urban and peri-urban agriculture	Mixed systems
	Food storage infrastructure	Post-harvest
	Improved food transport and distribution	Post-harvest
	Improved efficiency & sustainability of food processing, retail & agrifood industries; including reducing post-harvest losses / food waste	Post-harvest
	Bioeconomy (e.g., energy from waste)	Post-harvest
Infrastructure & technological	Increased food safety and quality monitoring	Post-harvest-Consumption/Nutrition
	International trade	

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