Impacts of Climate Change on Household Food Security in the Philippines

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1. Introduction

The increasing complexity of shocks (global, economic and political crises, calamities and disasters, and threats of climate change among others), and the limited, if not depleting capacities among poor and vulnerable segments of the population to assessment that can be used as basis for better design and implementation of policies and programs to mitigate and cushion the negative impacts of these shocks.

One of the emerging development concerns in recent years is that of the adverse implications of climate change. In the Philippines, where extreme weather conditions during El Nino and La Nina is already common, what makes climate change a threat in the country's agriculture sector though is the undefined shifting of climatic events such as rainfall, humidity and rising temperatures. This leads to the confusion of farmers on when to plant especially without proper scientific guidance which in turn affects the food security of the country.

Food security is defined as a state wherein all people have, at all times, physical, social and economic access to sufficient, safe and nutritious food that meets their dietary energy requirements and food preferences for an active and healthy lifestyle[1]. Being one of the goals of the agriculture sector under the Philippine Development Plan (PDP) 2011-2016, the national government thru the Department of Agriculture launched the Food Staples Sufficiency Program. Increasing productivity of the food staples such as rice corn, banana, cassava and sweet potato, as well as rural income, is necessary in achieving food security and reduction of poverty.

Appropriate policy measures need to be put in place to support the vulnerable population amidst problems of growing poverty incidence aggravated further by the threats and impacts of climate change on food security as well as on other human development outcomes. Consequently, it is important to examine existing data that can facilitate the design of informed policy-decisions and well-targeted safety net programs.

The community-based monitoring system (CBMS) is an important tool in monitoring the impacts of shocks at the micro level. It can facilitate the conduct of vulnerability and risk assessment and mapping as it generates the necessary disaggregated data (sub-national and household level data on socioeconomic variables and poverty indicators) for identifying and profiling the vulnerable population. The system can facilitate a better understanding of the nature and extent of exposure and vulnerability to shocks such as that of climate-change and in examining their capacities to mitigate and cope with the adverse implications of these shocks to their well-being and communities over time. Data from CBMS has been used in earlier studies to examine the impacts on poverty of the increase in rice and fuel prices (Reyes, et al. 2009), of the global financial crisis (Reyes, et al. 2010), and to monitor household coping responses during periods of complex shocks.

This technical report aims to: (1) examine the nature and extent of vulnerability of households in the Philippines to the impacts of climate change on food security; (2) profile vulnerable groups using available data; (3) analyze available regional, provincial, municipal/city, and household level indicators of

[1] FAO, Right to Food Glossary

vulnerability to food insecurity; (4) identify channels and indicators of the impacts of climate change on food security; (5) and assess the relative efficiency of different policy tools or adaptation measures simulating a range of policy options. To tackle these objectives, Section 2 elaborates on existing policies and programs related to climate change's impact on food security while Section 3 discusses related studies on the topic. Section 4 tackles the methodology employed to generate the results presented in Section 5. Finally, Section 6 discusses conclusion and recommendation.

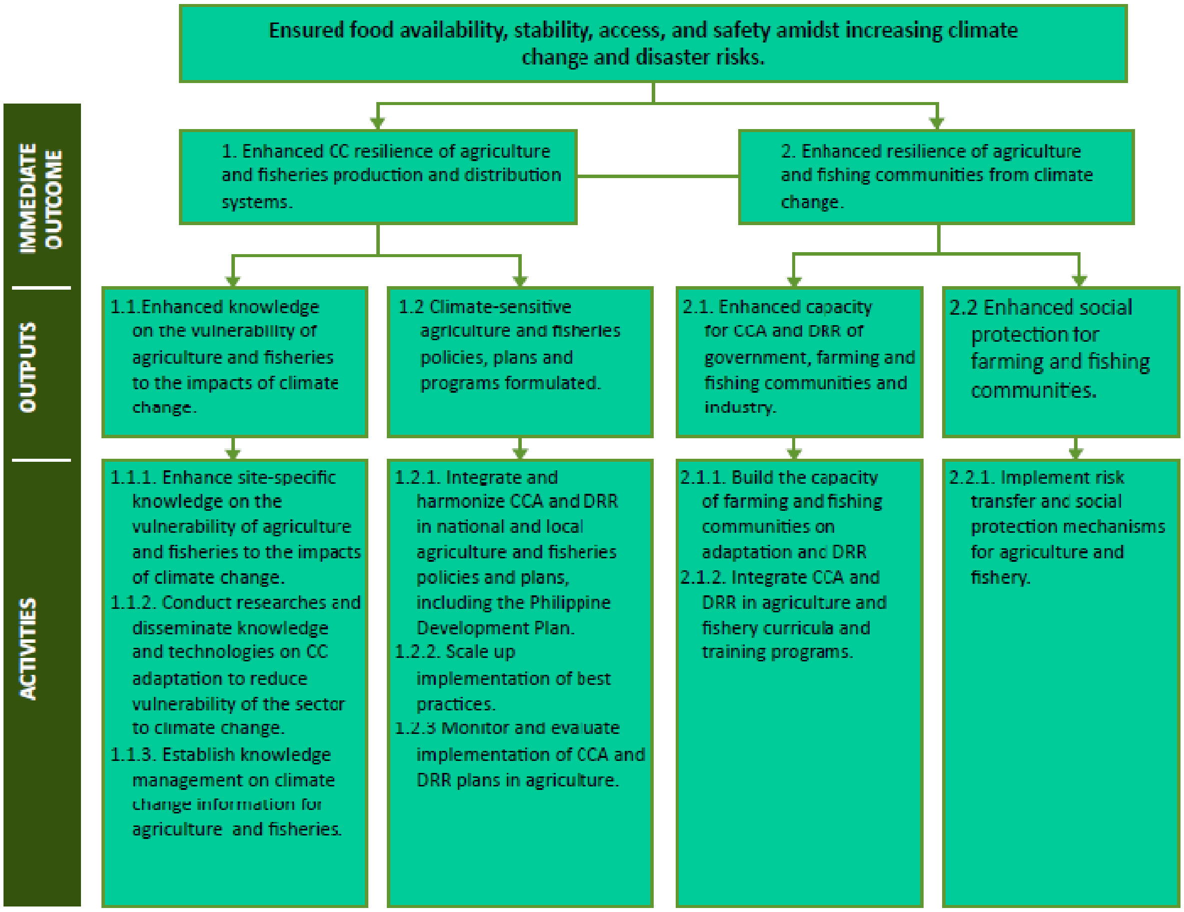
2. Policies and Programs Addressing Climate Change's Impacts on Food Security

2.1. National Climate Change Action Plan (NCCAP)

In 2009, Climate Change Act or Republic Act 9279 has been enacted to mainstream climate change into government policy formulations and establish the framework strategy and program on climate change. This act has also established an organizational structure called the Climate Change Commission. Its functions include formulating a framework strategy and program which was translated into the National Climate Change Action Plan in 2011 wherein one of the priorities is food security. Aside from that, the commission is also involved in mainstreaming of climate risk reduction into national, sector and local development plans and programs and recommending policies and key development investments in climate-sensitive sectors.

The threat of climate change to food security in the Philippines has called the attention of the national government to implement activities that will ensure availability, stability, accessibility and affordability of safe and health food, which is the intermediate outcome of the plan. In order to achieve this, figure 1 shows the immediate outcomes, as well as the outputs and the different activities that will be implemented until 2028:

Figure 1. Strategic Actions on Food Security for 2011-2028



Lifted from NCCAP Technical Document, 2011

The ability to provide adaptation measures that are well targeted and site-specific to the Philippine's food production sector is currently lacking which may be due to the lack of scientific information on vulnerability and adaptation technologies. Given this, the NCCAP identified several activities that will enhance the knowledge on the vulnerability of agriculture and fisheries.

First step in enhancing the knowledge on food production sector's vulnerability is through the "conduct of provincial-level vulnerability and risk assessments for agriculture and fisheries. In this assessment, "site-specific adaptation and mitigation interventions including the research and development agenda to test technologies and measures will be identified". As of November 2011, various studies have been conducted on vulnerability and risk assessments. According to the Inventory of Methods for Climate Change Adaptation Project, a total of 40 studies have been conducted so far which covered coastal and farming communities, crop specific studies on rice and corn, and assessment of various watersheds found in the country.

The Philippines Research and Development Agenda in support of the NCCAP, did an initial scoping of researches that might be classified under food security from the government agencies and found out that food security, is ranked second with approximately 160 researches – with Mindanao having the most number of researches. The following are some of the examples on technical physical researches conducted:

- Traditional rice landraces for wet and dry season cropping in Benguet (Benguet State University)
- Sweet potato cultivars for drought condition (Benguet State University)
- Cruciferous vegetable production under water stress condition (Benguet State University)
- Ecosystem based fisheries management to sustain fish catch (UP MSI
- Installation of solar powered backyard aquaponics system for vegetable-tilapia-prawn-catfish polyculture (CLSU-ICCEM)
- On-farm plant genetic resources, conservation development and use for climate change adaptation (Rice and Corn) (SeaRice)
- Effect of CC on reproduction and early development of economically important aquaculture species (SEAFDEC)
- Hermetic Storage of rice seeds (PhilRice)
- Rice Variety Development (drought tolerant, water submergence, salinity) (PhilRice)

However, gaps based from these researches were identified. Since rice and corn are the two most important crops in the country, most VA studies focus on them only. Other gaps that were identified are as follows: a.) lack of data on cost-effectiveness of mitigation and adaptation practices; b.) lack of site-specific studies; c.) lack of harmonize VA tools with high precision; d.) lack of hatchery and breeding techniques for marine species; e.) lack of interface with industry/community-based enterprises to upscale research results; and f.) lack of enabling mechanisms to translate scientific findings to policies. Furthermore, most of the studies on agriculture system and processes are land-based which leaves the fishery sector less well understood.

After the researches are done, "studies and simulation models will be done based on the vulnerability assessments and down-scaled climate scenarios, on the impacts of changing climates on major crops, livestock and fisheries production. The research and development agenda sector on climate change will be developed in order to conduct more specific short and long-term studies on climate-resilient crop varieties, climate-smart crop, livestock management, and best practices. These best practices will also be tested in fisheries and coastal management."

The information that will be gathered from these studies will be developed and disseminated thru the "climate information and database for agriculture and fisheries". Lastly, "a resource network is planned to be established wherein technical assistance on adaptation planning to local communities and appropriate adaptation approaches to both men and women farmers and fishers can be provided".

A policy requiring the national and local governments to include climate change into their respective plans and programs was passed in 2009. The NCCAP identified the formulation of climate-sensitive agriculture and fisheries policies, plans and programs as one of its outputs in ensuring food security. In order to achieve this, "the following activities are lined-up until 2028: a) Integration of gender-responsive CC adaptation and mitigation in agriculture and fisheries plans, programs, and budgets; and b) prioritization and enactment of a national land use law. The National Land Use Bill will institutionalize land use and physical planning at the national and local levels, and promote responsible and equitable allocation and administration of land and its corresponding natural resources. Under the bill, critical areas (such as national parks, upland watershed areas, and strategic agricultural and fisheries zones) will be identified and set aside."

In order to enhance the social protection for farming and fishing communities the implementation of risk transfer and social protection mechanisms for agriculture and fishery has been on-going via the following programs:

- **Agrarian Reform Beneficiaries-Agriculture Insurance Program (ARB-AIP)**
  A program being implemented by Department of Agriculture (DA) and Department of Agrarian Reform (DAR) in partnership with the Philippine Crop Insurance Corporation (PCIC) which aims to protect agrarian reform beneficiaries against losses due to pest and disease infestations, natural calamities and extreme weather conditions brought about by climate change. The national government allocated PhP 1 Billion for agricultural insurance coverage of at least 224,036 agrarian reform beneficiaries nationwide.

- **Weather-index Based Insurance**
  It is an agriculture risk transfer mechanism for climate change adaptation and risk reduction in the Philippines. Weather index insurance (WII) is a risk transfer instrument that pays out compensation based not on actual losses experienced by an insured individual, organization or institution, but once a weather index is triggered. After an extreme weather event such as floods or drought, an insured person or organization is assured of immediate compensation as long as a weather index is breached such as rainfall (if the amount of rainfall exceeded the normal amount), wind speed (the velocity of the wind exceeded the average wind speed passing through a particular locality) or dry days (number of days without rain has exceeded the average within a municipality).

  This program was just recently rolled-out in the Philippines by the Bankers Assurance Corporation (BAC) under the name of Credit Asenso. It offers lending institutions security for their operation or loan portfolio especially since the country is visited by typhoons at least 20 times per year. Some of these fall within the trigger events defined by the product. It uses a state-of-the-art satellite technology that determines event triggers for rainfall and wind speed. This technology ensures that claims are determined on a real time basis or can be viewed online thus there is no need for lengthy and time consuming claims investigations and loss adjustments. Based on their location in the Philippines, trigger indices for wind speed and rainfall have been developed for each municipality, which makes it an innovative product in the Philippine's micro-financing sector.

2.2. The Department of Agriculture Climate Change Program

Being the lead government agency in ensuring that the NCCAP's listed outcomes on food security can be achieved by 2028, the Department of Agriculture (DA) formulated specific programs and plans such as the following:

"2.2.1. Climate Information System for Agriculture and Fisheries
It shall be established in different attached agencies to generate timely and reliable information to aid in disaster risk reduction and management. Vulnerability and risk assessment mapping of productive areas will be done wherein the map-based ex-ante analysis could be done before the onset of cropping season. Aside from this, early warning systems will be established by improving meteorological predictions in partnership with PAGASA. Improvement of agromet stations will be spread out not just in regional/provincial level but also in major watershed, research centers, State Universities and Colleges and other stations. Lastly, pest population surveys of the Bureau of Plant Industry will be continued and a unit shall be established to develop predictive models to anticipate the resurgence of pests.
This program has just finished its Climate Change Vulnerability Mapping under the National Irrigation Authority (NIA) project and is currently undergoing project documentation for the release of funds.

2.2.2. Research and development for adaptive tools, technologies and practices

This is in line with the first expected output of the NCCAP which is to ensure site-specific knowledge on the vulnerability of agriculture and fisheries. DA has outlined specific plans and programs such as the following:

- New designs and construction protocols for agri-fishery infrastructure that can withstand strong winds, water intrusion and erosion, and other adverse impacts of the weather shall be developed.
- Breeding and screening for climate resilient crops: crops suited to changing weather patterns shall be developed such as early maturing crops, drought tolerant crops, crops that can withstand limited as well as excessive moisture, etc.
- Breeding and screening for heat tolerant livestock and poultry
- Agro-reforestation: Species trials involving fruit and multipurpose trees shall be conducted on representative upland watershed areas classified in accordance with the vulnerability and risk assessment maps
- Precision agriculture: Precision agriculture refers to a fine-tuned agricultural production that takes into consideration planting dates based on weather predictions, planting design that considers sun and wind exposures, varieties highly suited to the soil and weather patterns, and the delivery of water and other inputs at the right time and at the right amounts. Research on this area shall be done on a crop by crop or for livestock production and aquaculture species/breed by species/breed basis as well as by location including urban areas
- Urban agriculture: Vegetable farming especially during the rainy season in urban areas will ensure reliable supply. There is a need to develop manageable vegetable farming systems on urban structures as well as on limited urban spaces
- Organic farming practices: There is need to develop crop varieties, livestock breeds and fish strains suitable for organic production as well as effective organic inputs that will improve productivity and make organic produce less expensive.

2.2.3. Fully engaged Extension System
This includes the following:

- Early warning systems (EWS) for weather changesImprovedagri-fishery infrastructure design standards and construction protocols
- Soil moisture retention practices such as mulching, use of cover crops
- Balanced fertilization
  Organic farming tools and practices
- Highly efficient farm irrigation methods such as drip irrigation for fruit trees, intermittent irrigation for paddy rice, etc.
- Credit and grants programs for climate change
- Insurance programs for climate change

2.2.4.Repair and improvement of irrigation systems and establishment of SWIPS and SFRs
The National Irrigation Administration (NIA) with partner LGUs and irrigators associations shall see that national and communal irrigation systems are repaired and improved upon to reduce leakage and ensure efficient delivery of irrigation water at the right time and in the required amounts. SWIPS and SFRs shall be established to maximize water harvesting and minimize losses.
As of 2012, the Corn Program of DA has already installed shallow-tube wells in areas with pronounced dry season (Regions CAR, I, II and III). Aside from that, they have already facilitated supply of alternative irrigation water especially during the El Niño phenomenon."

2.3. Philippine Development Plan

Agriculture and Fisheries is one of the sectors included in the Philippine Development Plan for 2011-2016. This sector being the provider of food and vital raw materials for the rest of the economy should be competitive and sustainable. Two out of the three goals in order to achieve a competitive, sustainable and technology-based agriculture and fisheries sector are the following:

"2.3.1. Improved security and increased rural incomes
One of the programs under this goal that is related to climate change is the establishment of climate resilient agriculture infrastructure through enhanced technical design of irrigation and drainage systems and facilities, farm-to-market roads (FMRs), postharvest facilities (PHF), trading posts, among others

2.3.2.. Increased sector resilience to climate change risks
In order to adapt to the threats of climate change and extreme weather events in the agriculture and fisheries sector, sound scientific advice is needed regarding appropriate crop varieties, cropping patterns, and climate-vulnerable structures, including irrigation systems. The following are the strategies in order to achieve the goal in increasing resilience to climate change risks:

2.3.2.1. Reduce climate change-related risks and the vulnerability of natural ecosystems and biodiversity through ecosystem-based management approaches, conservation efforts, and sustainable environment and natural resources-based economic endeavors such as agri-ecotourism

2.3.2.2. Increase the resilience of agriculture communities through the development of climate change-sensitive technologies, establishment of climate-resilient agricultural infrastructure and climate-responsive food production systems and provision of support services to the most vulnerable communities

2.3.2.3. Incorporate natural hazards and climate risk in the agricultural land use plan or the Comprehensive Land Use Plan (CLUP)

2.3.2.4.Strengthen the capacity of communities to respond effectively to climate risks and natural hazards

2.3.2.5. Continue vulnerability and adaptation assessments especially in food production areas"

2.4. Department of Agrarian Reform (DAR) Interventions on Climate Change Adaptation and Mitigation

The Agrarian Reform Beneficiaries (ARBs) are not spared from the effect of the climate change. "It was estimated that more or less 1M ARBs will be hit by climate change. The department have predicted the following provinces, where most of their beneficiaries reside, to be flood-prone: Pangasinan, Pampanga, Masbate and Leyte. On the other hand, the following provinces are predicted to be landslide-prone: Benguet, Zambales, Nueva Vizcaya, Samar and Pangasinan. To minimize or completely eliminate the impacts of climate change, DAR formulated mitigation and adaptation interventions".

For their climate change adaptation, DAR will partner with various climate change implementing agencies and institutions for training in climate change concepts and adaptation measures. There is also an "on-going review and revision of Agrarian Reform Communities (ARC) Development Plans incorporating climate change adaptation and mitigation. Under this, the following will be conducted: a.) development of tools for assessment and planning; b.) conduct of consultation workshops. Another intervention is development of the Crop-based Farmer Field School Curriculum and extension in coordination with farmer groups. Soil and Water Conservation Technologies will also be introduced. One of the technologies to be introduced is the Sloping Agricultural Land Technology (SALT). Organic Vegetable Growing is under this and as of date, around 13, 622 ARBs in 259 ARCs are already adopting this practice. Lastly, susceptibility maps and disaster preparedness materials based from the Mines and Geosciences Bureau and PAG-ASA."

For the mitigation interventions, the following are the plans and programs that are currently being conducted by the department or will be conducted in the coming years: "a.) National Greening Program ; b.) Reduced Tillage Technology; c.) Integrated Farming Bio-System (IFBS) – it is the use of appropriate environment-friendly and sustainable farming technologies and the provision of adequate extension and support services. Around 16,161 are already adopters in 11 ARCs as of September 2011".

3. Review of Related Literature

Food security

The UN's Food and Agriculture Organization (FAO 2008), defines food security as a situation "when most people are able, by themselves, to obtain the food they need for an active and healthy life, and where social safety nets ensure that those who lack resources still get enough to eat" (Anbumozhi and Portugal, 2011, p.5). The FAO identifies four main dimensions of food security: physical availability of food, economic and physical access to food, food utilization and stability of the other three dimensions over time. According to the FAO, "for food security objectives to be realized, all four dimensions must be fulfilled simultaneously" (FAO, 2008).

Echoed by Anbumozhi and Portugal (2011), they argue that in looking at food systems these four dimensions of food security identified by FAO should be taken into consideration. Food availability refers to the global and regional food supply. Food accessibility on the other hand refers to the ability of individuals to purchase food in sufficient quantities and quality. Food stability refers to the maintenance of the continuity of food supply of seasonal production, while food utilization refers to the food consumption patterns, malnutrition, pest contaminations, diseases and people's capacity to obtain necessary nutrients from the food they consume.

Building on the FAO definition of food security, Pinstrup-Andersen (2009) suggests that "a household is considered food secure if it has the ability to acquire the food needed by its members to be food secure". He makes a distinction between transitory and permanent food insecurity, where the former describes "periodic food insecurity as for example seasonal food insecurity, while the latter describes a long-term lack of access to sufficient food". He adopts the USDA measure of household food security which "is based on household self-declarations, differentiates between low and very low food security…on the household-level resource constraints" (i.e. does the household have the resources to acquire the food needed?).

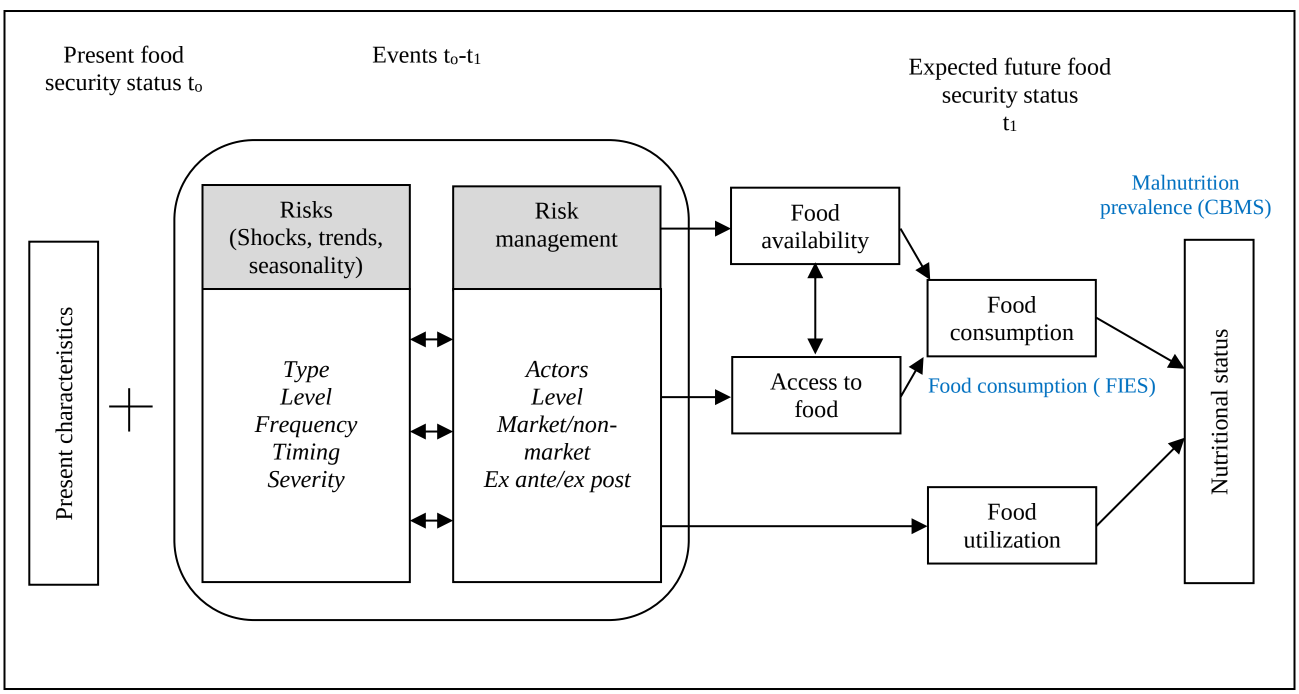
Ziervogel, et al. (2006) looked at food security in terms of availability, access, utilization, and livelihoods. They argue that a livelihoods understanding in defining food security is useful because "it emphasizes the importance of looking at an individual's capacity for managing risks, as well as the external threats to livelihood security, such as drought" (p.8).

According to Anbumozhi and Portugal, "Food security can be evaluated under two different perspectives: from a micro and a macro level. The micro-level food security refers to household and individual levels and evaluates the nutritional well-being of individuals, whereas the macro-level food security focus at a national policy level and assesses regular supplies of food in national, regional, and local markets." (p.5).

FAO refers to vulnerability in terms of food security as the "group of factors that places people in a situation where they are at risk of food insecurity, including factors that undermine people's capacity to deal with the situation" (FAO, 2000).

Lovendal and Knowles (2006) linked food security and vulnerability in their research. They provide a definition of vulnerability in terms of food security. They define vulnerability "relative to the negative outcome of food security and define as vulnerability people's propensity to fall, or stay, below the food security threshold within a certain time frame". They offered a framework for understanding food security by including risks and the ability at different levels to manage these to reduce the probability of people being food insecure in the future. The suggested framework looks at present characteristics of food security status, risks such as shocks, trends and seasonality, and risk management to predict future food security status which is measured by food availability, access to food, food consumption, food utilization and nutritional status.

Figure 2. Framework for vulnerability to food security



Source: Lovendal and Knowles, 2006

At the macro-level, according to the ADB report on Food Security and Climate Change in the Pacific (2008), the factor influencing food security include food importation, global food and fuel prices, disasters and emergencies, and factors such as traditional and subsistence agriculture, land and water resources, increased urbanization and globalization, technological constraints to agricultural production and private investment on agricultural production.

Echoing the importance of looking at food importation, Gingrich, et al. (2001) showed in their study that foreign exchange availability greatly affects food security in food-importing countries such as Indonesia and the Philippines. They argue that a combination of foreign exchange supplies, cereal prices and domestic cereal production determine the relative cost of food security imports. One implication, according to them, is that both countries should further diversify their export sectors to help stabilize export revenues.

On the other hand, Hoddinott and Yohannes (2002) suggest an alternative measure of food security. Using data from India, the Philippines, Mozambique, Mexico, Bangladesh, Egypt, Mali, Malawi, Ghana, and Kenya, they suggested using dietary diversity as an alternative measure because of four reasons, "1) a more varied diet is a valid outcome in its own right; 2) a more varied diet, either directly or indirectly through improved acquisition of micronutrients, is associated with a number of improved outcomes in areas such as birth weight, child anthropometric status, improved hemoglobin concentrations, reduced incidence of hypertension, reduced risk of mortality from cardiovascular disease and cancer; 3) such questions can be asked at the household or individual level, making it possible to examine food security and the household and intra household levels and 4) obtaining these data is relatively straightforward".

They define dietary diversity as the number of unique foods – foods were divided into categories: basic staples, luxury staples, vitamin-A rich, other roots and tubers, other fruits, other vegetables, beverages, spices and others. This was included with four other indicators of food security (per capita expenditures, caloric availability, caloric availability from staples, and caloric availability from non-staples). They concluded that the use of dietary diversity as an alternative measure is feasible and has uses.

Gittelson, et al. (1998) note that while "food security has long been used as an important macro-level indicator of agricultural stability and progress for both agricultural and economic researchers, little work has been done to operationalize the concept at the household level" (p.210). They argue that household food security as a concept should integrate "environmental, economic, and cultural factors" (p.210).

Sanchez (2000) suggests an integrated natural resource management approach that aims to address issues of food security while addressing poverty reduction while satisfying societal objectives for environment protection. The approach includes "identifying and quantifying the extent of food insecurity, rural poverty and resource degradation problems to be addressed in a given region, enhancing the direct utilitarian functions of natural resources, which consist of food, raw materials and income in the case of agriculture, enhancing the ecosystem functions of natural resources, such as carbon, nutrient and water cycling, erosion control and biodiversity, assessment of trade-offs between the options that enhance the food and income functions of systems and those options that enhance the ecosystem functions" and dissemination.

Webb, et al. (2006) expands the discussion on how to measure food security by suggesting a more qualitative approach. They suggest that measures for food insecurity should "1.) shift from using measures of food availability and utilization to measuring "inadequate access" (key to access is purchasing power and varies in relation to market integration, price policies and temporal market conditions) ; 2.) shift from a focus on objective to subjective measures; and 3.) emphasize fundamental measurement as opposed to reliance on distal, proxy measures".

Building on the FAO definition of food security Napoli (2010) notes that "an integral part of the multi-dimensional nature of food security is the nutritional dimension" (p.19) and that as mentioned earlier food security consists of four essential parts: food availability, food access, food utilization and stability.

On the other hand, the United States National Food Security Measure employs a more micro-level approach by looking at the dietary intake, nutritional status and physical well-being of individuals. The measure also assesses the "cognitive and affective components of uncertainty, unacceptability or unsustainability" (Wolfe and Frongillo, 2001, p.6) such as insecurity over future intake. Growth status is also used as an indicator, as well as precursors to food security such as income, total expenditure, and coping strategies. Wolfe and Frongillo (2001), in this regard, suggest that the experience of food insecurity itself is an important measure.

Anriquez, et al. (2012) offers a "guideline to construct household specific dietary energy requirements, in a way which is consistent both with the different needs of populations according to their physical constitution, age and gender; and consistent with the way FAO calculates energy requirements". They suggest that to be able to determine which household or individual is food insecure and to be able to quantify food energy gap, "actual household (individual) calorie intake should be compared with a relevant energy requirement threshold" which quantifies the necessary (minimum) or the recommended (average) energy requirement, to balance the energy expenditures needed to maintain body size and composition, and a level of necessary (minimum) or desirable (average) physical activity that is consistent with good health in the long run (Anriquez, et al., 2012).

Sarris and Karfakis (2010) developed a measure of rural household vulnerability which estimates idiosyncratic shocks. The methodology "integrates a major source of covariate shocks, with established techniques for estimating idiosyncratic shocks to estimate vulnerability of rural households in two regions of Tanzania". The findings suggest that the "major covariate risk relates to weather induced production variations as well as price variations that give rise to agricultural income variations" which make households vulnerable and forces them to adopt strategies such as "income and crop diversification" and "consumption smoothing strategies".

Capaldo, et al. (2010) proposed a vulnerability model to food security that sees vulnerability "result of a recursive process: current socio-economic characteristics and exposure to risks determine households' future characteristics and their risk-management capacity. This framework builds on the framework put forward by Lovendal and Knowles (2006) (see Figure 2).

The Food Insecurity and Vulnerability Information and Mapping System (FIVIMS) is broadly defined to "include any information system – or network of systems – that monitors the situation of people who are poor or vulnerable to transitory and/or chronic food insecurity". According to Weissman, et al., (2002), the FIVIMS "are networks of systems that assemble, analyse and disseminate information about the problem of food insecurity and vulnerability" which aims to raise awareness about food security issues, improve the quality of food security-related data and analysis, promote donor collaboration on food security information systems at country level, encourage better action programmes on poverty and hunger, and to improve access to information through networking and sharing" (p.278). According to Fresco and Baudoin (2002), "at the international level, FIVIMS implements diverse activities in support of national information systems, to enable them to become part of an international information exchange network" and "at the country level, FIVIMS works with a network of information systems that gather and analyse relevant national and sub-national data that measure food insecurity and vulnerability.

Building on the FIVIMS, Devereux, et al. (2004) proposes a FIVIMS Integrated Livelihoods Security Information System' (FILSIS) which supports a "two-track approach to fighting both food insecurity (i.e. dealing with shocks) and underlying household income poverty (i.e. strengthening livelihoods)" and focuses on livelihoods rather than poverty. Devereux, et al. (2004) suggests that a livelihood approach to food security "might provide a practical toolkit for linking the analysis of food insecurity with a multi-dimensional and people-centred analysis of poverty – looking beyond income and consumption levels to include an assessment of people's strategies, assets and capabilities".

Food security and climate change
According to Anbumozhiand Portugal (2011), there are four ways by which climate change would affect crop production and food security. They are:

1. Changes in temperatures and precipitation
2. Carbon dioxide effects
3. Water availability
4. Agricultural loses

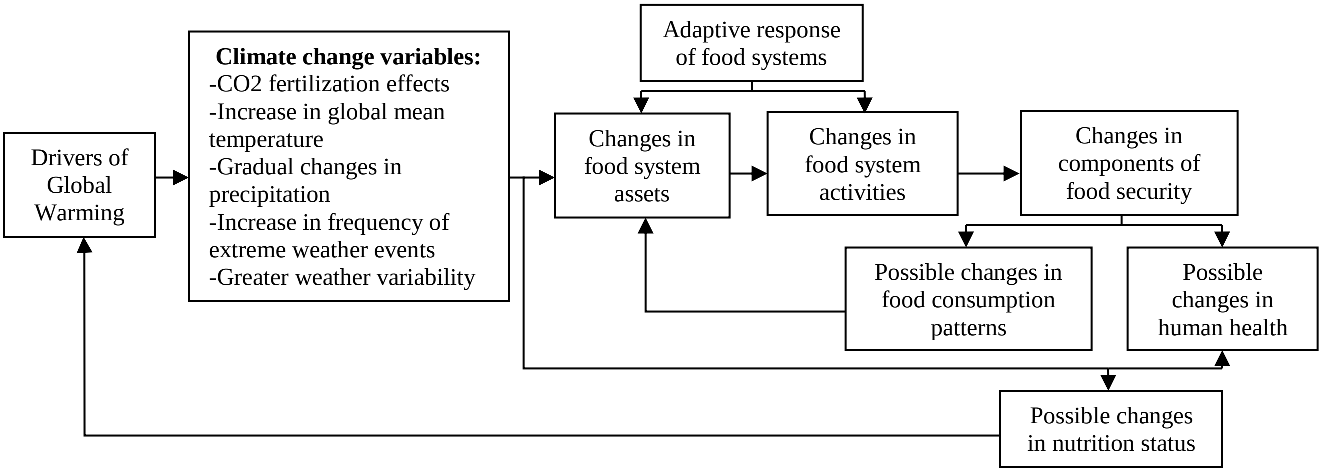
Table 1. Potential impacts of climate change on food systems

Climate Change Impacts	Direct consequences for food systems
Increased frequency and severity of extreme weather events	• Decreases in crop yields • Loss of livestock • Damage to fisheries and forests • Either an excess or shortage of water • Disruption of food supply-chains • Increased costs for marketing and distributing food
Rising temperatures	• Increased evapotranspiration, resulting in reduced soil moisture (land degradation and desertification) • Greater destruction of crops by pests • Greater threats to livestock health • Reduced quantity and reliability of agricultural yields • Greater need for cooling/refrigeration to maintain food quality and safety • Greater threat of wildfires
Shifting agricultural seasons and rainfall patterns	• Reduced quantity and quality of agricultural yields and forest products • Either an excess or shortage of water • Greater needs for irrigation
Sea level rise	• Damage to coastal fisheries • Direct loss of cultivable due to inundation an salinization of soil • Salinization of water sources

Source: Anbumozhi and Portugal, 2011

Figure 3 shows a conceptual framework from FAO "describing the dynamics of potential climate change impact and positive and negative feedback loops in the food security components." (Anbumozhi and Portugal, 20011, p.6).

Figure 3. Climate change variables and impacts on food security



Source:Anbumozhi and Portugal, 2011

Lobell, et al., looked at crop specifically to assess the impacts of climate change on food security. According to Lobell, et al. (2008), “crops which have relative strong dependence of historical production on rainfall were considered cases with uncertainties” suggesting that it is not sure whether or not climate change would have effect on these crops).”To ascertain which crops would most likely be affected by climate change, they expressed the need for more precise projection of rainfall. Finally, they suggested putting investment (prioritize) on crops that will be least affected by climate change, not a simple changing of planting dates or shifting to other crops.

In an earlier work, Rosenzweig and Parry (1994) looked at the potential effects on agricultural production (and hence food security) of climate change. They used a world food trade model to simulate the economic consequences of potential changes in crop yields to estimate changes in world food prices and in the number of people at risk of hunger. One finding is that there seems to be a big disparity between developed and developing countries in terms of agricultural vulnerability. General Circulation Models (GCMs) were tested in terms of CO2 levels, yield changes estimates, and farm-level adaptations. Adaptation included were changes in planting date, variety, crops, and applications of irrigation and fertilizer. In the world food trade model, it is predicted that in the climate change scenario, without direct CO2 effects, world cereal production would be reduced by 11 to 20 percent. Upon inclusion of CO2 effects, yield decreases between 1 to 8 percent. Price increases are estimated to be between ~24-145 percent and the number of hungry people would increase by ~1 percent for every 2-2.5 percent increase in prices. People at risk of hunger increase by 10 percent to almost 60 percent. Upon inclusion of farm adaptation in the world food trade model, world production levels are restored.

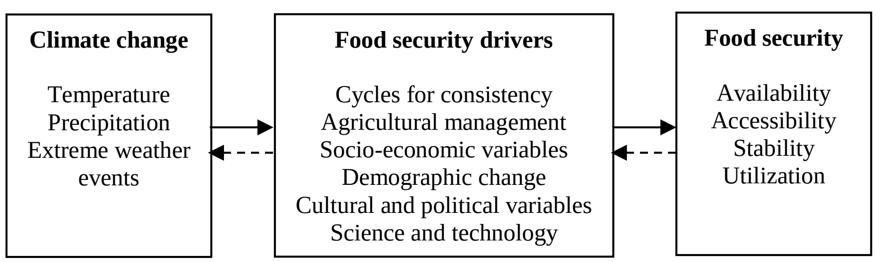
Scenarios near the high end of the IPCC range of doubled CO2 warming exerted slight to moderate negative on cereal production. The only scenario that yielded positive cereal production was one involving major and costly changes in agricultural systems (i.e., installation of irrigation). In sum, climate change is found to increase disparities in cereal production between developed and developing countries.

Building on Rosenzweig and Parry (1994), Parry, et.al (2004) suggests that changes in regional crop yields under each scenario are the result of the interactions among temperature and precipitation effects, direct physiological effects of CO2, and effectiveness and availability of adaptations.

Arnell, et al. (2004) on the other hand suggests that “the future impacts of climate change will depend to a large extent on the future economic, demographic, social and political characteristics of the world”. The paper downscaled the IPCC’s Special Report on Emissions Scenarios (SRES) world-region population and economic data scenarios to the national and sub-national scales for a global climate impact assessment of future food scarcity, water stress, exposure to malaria, coastal flood risk and wetland loss and terrestrial ecosystems. They suggested that urban and rural growth rates be considered. Two limitations of the SRES scenarios were identified: first, “there are considerable difficulties involved in moving from the scale at which the SRES scenarios were produced (11–13 world regions) to the much finer spatial resolution required by impacts models. A number of rather major assumptions had to be made, most specifically that all parts of a region would change at the same rate: this was applied to population, GDP and land cover” and; second, “whilst the SRES land cover trends are consistent with the narrative storylines, they are inconsistent with recent trends. Under none of the storylines is there a sustained continued deforestation, for example, and crop areas decrease under all of them”.

Ziervogel and Eriksen (2010) offer a framework for assessing the impacts of climate change on food security. They discussed linkages between climate change (temperature, precipitation, and extreme weather events), food security (availability, accessibility, stability and utilization) and its drivers (cycles for consistency, agricultural management, socio-economic variables, demographic change, cultural and political variables and science and technology).

Figure 4. Linkages between climate change and food security



Source: Chart taken from Ziervogel and Eriksen, 2010

According to them, the key issues that should be addressed to respond to food insecurity and managing transitions or innovation in cropping system include: chronic poverty, functioning markets, farmer attitudes toward managing risks, and reforming or improving the institutions responsible for managing food and agricultural systems.

In the Philippines, the Department of Agriculture expects the following impacts of different climatic events as shown in the table 2:

Table 2. Expected impacts of global climate change in the Philippine agricultural sector

No	Climatic Events	Impact	Source/Assumptions
1	Rainfall	Decrease by 20 percent, but increase in intensity. Increase	• IPCC 2007 • Godilano, E.C. 2005 • FAO (2006)

		risk of soil erosion and occurrence of landslides.	
2	Rainy Days	Decrease rainy days but intensity will be higher than normal, growing periods may shorten by approximately 30 days	• Rosenzweig and Parry, 1994 • IPCC 2007
3	Cyclone	Increase intensity and occurrence and may trigger landslides and flooding of coastal areas.	• IPCC 2007
4	Maximum temperature	Increase by three percent, more frequent and persistent El Niño episodes, and increased evaporation. Crop duration shortened between one and four weeks. Drought will be longer and more intense, heat waves occurrence.	• IPCC 2007 • NOAA, 2007
5	Flooding	Increase flooding depth, frequency, intensity, and severe landslides. Submergence of coastal communities and coastal erosion	• IPCC 2007, Brackenridge, G.R. and Anderson, E. (2004) • Dartmouth Flood Observatory USA (2009)
6	Ground Water Potential (GWP)	Decrease water availability, poor quality, and salt intrusion	• IPCC 2007 • Godilano, E.C. 2005
8	Cloudiness	Increase in total cloud cover, decrease photosynthesis. Clouds regulate the amount of sunlight received by the surface and so influence evaporation from the surface, which in turn influences cloud formation	• NOAA, 2007 • NASA Water Vapor Project (NVAP) 1992

Source: Department of Agriculture Policy and Implementation Program on Climate Change

Impacts on crops

As to how the production of crops would be affected most by climate change, results vary. Most argue, however, that climate change would affect different crops differently. Lobell and Field (2007) note that for crops that rely too much on water such as rice and soybean, precipitation would be key in explaining the effect of climate change but for other crops, temperature should be considered.

In the Philippines, agricultural production, according to Buan, et al. (1996), is "traditionally concentrated on a few main crops [with] rice and corn [as] the major food crops" (p.42) and corn acts as a major substitute for rice especially for Central Luzon and "is the main ingredient for livestock feeds, food products, and is important in industrial uses." (p.42). On the other hand, "coconut and sugarcane are the major commercial crops that constitute important export commodities" (p.42). Buan, et al. (1996) note that both rice and corn crops are "highly vulnerable to climate variability". Climate-related occurrences have historically affected rice and corn production losses between 1968 and 1990 according to Buan, et al. (1996). The study showed that for all scenarios there will be consistent decrease in corn yield, while for rice, results were rather more varied.

In a study on the relationship between yields for soybean and corn and climate trends, Kucharik and Serbin (2008) noted that temperature and precipitation both affected corn yields while for soybean yields, precipitation "had a slightly larger impact on the overall multiple regression results" (p.7).

Alexandrov, et al. (2002) also note the varied impacts of climate change on different crops. They showed that "the increase in simulated soybean seed yield for the next century was caused primarily by the positive impact of warming and especially by the beneficial direct CO2 effect" (p.379). On the other hand, decrease in the winter wheat yield "was caused primarily by a shortened growing season owing to projected warming and some increases in precipitation during the crop-growing season" (p.379). However, increasing the level of CO2 in the scenarios showed an increase in the yield of winter wheat. Comparing the two, if the CO2 levels increase, soybean yield will show a decline and winter wheat yield will increase.

The simulations conducted by Conde, et al. (1997) showed that "under incremental temperature and precipitation scenarios resulted in favourable (rain-fed maize) yield changes" (p.19). What their study suggested is that aside from precipitation and increase in CO2, important factors should also be considered such as soil and historical yield data.

Table 3. Summary of effects of climate change on crops

Crops	**Scenario**		**Effect**	**Sensitivity to**	**Source**
	Precipitation	**Temperature**			
Winter wheat	Increase	Increase	Decrease yield		Alexandrov, et al., 2002
Soybean	Increase	Increase	Increase yield	Precipitation	
Wheat, maize, barley		Increase	Decrease yield		Lobelland Field, 2007
Corn		Increase	Decrease yield		Buan, et al., 1996
Corn/Maize		Increase	Increase yield	One possible explanation for the increase was the climate of the region, which was usually affected by frost	Conde, et al., 1997
	Increase		Decrease yield		
Rice			Different for each rice variant	Maturity period of rice varieties maybe needed to consider	Buan, et al., 1996
			Variance in yield	There maybe other climate influences not accounted for	Lobelland Field, 2007

	Increase (minimum temperature in July-August)	Increase/Decrease in July – August	Increase yield	But in general an increase in temperature by as small as 0.3C is associated with a decline in yield, though there may be increase in yield if temperature increase by 1.5C and 3.0C, demand for irrigation water would be induced (evapo-transpiration	Mahmood, et al., 2012
	Increase (maximum temperature in July-August)		Decrease yield		
	Decrease (minimum temperature in September-October)		Increase yield		
	Decrease (maximum temperature in September-October)		Decrease yield		
	Decrease (min and max temperatures in September-October)	Increase	Decrease yield		

Adaptation to climate change

A survey of the literature showed that oft-cited short-term adaptation strategies include "changes in planting dates and cultivars; changes in external input such as irrigation; techniques in order to conserve soil water" (Alexandrov, et al. (2002), p.383). For example, for Austria, Alexandrov, et al. (2002) suggested that spring crops be sown earlier "in order to reduce yield loss or to further increase the projected gain resulting from an increase in temperature" (p.384).

Conde, et.al (1997) assessed the potential increase in production costs as a result of the implementation of adaptive measures to reduce climate change impacts. They suggested fertilization as a measure for adapting to climate change in Mexico. However, they noted the importance of subsidies from governments to be able to continue both maize production and fund the use of fertilizers. However they also noted that "under a non-subsidy policy, the application of this adaptive measure would become unfeasible due to the high production costs involved, since profits would be reduced and losses could even occur" (p.21).

Burke and Lobell (2010), on the other hand, differentiated between ex-ante and ex-post measure. While ex-ante measures refers to the action taken in "anticipation of a given climate realization" which often center around diversification of crops among others, ex-post measures are responses "undertaken after the event is realized" which include "drawing down cash reserves or stores of grain, borrowing from formal or informal credit markets or family, selling assets such as livestock, or migrating elsewhere in search for work in non-affected regions" (p.135). However, Burke and Lobell (2010) argued that not all strategies for adaptation are available to farmers. They noted that "existence of social safety nets and functioning financial markets ensure that farmers are either insured against losses, can borrow around them, or can receive help from the government to maintain livelihoods during bad times” (p.135).

4. Methodology

The methodology builds on the framework of Lovendal and Knowles (2006) and the study by Karfakis, et al. (2010). Consistent with the literature, food insecurity will be measured in terms of (1) food expenditure and (2) malnutrition. Correspondingly, two datasets are employed, namely: the 2009 Family Income and Expenditure Survey (FIES) and the 2007-2010 pooled Community Based Monitoring System (CBMS) data of 16 provinces. The model specification and estimation methodology will depend on the available variables and measure of food security available from each of the datasets. The following subsection presents the matching of variables across different surveys with the variables used by Karfakis, et al (2010) in their study.

Data mapping
Identifying the variables for the model as executed in the FAO study is almost straightforward for the national survey of the Philippines which is the FIES as well as for the CBMS data of local government units (LGUs). Table 4 shows mapping of the variables (dependent, explanatory and instruments) used in the FAO study with FIES and CBMS data.

Table 4. Data and variable mapping and initial variables

Model variable		**Metrics or substitute metrics**		
		FAO model	*FIES data*	*CBMS data*
Dependent variable	Food security	Value of food consumed per adult equivalent	***foodexp***: Per capita expenditure on food	***malnutrition*** With malnourished children 0-5 years old
Explanatory variables	Agricultural productivity	Value of agri production per acre	***cropinc***:	
			Income from crop farming	
	Characteristics of the head of the household	Age of HH head	***age_yr***: Age of HH head	
		Years of education of HH head	***educlvl*** :	

			Categorized educational attainment	
		Female Head	***fhead:***	
			Female Head	
		Indigenous HH	[no counterpart metric]	***ipindHH:***
				Indigenous HH
	Access to migration channels	Access to HH migration network	***migrnet:***	***migrnet:***
			With amount of cash receipts, gifts, relief and assistance from abroad	With amount of cash receipts, gifts, relief and assistance from abroad (remittance from OFWs combined with other support from abroad)
	Characteristic of household dwelling	Number of rooms in dwelling	[no counterpart metric]	
			mshous:	
			HH with strong construction materials of walls and roof	
	Access to information and non-agri assets	HH has access to safe water	***sws:***	
			HH has access to safe water	
		Number of radios owned	***nradio:***	
			Number of radios owned	

		Number of TV sets owned	***ntv:***	
			Number of TV sets owned	
	Communication infrastructure	Time to nearest health facility (min)	[no counterpart metric]	
			tele:	
			With telephone / landline	
		Time to nearest primary school (min)	[no counterpart metric]	
			[no counterpart metric]	
	Household transportation	Number of bikes in HH	***car:***	
			With motorcycles/ vehicles	
	Availability of farmland	Agri land operated (imputed)	*(as agricultural asset in instruments)*	
	Social infrastructure	Participation in community organization	[no counterpart metric]	***mworg:*** HH members who participate in community organization
		HH received loan	***payloan:***	***recloan:***

			Indicator on HH Cash loan payments	Household access to credit programs
	Social protection	Number of government programs accessed	[no counterpart metric]	
		Number of NGO prgrams accessed	[no counterpart metric]	***privpind:***
				NGO prgrams accessed
			payprem:	
			Indicator on HH expenditure on life insurance and retirement premiums	
		Illness shock	[no counterpart metric]	***illshock:***
				At least one member of HH got sick
Instruments	Climate variables	Temperature (change)	***drfyr, dseasonrf, dvolrf, dtmin, dtmax:***	
			Temperature, rainfall from Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)	
	Agricultural Assets			***agriorg:***

		HH participates in agricultural producers organization	[no counterpart metric]	Membership in agricultural organization
		HH used chemical fertilizer	[no counterpart metric]	
		HH used organic fertilizer		
		HH used pesticides		
				plow/ harrow/ thshel/ dryer/ irpump/ seed/:
				Agri or post harvest equipment/ facilities used by HH other than insecticide/ pesticide sprayer (plow, harrow, thresher/sheller, seed purchase, irrigation pump)
		road_den, fmrexp, irriexp, fert_cost:		

	Agricultural assistance/ infrastructure	Road density, expenditure on farm to market roads, expenditure on irrigation, cost of fertilizer policy variables (Secondary data)

[1] In the case of this study, agriculture production is potentially endogenous in explaining food consumption.

[1] The first stage equation includes dummy for time (quarter) to control for the pooled time-series.

The variables in Table 4 will be the initial set of variables in estimating the models as discussed in the following model scenarios.

Model scenarios

Consider the following model

$$\text{food security} = f\begin{pmatrix} agri\ income,\ hh\ head\ characteristics, \\ access\ to\ migration\ channels, \\ household\ dwelling,\ non-agricultural\ assets, \\ communication\ infra, \\ household\ transport,\ social\ infra,\ social\ protection \end{pmatrix} + u \qquad (1)$$

$$\text{agri income} = f\begin{pmatrix} [climatology: rainfall, seasonality, \\ volatility, temperature], \\ agri\ assets,\ agri\ assistance\ or \\ infrastructure,\ etc., \\ [second\ stage\ variables] \end{pmatrix} + v \qquad (2)$$

where the dependent variable has finite mean and the explanatory variables can be continuous or categorical. By assumption, the error terms u and v have zero mean and zero correlation with any of the explanatory variables.

In the event that at least one of the explanatory variables, say agricultural productivity, is correlated with the error term, estimates for the coefficients of the independent variables can be inconsistent[2]. Instrumental variables (IV) method addresses this by introducing observable variable that is uncorrelated with the error term but partially correlated with the endogenous variable.

Similar to FAO study of Karfakis, et al. (201), modeling using FIES dataset will work around the two-stage least squares (2SLS) method in estimating the coefficients of the following model as analog to equation (1).

[2] In the case of this study, agriculture production is potentially endogenous in explaining food consumption.

$$\text{food expenditure} = f\begin{pmatrix} agri\ income,\ hh\ head\ characteristics, \\ access\ to\ migration\ channels, \\ household\ dwelling,\ non-agricultural\ assets, \\ communication\ infra, \\ household\ transport,\ social\ infra,\ social\ protection \end{pmatrix} + u \qquad (3)$$

where the same function for agricultural income. On the other hand, IV probit regression will be implemented on CBMS data with dependent variable *malnutrition,*[3]

$$\Pr(\text{malnutrition}) = f\begin{pmatrix} agri\ income,\ hh\ head\ characteristics, \\ access\ to\ migration\ channels, \\ household\ dwelling,\ non-agricultural\ assets, \\ communication\ infra, \\ household\ transport,\ social\ infra,\ social\ protection \end{pmatrix} + u \qquad (4)$$

This is operationalized by focusing on households engaged in crop farming and gardening. They are approximately 30 percent of the original dataset, i.e. 12,000 households for FIES and 500,000 for CBMS. In the case of CBMS malnutrition, the focus will be on households with members 0-5 years old or 40% of the agricultural households, or about 220,000 households.

Climatology measures

Climate elements, in terms of rainfall and temperature, impact food insecurity through agricultural production (farming income). To operationally represent them, three measures of rainfall and two measures of temperature were explored: absolute level of rainfall, rainfall volatility, rainfall seasonality, minimum temperature and maximum temperature. Absolute level of rainfall is a function of the (moving) average of the monthly values of the climate variables, i.e.

$$\overline{RF}_t = \frac{1}{12t}\sum_{i=1}^{12t} RF_i$$

Given the average rainfall, the standard deviation can be represented by

$$SD_t = \sqrt{\frac{1}{12t-1}\sum_{i=1}^{12t}(RF_i - \overline{RF}_t)^2}$$

where RF_i represents the rainfall value at month *i* and *t* is the number of years. Now, volatility is the

[3] The first stage equation includes dummy for time (quarter) to control for the pooled time-series.

coefficient of variation given the number of years

$$CV_t = \frac{SD_t}{\overline{RF}_t}$$

where SD_t is the standard deviation while the seasonality index takes on Walsh and Lawler's (1981) measure

$$SI_y = \frac{1}{\overline{RF}_{1|y}} \sum_{i=1}^{12} \left| RF_{i|y} - \frac{\overline{RF}_{1|y}}{12} \right|$$

That is, for a given year y, $\overline{RF}_{1|y}$ is the average for the year and $RF_{i|y}$ is the value of rainfall on the i^{th} month. The seasonality measure for a collection of years $\underline{y}$ is the average of all seasonality indices across those years,

$$SI_{\underline{y}} = \frac{1}{n(\underline{y})} \sum_{i=y_1}^{y_{n(\underline{y})}} SI_y$$

The seasonality index facilitates measurement of the variability of rainfall in terms of seasonality over the year. Sumner, et al (2001) provides indicative classification based on SI_y as shown in Table 5.

Table 5. Rainfall seasonality based on SI_y

<0.19	Precipitation spread throughout the year
0.20–0.39	Precipitation spread throughout the year, but with a definite wetter season
0.40–0.59	Rather seasonal with a short drier season
0.60–0.79	Seasonal
0.80–0.99	Markedly seasonal with a long dry season
1.00–1.19	Most precipitation in <3 months
>1.20	Extreme seasonality, with almost all precipitation in 1–2 months

Given the aforementioned formulas, the climate shocks are measured through change in each climate variable for each year compared to long run average which is set as 1979-2006. These were computed using the following:

1. Change in current year average rainfall to long run average in 1979-2006:

$$dRF_y = 100\left(\frac{\overline{RF}_{1|y}}{\overline{RF}_{28|1979-2006}} - 1\right)$$

2. Change in current year rainfall seasonality relative to long run seasonality in 1979-2006:

$$dSI_y = 100\left(\frac{SI_y}{SI_{1979-2006}} - 1\right)$$

3. Change in current year rainfall volatility relative to long run volatility in 1979-2006:

$$dCV_y = 100\left(\frac{CV_{1|y}}{CV_{28|1979-2006}} - 1\right)$$

4. Change in maximum/minimum temperature in current year compared to long run average in 1979-2006:

$$dTMAX_y = \max_y(TMAX) - \frac{1}{28}\sum_{i=1979}^{2006} \max_i(TMAX)$$

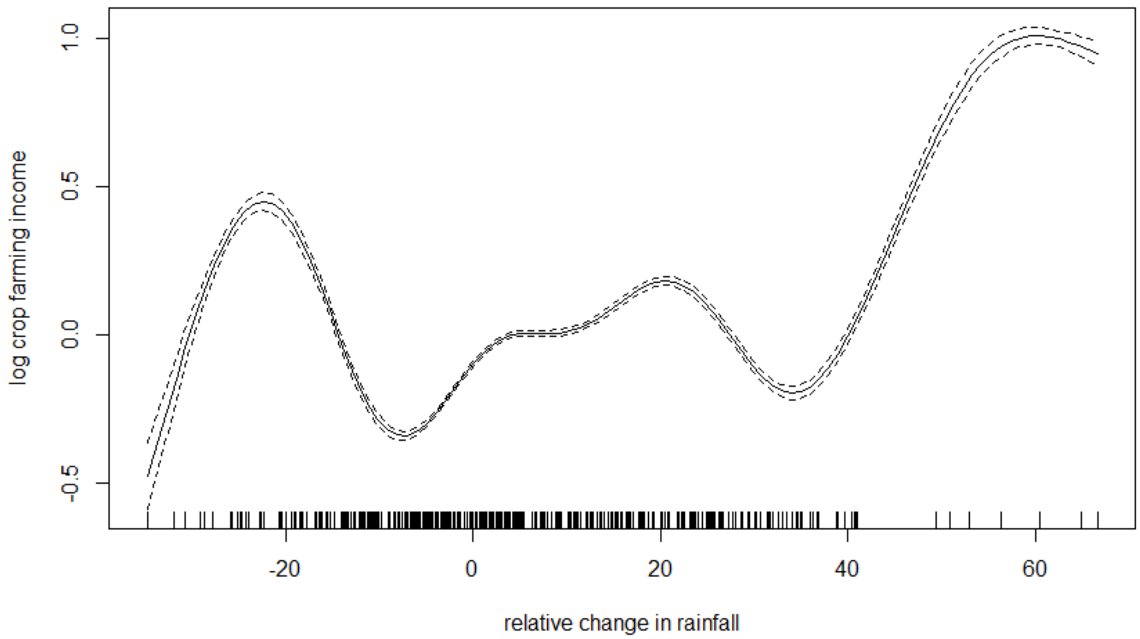
$$dTMIN_y = \min_y(TMIN) - \frac{1}{28}\sum_{i=1979}^{2006} \min_i(TMIN)$$

Where $\max_i(TMAX)$ and $\min_i(TMAX)$ are maximum and minimum temperature at year i, respectively.

Estimation

The final model specification varies according to the underlying trend in each dataset. Hence, the choice of level or form of measurement is essential in coming up with the final model. Take, for example, the climatology measures, including each of the climate variables without transformation is taken generally as assuming that the relationship between income from agriculture and say change in rainfall is linear. In this subsection, the objective is to establish the fact that the relationship is non-linear and interpretation of the trend will be deferred until the specific datasets since there are other explanatory variables.

Figure 5. General Additive Model Plot, Crop Farming income versus Relative Change in Rainfall, CBMS 2007-2010



Although not utilized in this text, consider a simple General Additive Model (GAM) (Tibshirani, 1986) to fit a non-parametric regression of crop farming income on relative change in rainfall. It can be seen in

Figure 5 that the relationship is far from linear[4]. In fact, chi-square test of linearity between GAM and a usual linear model of crop farming on rainfall yields a significant result (deviance=-7.998). Hence, assuming a linear model might not fit the data so well.

However, fitting a GAM may pose interpretability issues on the result not to mention that we have a structural model. Hence, piecewise regression was adopted in estimating a non-linear relationship between crop farming income and change in climate measures. Knots at (-20, 10, 0, 10, 20) have been adopted for rainfall relative measures while increase/decrease for temperature measures. For instance, Figure6 and 7 show demonstrative plot of piecewise regressions (Baum, 2006) of crop farming income on relative change

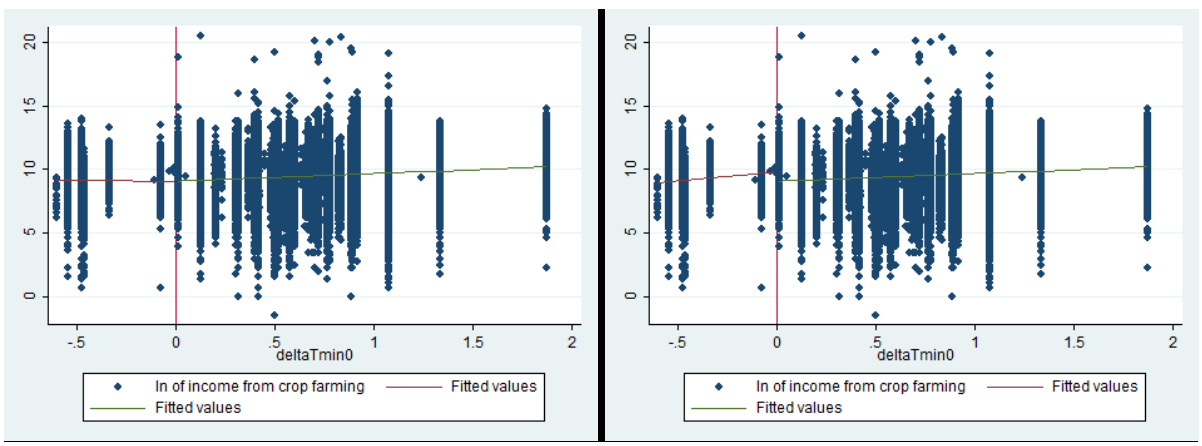
[4] CBMS data is usually used due to larger number of observations.

in rainfall and temperature. Note that indeed the effects change locally. Furthermore, the choice of measure consequently assumes jumps between the knots and the magnitude of jumps are significantly different.

Figure 6. Fitted values of regression without (left chart) and with spline dummy (right chart), Change in Rainfall, CBMS 2007-2010

Note: F-test for equality of dummies significant

Figure 7. Fitted values of regression without (left) and with spline dummy (right), Change in TMIN, CBMS 2007-2010



Note: F-test for equality of dummies significant

Another challenge on interpretability is collinearity between climate variables. For example, the three measures of rainfall change are inherently correlated since they are first and second order measures of rainfall (average and dispersion). This leads us to have four models for each of the dataset, which will be discussed in the results.

Standard assumptions on the error terms are to be validated and tests for weak instrument, exogeneity and overidentification are to be undertaken through the instrumental variable regression module in Stata (see appendix). It is inevitable in some cases to encounter violation of assumptions but are taken as it is either due to data issues or due to interpretability. For instance, overidentification may be a problem in FIES dataset (Sargan's statistic) which might be due to the number of instruments. Outliers can be menacing in this case and have been identified using Cook's distances. Many of them are ignored in order to balance the regions, provinces and municipalities to be retained which is an integral element of the objectives in this study.

Given the estimation procedure, this paper presents the eight models—four independent climate variable models for each data set. The results will be discussed in the succeeding section.

5. Results

Having different set of samples with different set of time periods may show different trends in the effects of climate shocks as well as its covariates. It is important however, to depict the expected change in climate variables in the future to facilitate interpretation of the manifestation of changes in climate.

Changes in climate

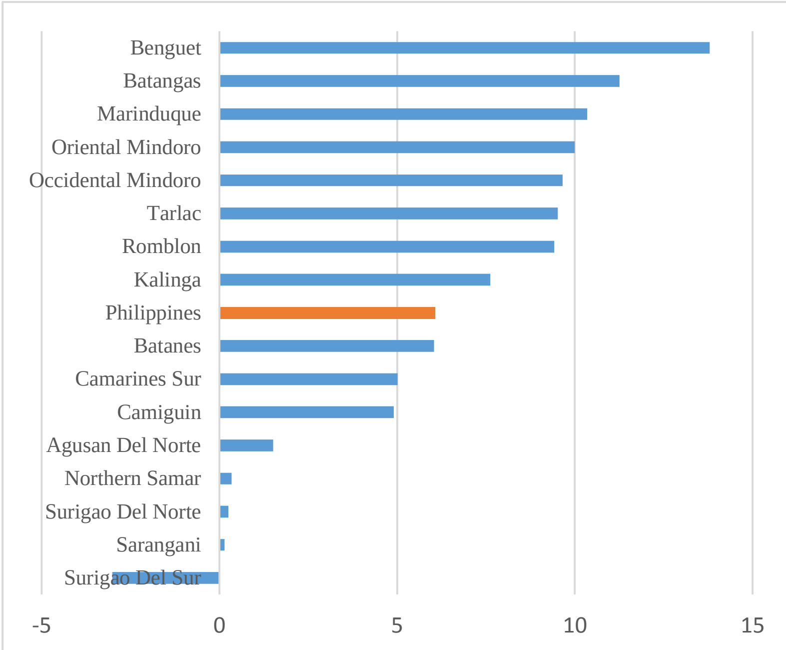
Table 6 shows the general changes in the measures of climate change used in this study. It can be noted that, overall, all of the climate variables will increase in the future except for the rainfall seasonality. However, only the maximum temperature and minimum temperature will have a significant change, at 37 percent and 47 percent respectively. A closer inspection across provinces will show that there are varying changes in the inspected climate variables.

Table 6. Change in climate variables 1979-2006 and 2011-2040, Philippines

Climate variable	Mean		Change
	1979-2010	2011-2040	
Mean cumulative annual rainfall	2693.2	2827.7	5.0%
Mean rainfall seasonality	0.50	0.50	0.3%
Volatility of rainfall	0.65	0.67	3.7%
Mean maximum annual temperature (degree C)	32.10	32.47	37.0%
Mean minimum annual temperature (degree C)	20.16	20.63	47.0%

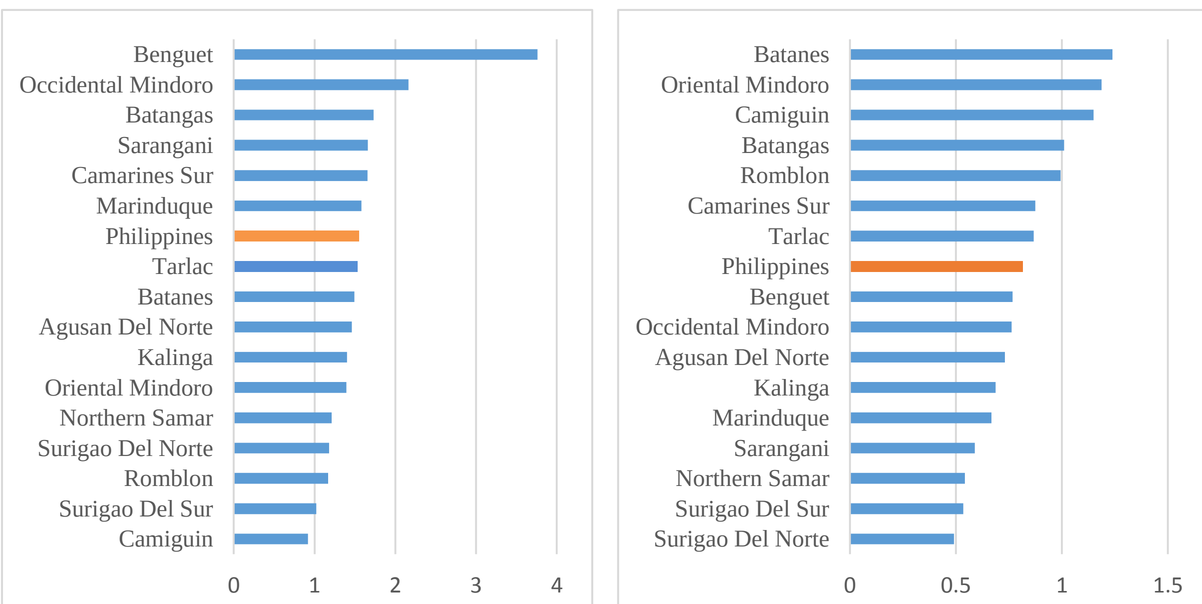
Figure shows the provinces covered by CBMS in comparison with the country average. It shows that although Philippines is expected to have increased rainfall in the future, CBMS coverage includes some provinces that decreased in rainfall. Similarly, it can be seen in Figure9 that still, many provinces in the CBMS dataset will likely experience lower increase in minimum temperature than the country average.

Figure 8. Difference in rainfall (1979-2006, 2011-2040)



Source: Provincial estimates provided by PAGASA-AMICAF Project Team based on the MPEH5 estimates using the Global Climate Model

Figure 9. Relative differences in minimum (left) and maximum (right) temperature (1979-2006, 2011-2040)



Source: Provincial estimates provided by PAGASA-AMICAF Project Team based on the MPEH5 estimates using the Global Climate Model

Different data, different results

These findings serve as guidance on the expected differences in trends in the national and CBMS results. Hence, although general trends of effects of climate on crop farming income and eventually on vulnerability to food insecurity maybe expected to be consistent, there is an expected disparity in trends as well in some of the factors that will be exhibited in later parts of this paper. It is worth mentioning that 2009 marks the year of Ondoy and higher rainfall can be expected in this year compared to other years. This is also coupled with differences in time periods (2009 and 2007-2010), differences in scope (national sample and censuses from 16 provinces), and differences in food insecurity measures (value of food consumption and malnutrition).

A. Family Income and Expenditure Survey 2009

Effect of climate variables on income from crop farming and gardening and vulnerability

Using the data of Family Income and Expenditure Survey for 2009, the different measures of rainfall and temperature have varying effects on crop farming and income and subsequently on food insecurity. Table 7 shows the effect of percent change in level of rainfall, seasonality, volatility, decrease in minimum temperature and increase in maximum tempearture on income from crop farming and gardening.

Table 7. Effect of different climate variables on income from crop farming and gardening, FIES 2009

Categories	ln of income from farming and gardening							
	Rainfall		Seasonality		Volatility		Temperature	
	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
<-20%			0.017***	0.001	0.014***	0.001		
<=20% - <-10%			-0.072	0.086	-0.016	0.015		
-10% - <0%	0.166***	0.015	0.047***	0.011	-0.014*	0.007		
0%-<10%	0.031***	0.012	-0.026**	0.012	0.043***	0.012		
10% - <20%	-0.015**	0.007	0.053***	0.014	-0.209**	0.098		
>=20%	-0.005***	0.001	-0.026.	0.017	0.007	0.007		
Dummies								
<-20%			-0.058	0.530	0.932***	0.262		
<=2-0% - <-10%			-1.992*	1.195	-0.215	0.330		
-10% - <0%	0.866***	0.088	-0.614	0.533	0.304	0.262		
0%-<10%	-0.261***	0.093	0.744	0.532	-0.038	0.266		
10% - <20%	-0.094	0.119	-1.651***	0.566	3.328**	1.536		
Decrease in min temp							0.990***	0.338

Increase in max temp							-0.249***	0.064
Dummies								
Decrease in min temp							0.728***	0.078
Increase in max temp							0.028	0.029
	ln per capita food expenditure							
ln of income from farming and gardening	0.141***	0.014	0.131***	0.014	0.167***	0.016	0.169***	0.016

Sig. codes *** 2.5% ** 5% * 10% . 15%

Percent change in rainfall

Change in level of rainfall expressed in terms of percent change in current level of rainfall relative to 1979-2006 average rainfall has varying effect on income from crop farming and gardening as well as on food insecurity. Small relative changes in level of rainfall increase income from crop farming and gardening and expectedly extreme increase in level of rainfall (i.e. more than 10%) decreases income from crop farming and gardening. In particular, decrease in rainfall, translated to greater than zero to 10 percent relative change, tends to significantly increase income. Similarly, income increases when level of rainfall increases up to less than 10 percent. However, significant decrease in income is observed when percent change in rainfall is equal or more than 10 percent.

Percent change in seasonality

Different ranges of percent change in seasonality of rainfall give mixed impact on income from crop farming and gardening. For more than 20 percent decrease in seasonality of rainfall, income significantly increases. The same trend is true when the decrease in seasonality is more than zero to 10 percent and more than 10 percent to less than 20 percent. When percent change in seasonality falls between -20 percent to -10 percent and 0 percent to 10 percent or more than 20 percent, income will decrease. Generally, crop farming and gardening income increases when rainfall is less seasonal. However, more seasonal rainfall have mixed effects on crop farming income.

Percent change in volatility

Mixed effects are observed when there are relatively small changes in rainfall volatility. Decrease in volatilty translated to 0-10 percent change will significantly reduce income from crop farming and gardening. The same trend is also observed when volatility increases between 10 to less than 20 percent. Increase in volatility between 0-10 percent significantly increases income. However, extreme negative change in rainfall volatility (e.i., more than 20%) increases crop farming income.

Temperature

Minimum and maximum temperatures have opposite effects on crop farming and gardening income. Decrease in 2009 minimum temperature relative to the 1979-2006 average minimum temperature is significant and positive with regard to income from crop farming and gardening. On the other hand, increase in maximum temperature affects income negatively and significantly. These effects imply that hotter temperature means lower crop farming income while colder temperature means higher farming income.

Effects of crop farming income on food insecurity as measured by per capita food expenditure are consistent across the models. Increase in crop farming and income will lead to increased per capita food expenditure hence will reduce vulnerability of population to food insecurity.

Covariates

Demographic characteristics

Across all climate shocks, age of the head of the family is negatively correlated with income from crop farming and gardening. Female headed family is also negatively associated with income. Educational attainment of the head of the family generally has negative effect on income which indicates that lower educational attainment is associated with higher reduction in income. Age, sex and educational attainment of the head of the family with regard to food expenditure is positive and significant. A year added on age of the head of the family increases food expenditure by .006. In addition, as level of educational attainment increases, food expenditure also increases..

Assets

Proxy variables of non-agricutural assets such as strong materials of walls and roof and access to safe water have different effect on income. Dwelling unit with strong walls and roof has positive effect on income, however families with access to safe water supply have negative effect. With regard to food expenditure, both have significant positive effect. In particular, there is about 5 percent increase in food expenditure among those families with strong materials of walls and roof as compared to those made from light/makeshift materials. Similarly, expenditure on food is higher by 6 percent among families with access to safe water.

Family's access to information as approximated by ownership of radio and TV significantly influences income from crop farming and gardening as well as food expenditure. Income of families with radio is 13-15 percent higher than the income of families without radio. Families who own a TV have higher income of about 6-9 percent as compared to those families who do not own a TV. Both the ownership of radio and TV increase food expenditure by 2 percent and 9 percent, respectively.

Ownership of car and motorcycle as proxies to family's access to transportation is significantly associated with both income and food expenditure. Ownership of car tends to increase income by almost 51-54 percent and thus increases spending on food by 15-17 percent. Onwership of motorcycle also gives higher income by 16-20 percent therefore food spending increases by 6-7 percent.

Infrastructure

Included in the models are several variables that are proxies of communication infrastructure (ownership of telephone), financial infrastructure (cash loan payments) and social welfare infrastructure (expenditure on insurance and premiums). These variables, however, tend to have different effect on income. For instance, both ownership of telephone and payments to loan affect income positively while expenditure on social welfare affects income negatively. With respect to spending on food, both ownership of telephone and expenditure on social welfare are associated with higher spending on food while expenditure on loan decreases spending on food but not significant.

Policy Variables

Both policy variables included in the models are significantly associated with income from crop farming and gardening. Across all models, a unit increase in spending on farm-to-market roads will increase income by 0.1 percent. Also, a unit increase in spending on irrigation for palay significantly increases income by 2-3 percent. These results imply that policies directed toward agriculture infrastructures will provide farmers higher income and as a result will increase food expenditure that will lead to reduce food insecurity.

Location

Location of familes as either in rural or urban areas significantly affect income from crop farming and gardening. For instance, income from crop farming and gardening of those families living in rural area is higher than those families in urban areas at about 10-13 percent.

Effects of climate shocks on the likelihood of being food insecure

Level of rainfall and temperature as climate shocks have opposite effects on food insecurity in the future. At the national level, proportion of food insecure families due to temperature shock will increase by 0.43 percent while relative change in level of rainfall will reduce proportion of food insecure families in the future by 0.18 percent.Variations on the effects of climate shocks are more pronounced at the regional level as shown in table 8. For rainfall shock, there are regions that are negatively affected but there are also regions that are positively affected. In particular, Caraga region will experience increase in proportion of familes who are food insecure in the future. However, nine regions namely Ilocos, Cagayan Valley, Bicol, Central and Eastern Visayas, Zamboanga, Northern Mindanao, Davao and ARMM will benefit from the change in rainfall and in turn lower proportion of food insecure families (Map 1). On the other hand, temperature shock will negatively affect almost all regions leading to increase in food insecure families as shown in Map 2.

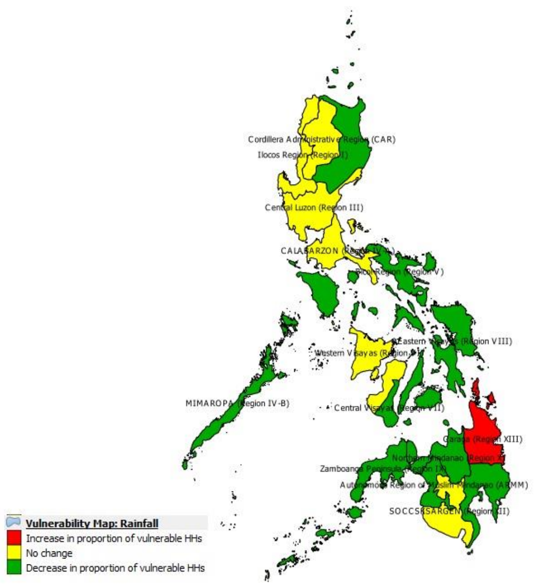
Table 8. Predicted and projected vulnerability, rainfall and temperature model, FIES 2009

Region	Rainfall		Temperature	
	Predicted 2009	Projected (2011-2040)	Predicted 2009	Projected (2011-2040)
Philippines	13.45%	13.27%	13.45%	13.88%
I - Ilocos Region	3.80%	3.80%	3.80%	4.05%
II - Cagayan Valley	1.68%	1.57%	1.57%	2.13%
III - Central Luzon	1.90%	1.90%	1.90%	2.47%
IVA - CALABARZON	5.52%	5.52%	5.52%	5.71%
V - Bicol Region	11.31%	10.89%	11.31%	12.15%
VI - Western Visayas	8.65%	8.65%	8.65%	9.16%
VII - Central Visayas	27.94%	27.33%	28.06%	28.43%
VIII - Eastern Visayas	17.40%	17.30%	17.30%	17.82%
IX - Zamboanga Peninsula	29.33%	29.07%	29.33%	29.33%
X - Northern Mindanao	21.48%	21.19%	21.34%	21.77%

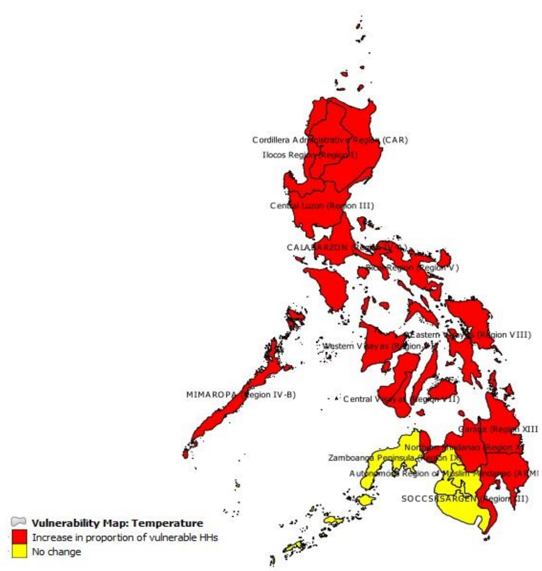
XI – Davao	17.70%	17.33%	17.70%	17.94%
XII - SOCCSKSARGEN	14.74%	14.74%	14.74%	14.74%
CAR	7.27%	7.27%	7.27%	8.55%
ARMM	8.74%	8.21%	8.95%	8.95%
XII – Caraga	22.19%	22.49%	22.19%	22.64%
IVB – MIMAROPA	14.53%	14.29%	14.53%	15.02%

Source of basic data: Philippine Statistics Authority – Food and Income Expenditure Survey 2009

Map 1. Change in predicted and projected vulnerability, rainfall model, FIES 2009



Map 2. Change in predicted and projected vulnerability, temperature model, FIES 2009



Source of basic data: Philippine Statistics Authority – Food and Income Expenditure Survey

Chronic and transient food insecurity due to rainfall and temperature shock

At least 8 in every 10 families who are food secure today will still remain food secure in the future, given rainfall and temperature as climate shocks. Proportion of families who are chronically food insecure due to changes in level of rainfall and temperature are about 13.2 and 13.5 percent, respectively. Furthermore, transitory food insecure due to rainfall is about 0.2 percent and slightly higher for temperature shock at 0.4 percent. Across the regions, Zamboanga region has the highest proportion of families who are chronically food insecure (both in rainfall level and temperature) with almost 30 percent of the families in the region experiencing this. Proportion of never food insecure families is highest in Cagayan Valley region where 9 in every 10 families did not experience and will not experience food insecurity in the future. On the other hand, Central Visayas and Davao regions will have the highest proportion of families who are transitory food insecure given level of rainfall as the climate shock. It is worth noting that more than 1 percent of the families in CAR region are transitory food insecure due changes in temperature in the future.

Table 9. Characteristics of families in chronic and transient food insecurity by region , FIES 2009

Province	Rainfall			Temperature		
	Never food insecure	Transitory food insecure	Chronically food insecure	Never food insecure	Transitory food insecure	Chronically food insecure
Philippines	86.52%	0.24%	13.24%	86.12%	0.43%	13.45%
I - Ilocos Region	96.20%	0.00%	3.80%	95.95%	0.25%	3.80%
II - Cagayan Valley	98.32%	0.11%	1.57%	97.87%	0.56%	1.57%
III - Central Luzon	98.10%	0.00%	1.90%	97.53%	0.57%	1.90%
IVA - CALABARZON	94.48%	0.00%	5.52%	94.29%	0.19%	5.52%
V - Bicol Region	88.69%	0.42%	10.89%	87.85%	0.84%	11.31%
VI - Western Visayas	91.35%	0.00%	8.65%	90.84%	0.52%	8.65%
VII - Central Visayas	72.06%	0.61%	27.33%	71.57%	0.37%	28.06%
VIII - Eastern Visayas	82.49%	0.31%	17.19%	82.18%	0.52%	17.30%
IX - Zamboanga Peninsula	70.67%	0.27%	29.07%	70.67%	0.00%	29.33%
X - Northern Mindanao	78.52%	0.29%	21.19%	78.23%	0.44%	21.34%
XI - Davao	82.18%	0.61%	17.21%	82.06%	0.24%	17.70%
XII - SOCCSKSARGEN	85.26%	0.00%	14.74%	85.26%	0.00%	14.74%
CAR	92.73%	0.00%	7.27%	91.45%	1.27%	7.27%
ARMM	91.26%	0.53%	8.21%	91.05%	0.00%	8.95%
XII - Caraga	77.51%	0.30%	22.19%	77.36%	0.45%	22.19%
IVB - MIMAROPA	85.47%	0.25%	14.29%	84.98%	0.49%	14.53%

Source of basic data: Philippine Statistics Authority – Food and Income Expenditure Survey

Characteristics of vulnerable families

Differences on the characteristics of families among the never food insecure, transient food insecure and chronically food insecure are also evident as shown in table 10. Families who are chronically food insecure have relatively higher dependence on crop farming and gardening. However, it is worth noting that transitory food insecure families affected by rainfall shock have relatively higher dependence on crop farming and gardening income at about 40 percent. Food insecurity is likely to be experienced by families with younger heads. Table 10 shows that average age of head among never food insecure families is higher than those families who are transitory food insecure and permanently food insecure. Families with higher household size have higher tendency to be food insecure. For instance, transitory food insecure and permanently food insecure families have higher household size as compared to those permanently food secure families. Lower educational attainment of the head of the family is also associated with food insecurity. Dwelling unit with strong materials of walls and roof lessens the tendency of being food insecure.

Permanently food secure families have the highest proportion with strong walls and roof among the three groups. Families with more assets such as TV, radio, telephone, car, and motorcycle are more likely to be food secure. Access to social welfare such as insurance/retirement and access to credit lessen the tendency of being food insecure.

Table 10. Characteristics of chronic and transient food insecure families, FIES 2009

Characteristic	**Rainfall**				**Temperature**		
	All	Never food insecure	Transitory food insecure	Chronically food insecure	Never food insecure	Transitory food insecure	Chronically food insecure
Share of crop farming income to total income	35.85%	35.46%	41.37%	38.35%	35.46%	33.36%	38.43%
Female headed	11.82%	4.66%	6.66%	6.61%	12.50%	7.41%	7.57%
Age of head	51.6	52.3	50.7	46.9	52.4	47.4	46.9
Family size	4.9	12.5	6.5	7.5	4.7	6.6	6.6
With strong house	61.37%	66.29%	25.81%	29.92%	66.32%	50.00%	30.03%
With radio	51.35%	54.04%	45.16%	33.91%	54.08%	46.30%	34.08%
With telephone	53.00%	58.13%	22.58%	20.08%	58.23%	35.19%	20.12%
With tv set	54.60%	60.44%	25.81%	16.98%	60.56%	33.33%	17.13%
With car	4.23%	4.89%	-	-	4.90%	1.85%	-
With motorcycle	15.97%	18.13%	3.23%	2.09%	18.18%	5.56%	2.17%
Urbanity(rural)	84.99%	83.97%	87.10%	91.60%	83.95%	87.04%	91.55%
No grade	6.04%	5.17%	12.90%	11.62%	5.17%	5.56%	11.67%
Elementary level	33.16%	30.60%	51.61%	49.52%	30.61%	29.63%	49.62%
Elementary graduate	24.35%	24.67%	6.45%	22.59%	24.61%	33.33%	22.40%
High school level	11.64%	12.13%	16.13%	8.40%	12.15%	11.11%	8.45%
High school graduate	14.82%	16.11%	12.90%	6.38%	16.11%	18.52%	6.39%
College level	6.13%	6.88%	-	1.37%	6.90%	1.85%	1.35%
College and post graduate	3.87%	4.45%	-	0.12%	4.44%	-	0.12%
With remittance	19.04%	21.38%	-	4.05%	21.45%	7.41%	3.99%
With safe water	69.32%	72.43%	35.48%	49.58%	72.43%	72.22%	49.27%
With cash loan payments	25.36%	27.03%	19.35%	14.54%	27.05%	25.93%	14.49%
With expenditure on insurance and retirement	14.77%	16.80%	-	1.79%	16.87%	-	1.76%

Source of basic data: Philippine Statistics Authority – Food and Income Expenditure Survey

Policy Options

Based on the models, projected changes in temperature will lead to about 60% percent decrease in crop farming income. Such impact on income will definetly put farmers at risk in terms of food security. This impact, however, can be mitigated by policy interventions. Using our model, policy interventions can be in the form of increased expenditures on agricultural infrastructure such as farm to market roads and irrigation for palay (Figure 10). At the family level, increase in level of education of head of the family, ownership of radio and access to remittances can also be usedto mitigate the negative effects of changes in temperature (Figure 11).

Figure 10. Increasing expenditure on farm-to-market road and irrigation of palay at current value of temperature, FIES 2009

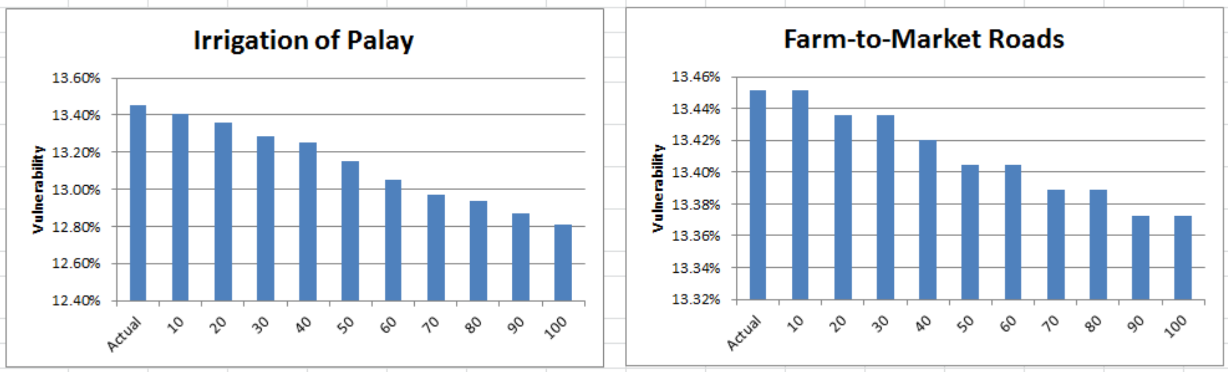
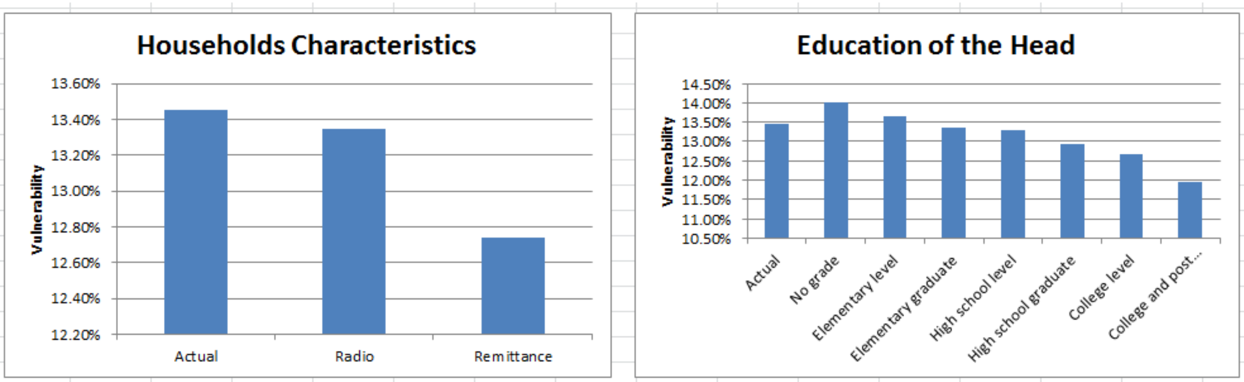


Figure 11. Increasing ownership of asset, and access to remittance and enhancing education at current value of temperature, FIES 2009



B. CBMS 2007-2010

Climate shocks

Models of food insecurity using CBMS 2007-2010 data suggest the expected general trend that higher rainfall or hotter temperatures means lower crop farming income. Furthermore, small relative changes in rainfall effect increase in crop farming and gardening although in different pace. It is notable, however, that higher increase in rainfall still means lower crop farming income. On the other hand, seasonality and volatility have varied effects such that small changes have positive effects on crop farming income. Finally, temperature model suggests that increase in minimum temperature increases crop farming income to some extent while maximum temperature decreases income from farming and gardening to some extent as well. This means that temperature must not be too cold (too low minimum temperature) and must not be too hot (too high maximum temperature).

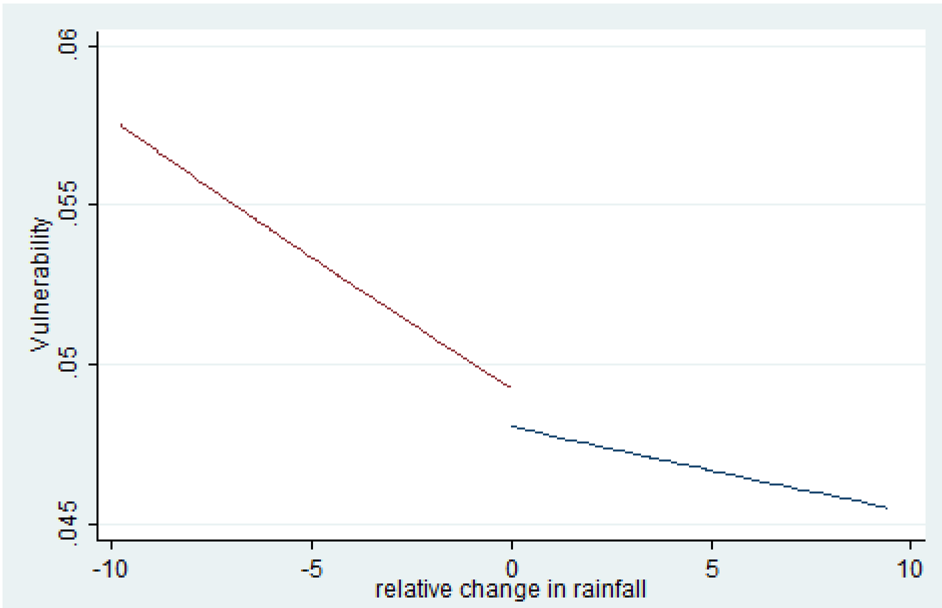
Table 11. Effect of different climate shocks on income from crop farming and gardening, CBMS 2007-2010

Effect on Malnutrition model	**Income from crop farming (log)**							
	-0.248***		-0.258***		-0.256***		-0.253***	
Climate Variables	**Rainfall**		**Rainfall seasonality**		**Rainfall volatity**		**Temperature**	
	Coef.	*Robust SE*	*Coef.*	*Robust SE*	*Coef.*	*Robust SE*	*Coef.*	*Robust SE*
Percent change								
<=-20%	-0.07***	0.006	0.003***	0.001	0.02***	0.001		
>-20% - <=-10%	0.03***	0.004	0.02***	0.005	0.02***	0.002		
>-10% - <=0%	0.03***	0.004	-0.003	0.003	0.01***	0.002		
>0% - <=10%	0.01***	0.004	0.001	0.004	0.03***	0.003		
>10% - <=20%	0.03***	0.003	0.003	0.004	0.005	0.004		
>20%	0.01***	0.001	0.01***	0.001	0.01***	0.003		
Percent change intercept								
<=-20%	base		base		base			
>-20% - <=-10%	1.70***	0.157	0.23***	0.069	-0.16***	0.042		
>-10% - <=0%	1.52***	0.148	0.02	0.035	-0.37***	0.032		
>0% - <=10%	1.57***	0.146	0.02	0.036	-0.71***	0.036		
>10% - <=20%	1.32***	0.149	0.06	0.067	-0.53***	0.068		
>20%	1.42***	0.151	-0.08*	0.045	-0.74***	0.081		
Change in temperatures								
Change in minimum temperature							0.64***	0.044
Decrease in minimum temperature (dummy)							-0.33***	0.049
Change in maximum temperature							-0.09***	0.021
Increase in maximum temp (dummy)							0.09***	0.027
Sig. codes *** 2.5% ** 5% * 10% . 15%								

Change in rainfall

As mentioned earlier, change in rainfall affects crop farming income positively which ultimately reduces vulnerability to malnutrition vulnerability. For instance, for every percent change in the -10 to 0 percent range, income crop farming increases by approximately 3 percent. This in turn affects drops on vulnerability to food insecurity in terms of malnutrition. To demonstrate, figure 12 shows an approximate plot of change in rainfall in the -10 to 10 percent range and its effect on food insecurity. From -10 to 0 percent, a percent difference effects a 0.001 drop in vulnerability while from 0 to 10 percent, vulnerability drops approximately by 0.0003.

Figure 12. Effect of -10 to 10 percent change in rainfall on vulnerability, CBMS 2007-2010



Change in rainfall seasonality

Every range of seasonality have positive effect on crop farming income except in the -10 to 0 percent range. They, however, have different in magnitude and statistical significance. From -100 to -20 percent, a percent change translates to about .3 percent increase in crop farming income while from -20 to -10 percent, a percent change effects about 2 percent increase in crop farming income.

Change in rainfall volatility

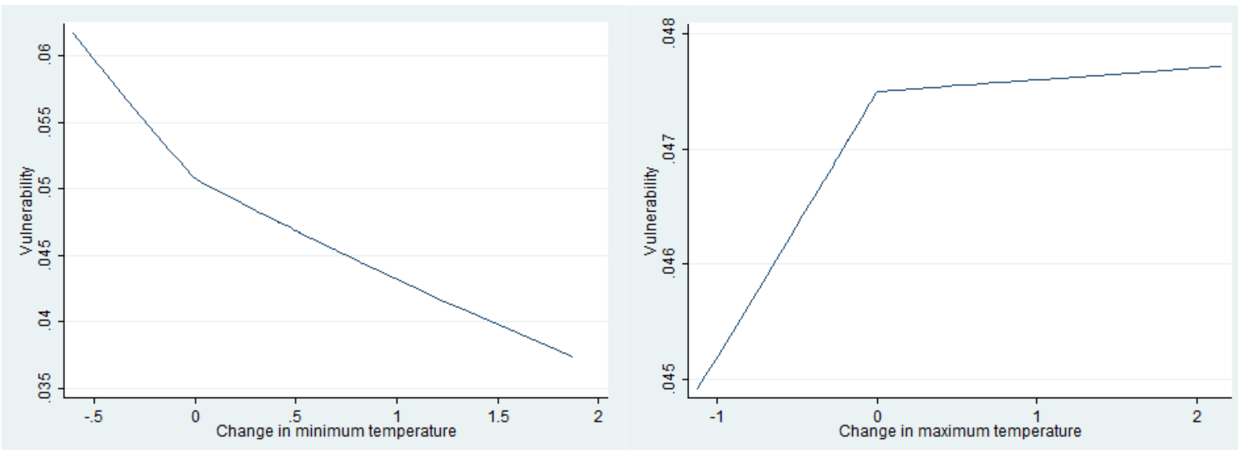
Almost similar to seasonality, ranges of change in rainfall volatility has consistent positive effects on crop farming income. From -100 to -10 percent, a percent change translates to about 2 percent increase in crop farming income. From -10 to 0 percent as well as 20-100 percent change effects about 1 percent change in crop farming income.

Change in temperature

Minimum and maximum temperature have, expectedly, opposite effects on crop farming income and consequently on vulnerability. If the change in minimum temperature is higher by one degree, log of crop farming income also increases by 0.64. On higher changes in temperatures (0 degrees above), the increase in crop farming income is less by 0.33. In terms of vulnerability, if the change is higher by one degree, there is approximately 0.02 reduction in vulnerability (see Figure 13). This reduction becomes slower in higher positive changes in temperature, about 0.01.

Changes in maximum temperature demonstrates effects contrary to minimum. A degree higher change in maximum temperature effects about 0.02 drop in log crop farming income. On higher changes in maximum temperatures (0 degrees above), the drop in crop farming income is less by .01. These effects in turn translates to approximately 0.002 increase in vulnerability, although the rate becomes slower by 0.002 in higher changes.

Figure 13. Effect of change in minimum and maximum temperature on vulnerability, CBMS 2007-2010



Covariates

Demographic characteristics

Age of the household head is consistently associated with lower probability of being malnourished across all climate shocks. In addition female-headed households are less likely to have malnourished children. On the other hand, households with indigenous member are more likely to have malnourished children as well as those who have experienced illness in their households. Higher educational attainment of the household head appear to reduce probability of malnourished children.

Household assets and infrastructure

Ownership of assets and access to infrastructure have mitigating effects on vulnerability to food insecurity in terms of malnutrition. Those with safe water are less likely to have malnourished children compared to those without safe water. Access to communication such as cellphone and telephone also reduces the likelihood of having malnourished children. This is also similar with those who have access to media and information such as radio. On the other hand, access to government programs is likely associated with malnutrition as well as higher prices of food.

Policy Variables

Agricultural assets shows a robust effect on agricultural income and in turn on food insecurity. For instance those with agricultural organization, thresher, dryer or irrigation pump will likely have more income on agriculture and in turn mitigate vulnerability to food insecurity. On the other hand, this could be countered by cost of fertilizer which lowers agricultural income (-1.22) but can be compensated by expenditure on farm to market roads (0.02).

Effects of climate shocks on the likelihood of being food insecure

The models also consistently indicate that increasing crop farming income effect decrease in vulnerability. Hence, higher rainfall or unstable rainfall, extremely cold, or extremely hot temperature may lead to higher vulnerability of having malnourished children. This is the basis of vulnerability of the households to food insecurity in the future.

The expected changes in climate variables, specifically rainfall and temperature effect varying changes in vulnerability of households to food insecurity. Table 12 shows that Benguet, Camarines Sur, Camiguin, Surigao del Norte, Surigao del Sur, Sarangani will likely have more households to be food insecure compared to their present food insecurity figure based on the rainfall model. In the case of the temperature model, there are more provinces that will have their households experience more vulnerability. Only Agusan Del Norte, Camiguin, Northern Samar and Surigao Del Norte will not have increased food insecurity. It can be noted that Surigao del Sur and Marinduque has the highest expected jump in food insecurity with respect to rainfall and temperature model respectively. Maps 4 and 5 show the location of the 16 provinces.

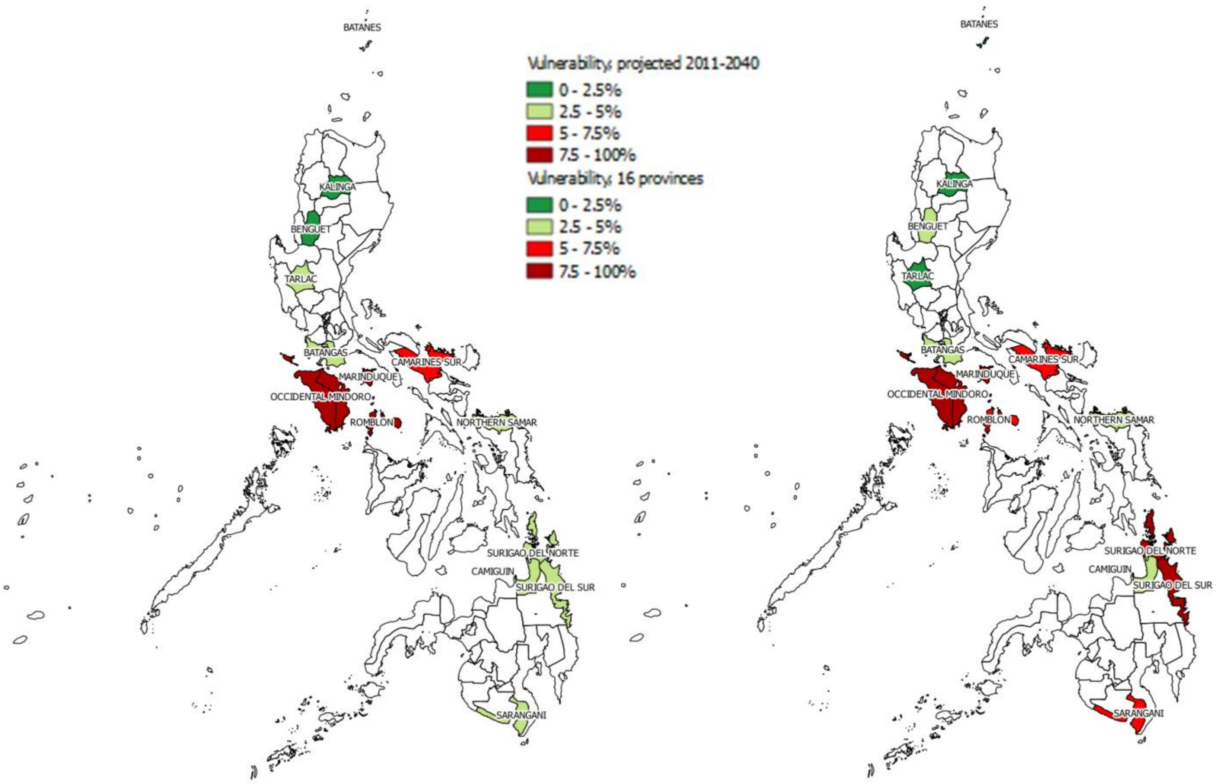
Table 12. Actual, predicted and projected prevalence of malnutrition, CBMS 2007-2010

	Rainfall		**Temperature**	
Province	Predicted (2007-2010)	Projected (2011-2040)	Predicted (2007-2010)	Projected (2011-2040)
Agusan Del Norte	4.02%	2.82%	3.99%	3.65%
Batanes	3.38%	2.03%	3.15%	3.49%
Batangas	3.08%	2.75%	3.13%	4.42%
Benguet	1.95%	3.35%	1.97%	3.33%
Camarines Sur	5.95%	6.72%	5.98%	5.99%
Camiguin	1.78%	1.81%	1.81%	1.74%
Kalinga	1.79%	1.33%	1.81%	2.10%
Marinduque	11.94%	11.87%	12.07%	17.22%
Northern Samar	4.73%	3.86%	4.82%	1.87%
Occidental Mindoro	11.05%	9.66%	11.36%	14.46%
Oriental Mindoro	9.11%	8.76%	8.95%	11.06%
Romblon	10.63%	6.33%	10.76%	13.34%
Surigao Del Norte	4.78%	7.62%	4.76%	4.53%
Surigao Del Sur	4.40%	8.17%	4.35%	5.62%
Tarlac	2.55%	2.30%	2.55%	3.38%
Sarangani	4.58%	6.15%	4.63%	5.22%

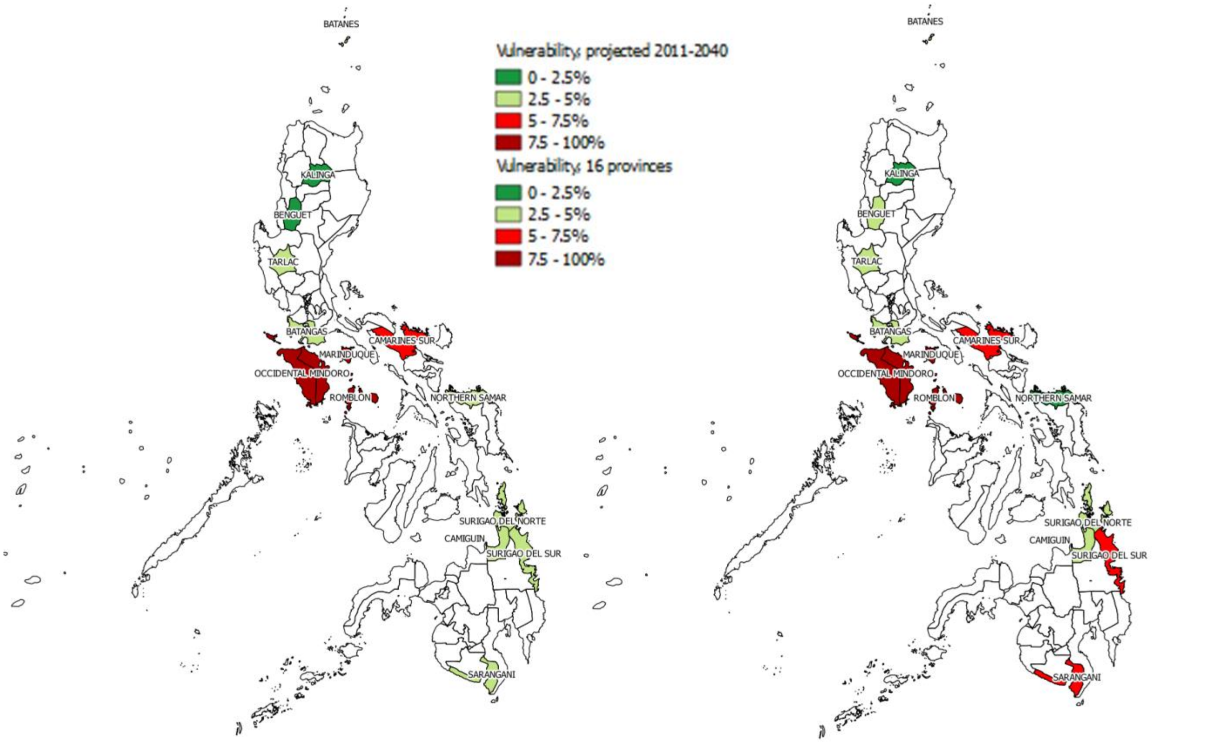
Source of basic data: Pooled CBMS 2007-2010 Census

To illustrate this visually, Map 3 and 4 show the projected change in vulnerability across the 16 provinces of CBMS data using the rainfall and temperature models. There are apparent shifts in colors particularly Camarines Sur, Surigao del Norte, Surigao Del Sur and Sarangani. Map 5 demonstrates the spatial distribution in Surigao Del Norte.

Map 3. Predicted (left) and projected (right) vulnerability, rainfall model, CBMS 2007-2010

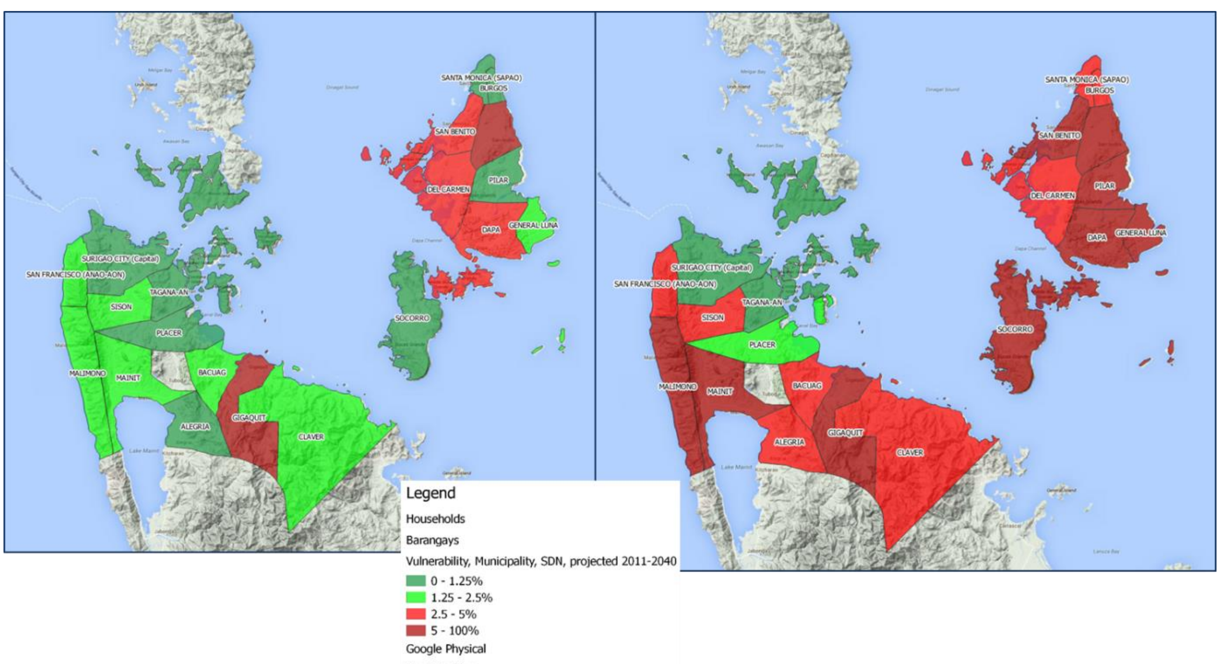


Map 4. Predicted (left) and projected (right) vulnerability, temperature model, CBMS 2007-2010



Source of basic data: CBMS Census, 2007-2010

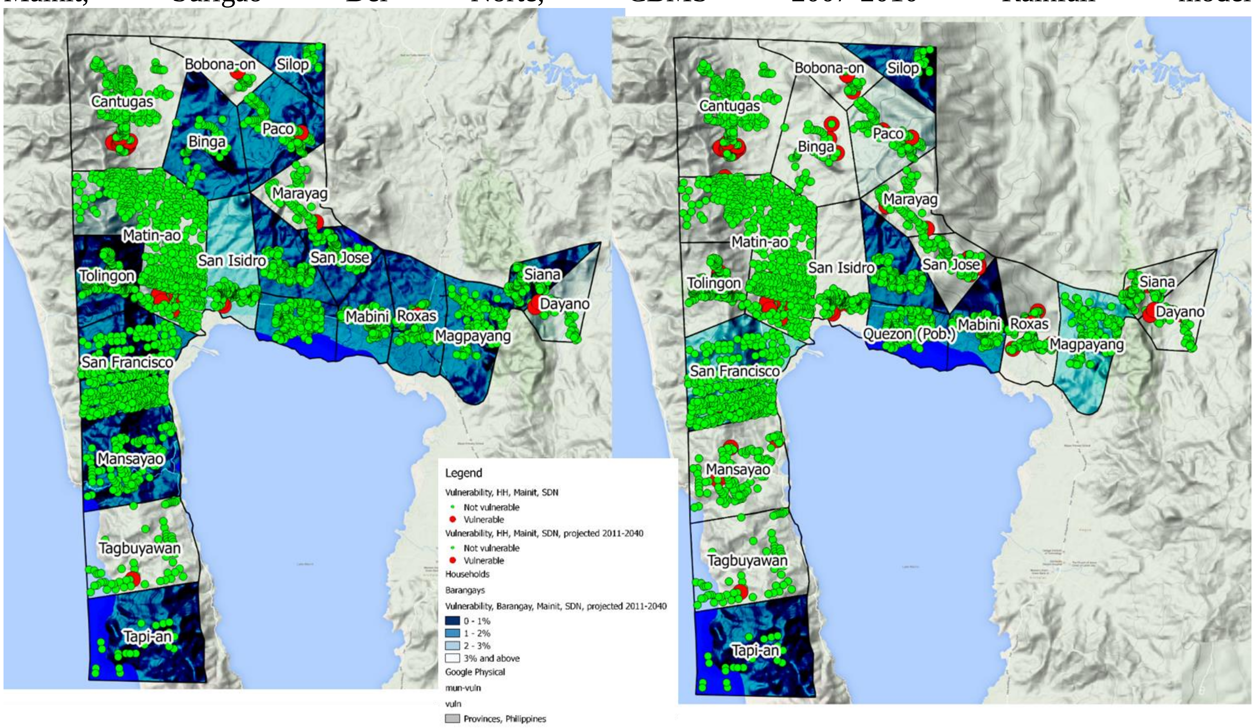
Map 5. Current (Left) and Projected (Right) Prevalence of Malnutrition, Municipalities, Surigao Del Norte, CBMS 2007-2010 Rainfall model



Source of basic data: CBMS Census, 2007-2010

Shift in vulnerability among households and barangays in Mainit, Surigao Del Norte can be seen in Map 6.

Map 6. Current (Left) and Projected (Right) Prevalence of Malnutrition among Households and Barangays, Mainit, Surigao Del Norte, CBMS 2007-2010 Rainfall model



Source of basic data: CBMS Census, 2007-2010

Chronic and transient food insecurity

Table 13 shows the proportion of chronic and transient food insecurity by province. It can be seen from the table that Marinduque has the highest incidence of chronic food insecurity among the 16 provinces in both the rainfall model and temperature model. This is followed by Occidental Mindoro in both models. On the other hand, Kalinga has the lowest incidence of chronic food insecurity in terms of the rainfall model while Camiguin is the lowest in terms of the temperature model. Romblon has the highest incidence of transient food insecurity in the rainfall model while Marinduque has the highest incidence of transient food insecurity in the temperature model. Notice that persistency of MIMAROPA regions in the ranking.

Table 13. Chronic and transient food insecurity based on rainfall and temperature models, 16 Provinces CBMS 2007-2010

Province	Rainfall			Temperature		
	Never food insecure	Transitory food insecure	Chronically food insecure	Never food insecure	Transitory food insecure	Chronically food insecure
Agusan Del Norte	95.97%	1.22%	2.81%	96.00%	0.35%	3.64%
Batanes	96.62%	1.35%	2.03%	96.51%	0.34%	3.15%
Batangas	96.52%	1.13%	2.35%	95.58%	1.29%	3.13%

Benguet	96.16%	2.39%	1.46%	96.65%	1.40%	1.95%
Camarines Sur	93.11%	1.12%	5.77%	93.71%	0.61%	5.68%
Camiguin	98.03%	0.34%	1.63%	98. 15%	0.15%	1.70%
Kalinga	98.12%	0.64%	1.24%	97.90%	0.29%	1.81%
Marinduque	87.36%	1.47%	11.17%	82.78%	5.15%	12.07%
Northern Samar	95.11%	1.19%	3.70%	95.06%	3.20%	1.74%
Occidental Mindoro	88.42%	2.45%	9.13%	85.54%	3.10%	11.36%
Oriental Mindoro	90.89%	0.36%	8.76%	88.94%	2.11%	8.95%
Romblon	89.37%	4.29%	6.33%	86.66%	2.58%	10.76%
Surigao Del Norte	91.93%	3.74%	4.33%	94.72%	1.27%	4.01%
Surigao Del Sur	91.75%	3.92%	4.33%	94.35%	1.34%	4.31%
Tarlac	97.45%	0.25%	2.30%	96.62%	0.83%	2.55%
Sarangani	93.79%	1.69%	4.52%	94.61%	0.94%	4.45%

Source of basic data: Pooled CBMS 2007-2010 Census

Table 14 shows the characteristics of households in terms of their current food insecurity in comparison to their future. Comparing the three statuses, it can be seen that chronically food insecure households tend to have youngest and least educated heads. They also have highest share of dependents, have the biggest households and most likely to have indigenous member. In addition to that, they are most likely to experience illness in the household. These households also are least likely to have strong house, electricity, radio, vehicles and cellphone. A notable characteristic is that they can be found most likely in the rural areas, and most dependent on crop farming income yet they tend to least likely have agricultural organization, thresher, dryer or irrigation pump. These trends are consistent across the rainfall and temperature models.

Table 147. Characteristics of households in chronic and transient food insecurity based on rainfall temperature models, 16 Provinces CBMS 2007-2010

Characteristic	**All**	**Rainfall**			**Temperature**		
		Never food insecure	Transitory food insecure	Chronically food insecure	Never food insecure	Transitory food insecure	Chronically food insecure
Share of crop farming income to total income	43.11%	42.93%	45.65%	46.06%	42.97%	44.96%	45.46%
Female headed	6.21%	6.43%	2.51%	2.95%	6.42%	2.75%	3.09%
Age of head	40.94	41.24	36.83	36.12	41.26	36.45	36.11
Share of dependents (0-14, 65 and above)	49.40%	48.86%	56.90%	58.33%	48.85%	57.29%	58.01%
Household size	5.85	5.76	7.16	7.38	5.76	7.09	7.28
IP indicator	25.11%	22.98%	53.29%	60.67%	22.86%	46.06%	64.07%
With strong house	42.26%	43.85%	21.74%	15.43%	43.91%	20.95%	15.77%
Owned house	58.25%	58.47%	52.53%	55.61%	58.41%	55.44%	55.92%
With electricity	62.75%	64.96%	33.70%	25.82%	65.12%	31.61%	24.97%
With radio	41.52%	43.01%	19.33%	17.66%	43.02%	18.99%	18.64%
With telephone	2.11%	2.24%	0.06%	0.19%	2.24%	0.00%	0.20%
With cellphone	36.09%	38.12%	4.85%	4.01%	38.19%	4.34%	4.16%
With vehicles	15.17%	15.97%	2.74%	2.62%	16.00%	2.84%	2.66%
Availed govt prog	30.82%	28.93%	56.90%	62.45%	28.98%	56.52%	59.98%

Illness shock	41.76%	40.03%	63.34%	71.09%	39.93%	66.45%	70.62%
Urbanity	11.70%	12.29%	2.88%	2.21%	12.33%	1.67%	2.29%
No grade	5.90%	3.77%	23.37%	46.33%	3.65%	26.52%	45.61%
Elementary level	33.52%	32.99%	51.71%	38.02%	33.03%	51.80%	37.15%
Elementary graduate	18.79%	19.36%	13.60%	8.20%	19.38%	11.78%	8.94%
High school level	14.34%	14.90%	8.04%	4.55%	14.92%	6.77%	5.05%
High school graduate	15.87%	16.73%	2.60%	2.13%	16.74%	2.64%	2.41%
College level	8.06%	8.52%	0.62%	0.67%	8.54%	0.50%	0.73%
College and post garduate	3.51%	3.73%	0.06%	0.10%	3.74%	0.00%	0.10%
Income from crop farming (log)	9.46	9.49	9.13	8.94	9.50	9.03	8.89
With agri org	2.79%	2.84%	2.65%	1.89%	2.86%	1.70%	1.75%
With thresher	21.46%	22.48%	6.58%	4.35%	22.50%	5.51%	5.13%
With dryer	8.20%	8.68%	0.99%	0.62%	8.69%	0.76%	0.74%
With irrigation pump	11.80%	12.46%	1.44%	1.04%	12.47%	1.58%	1.28%

Source of basic data: Pooled CBMS 2007-2010 Census

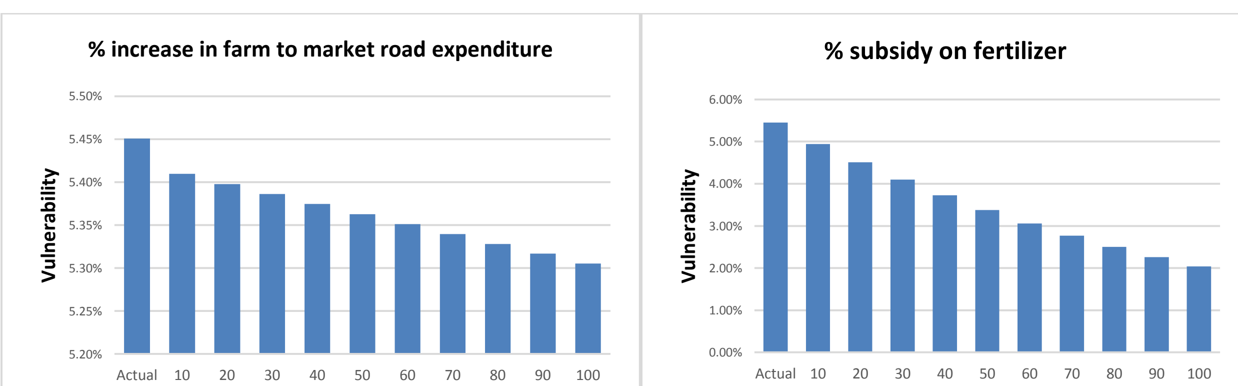
Source of basic data: CBMS Census, 2007-2010

Policy options

The results likely depict a grim picture of food insecurity in some parts of the country given the 16 CBMS provinces. The models suggest some of the policy options to adopt as counter measure in case of rise in vulnerability. Some of these are:

- Human capital in terms of education;
- Government expenditure on agriculture in terms of farm to market road;
- Government assistance in terms of subsidy on fertilizers; and
- Enhanced agricultural infrastructure

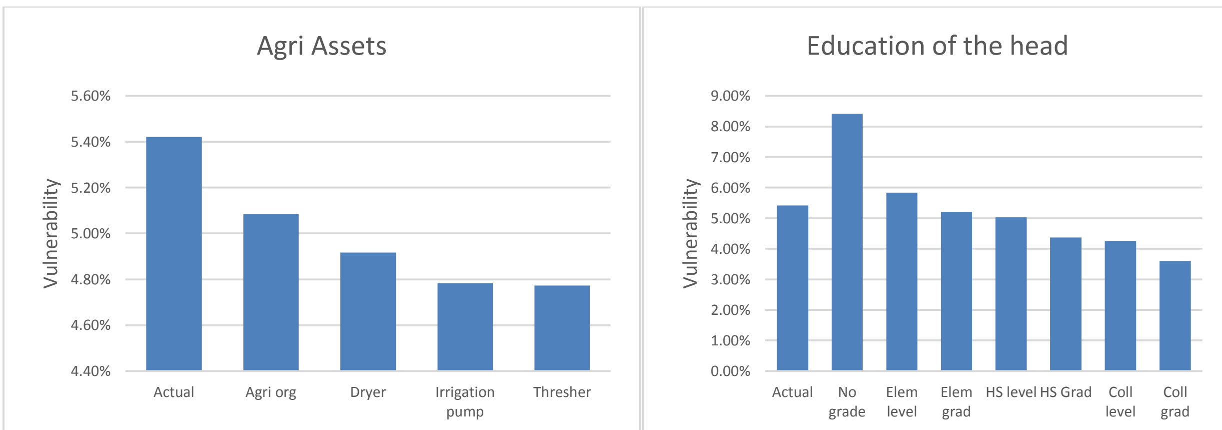
Figure 14. Increasing farm-to-market road expenditure and subsidy on fertilizer at current value of rainfall, CBMS 2007-2010



Source of basic: Pooled CBMS 2007-2010 Census

Figure 15 shows the expected results in adopting some of the policy options at current values of rainfall. For instance, increasing farm to market road expenditure by 20 percent might likely lead to a 0.05 percent reduction in vulnerability. On the other hand, subsidizing 30 percent of fertilizer cost might likely lead to about 1.25 percentage point reduction in vulnerability. Similarly, investing in human capital also reduces vulnerability. Enabling farming households' heads finish at least high school level might reduce the actual vulnerability on the average. Furthermore, providing enhanced agricultural facilities or infrastructure can lead to reduced vulnerability. Having a thresher has the highest impact on vulnerability reduction followed by irrigation pump, dryer and having agricultural organization.

Figure 15. Providing more agricultural infrastructure and enhancing educationat current value of rainfall, CBMS 2007-2010



Source of basic: Pooled CBMS 2007-2010 Census

6. Conclusions and recommendations

Although having different datasets at different points in time, the study reveals that change in climate variables likely transmit its effects on the households through farming income in the form of food insecurity. The effects have been shown to be statistically significant to effect change in farming income together with other factors that are available such as government expenditure on agriculture, farm inputs, and infrastructure. Farming income then tends to significantly affect vulnerability to food insecurity given other idiosyncratic factors of the households such as education, demography, access to infrastructure and housing. Hence, images of food insecurity can be depicted using the structural models established in this study.

Rainfall levels and stability and extreme temperatures affect crop farming consistently across models. Extreme increase in level of rainfall decreases income from crop farming and gardening and consequently increases vulnerability to food insecurity. Higher temperatures, albeit having opposite effects with respect to minimum and maximum, tend to eventually decrease farming income and will likely effect increse in vulnerability to food insecurity. This means that temperature must not be too cold (too low minimum temperature) and must not be too hot (too high maximum temperature). This explains that at the national level, changes in temperature lead to increased vulnerability to food insecurity which is also true in some of the provinces. However, changes in level of rainfall will increase vulnerability in some parts of the country.

Having measures of vulnerability in the future allowed the projection of households who will be never food insecure, transitory food insecure, and chronically food insecure. Consistent findings drawn from projections convey that chronically food insecure households tend to have younger and less educated heads. They also have the biggest family or household size. In addition, these households also are less likely to have strong house, and less access to assets (including agricultural assets) and information. Also, they can be found most likely in the rural areas and relatively more dependent on crop farming income. These measures and findings open for a more incisive targeting in order to arrest food insecurity efficiently and these were demonstrated in the maps.

Aside from the characteristics at the household level, the models suggest some policy options to be adopted as counter measure in case of rise in vulnerability. These include: enhancing human capital in terms of education; increasing government expenditure on agriculture in terms of farm to market road, irrigation of palay or subsidy on fertilizer; and increasing household or family access to assets including agricultural assets.

References

Agresti, A.An Introduction to Categorical Data Analysis.Wiley Series in Probability and Statistics.Wiley, 2007.

Alexandrov, V., Eitzinger, J., Cajic, V. and Oberforster, M. (2002). Potential Impact of Climate Change on Selected Agricultural Crops in North-Eastern Austria. *Global Change Biology*, Vol.8, 372-389.

Anbumozhi, V. and Portugal, J. (2011). Adapting to climate change and achieving food security: Prospects and frameworks. *Presented during the ADBI-APO-KPC Workshop on Climate Change and Its Impact on Agriculture, December 13-16, Seoul, South Korea.*

Anriquez, G., Karfakis, P., Daidone, S. and Mane, E. (2010).Measuring Dietary Energy Deficiency and the Impact of Food Price Variations at the Household Level.*ESA Working Paper No.10-02.*

Arnell, N. W., Livermore, M. L., Kovats, S., Levy, P. E., Nicholls, R., Parry, M., et al. (2004). Climate and socio-economic scenarios for global-scale climate change impacts assessments: characterising the SRES storylines. *Global Environmental Change* , 3-20.

Baum, C.F., An Introduction to Modern Econometrics Using Stata, Taylor and Francis, 2006.

Buan, R.D., Maglinao, A.R., Evangelista, P.P. and Pajuelas, B.G. (1996). Vulnerability of Rice and Corn to CLimate Change in the Philippines. *Water, Air and Soil Pollution*, Vol.92, 41-51.

Capaldo, J., Karfakis, P., Knowles, M. and Smulders, M. (2010). A Model of Vulnerability to Food Insecurity. *ESA Working Paper, No.10-03*, Food and Agriculture Organization.

Conde, C., Liverman, D., Flores, M., Ferrer, R., Araujo, R., Betancourt, E., Villareal, G. and Gay, C. (1997). Vulnerability of Rainfed Maize Crops in Mexico to Climate Change. *Climate Research,* Vol.9, 17-23.

Devereux, S., Baulch, B., Hussein, K., Shoham, J., Sida, H., Wilcock, D. (2004). Improving the Analysis of Food Insecurity: Food Insecurity Measurement, LivelihoodsApproaches and Policy: Applications in FIVIMS. Rome: FAO FIVIMS.

Food and Agriculture Organization (2008). An Introduction to the Basic Concepts of Food Security. , Food and Agriculture Organization.

Fresco, L., and Baudoin, W. (2002). Food and Nutrition Security Towards Human Security. *Paper presented during the International Conference on Vegetables, Food and Nutrition Security Towards Human Security.*

Gingrich, C. D., Horst, C. D., and Umidha, C. (2001). Foreign Exchange, Food Security, and Financial Crisis in Indonesia and the Philippines. *ASEAN Economic Bulletin* , 305-319.

Gittelsohn, J., Mookherji, S. and Pelto, G. (1998). Operationalizing Household Food Security in Rural Nepal. *Food and Nutrition Bulletin,* Vol.19, No.3, pp. 210-222.

Hoddinott, J., and Yohannes, Y. (2002). Dietary Diversity as a Food Security Indicator. *FCND Discussion Paper* .

Hosmer, David W., and Lemeshow, S. Applied Logistic Regression, 2nd ed. John Wiley and Sons, Canada, 2000.

Khmaladze, Estate V. Statistical Analysis of Electricity Prices. Journal of Data Science. 2007.

Kim, M.K. (N.d.) Rice Yield Falls and Its Variability Rises Under Global Warming in Southeast Asia. Accessed from FARMD <https://www.agriskmanagementforum.org/content/rice-yield-falls-and-its-variability-rises-under-global-warming-southeast-asia> on July, 22, 2013.

Lobell, D. B., Burke, M. B., Tebaldi, C., Mastrandrea, M. D., Falcon, W. P., and Naylor, R. L. (2008). Prioritizing Climate Change Adaptation Needs for Food Security in 2030. *Science* , 607-610.

Lobell, D. and Field, C. (2007). Global Scale Climate-Crop Yield Relationships and the Impacts of Recent Warming. *Environmental Research Letters,* Vol.2, 1-7.

Lovendal, C. R., and Knowles, M. (2006). Tomorrow's hunger: A framework for analysing vulnerability to food security. *UNU-Wider Research Paper* .

Mahmood, N., Ahmad, B., Hassan, S. and Bakhsh, K. (2012). Impact of Temperature and Precipitation on Rice Productivity in Rice-Wheat Cropping System of Punjab Province. *The Journal of Animal and Plant Sciences,* Vol.22, No.4, pp.993-997.

Melgar-Quinonez, H. R., Zubieta, A. C., MkNelly, B., Nteziyaremye, A., Gerardo, M. F., and Dunford, C. (2006). Household Food Insecurity and Food Expenditure in Bolivia, Burkina Faso, and the Philippines. *The Journal of Nutrition* .

Napoli, M. (2010). Towards a Food Insecurity Multidimensional Index (FIMI). Universita Degli Studi.

Parry, M. L., Rosenzweig, C., Iglesias, A., Livermore, M., and Fischer, G. (2004). Effects of climate change on global food production under SRES emissions and socio-economic scenarios. *Global Environmental Change* , 53-67.

Karfakis, P., Knowles, M., Smulders, M., andCapaldo, J. (2010) Effects of global warming on vulnerability to food insecurity in rural Nicaragua.*ESA Working Papers 11-18,* Food and Agriculture Organization.

Pinstrup-Andersen, P. (2009). Food security: definition and measurement. *Springer Science*.

Reyes, C.M. et al (2009), Impacts of Changes in Prices of Rice and Fuel on Poverty in the Philippines. Retrieved from (http://www.pep-net.org/fileadmin/medias/pdf/CBMS_country_proj_profiles/Philippines/policy_briefs_conf_09/PB_PriceShocks_Phils.pdf).

Reyes, C. M., Sobreviñas, A., and De Jesus, J. (2010), The Impact of the Global Financial and Economic Crisis on Poverty in the Philippines. Retrieved from (http://www.pep-net.org/fileadmin/medias/pdf/CBMS_country_proj_profiles/Philippines/policy_briefs_conf_09/PB_GFC_Phils.pdf)

Rosenzweig, C., and Parry, M. (1994). Potential Impact of Climate Change on World Food Supply. *Nature* .

Sanchez, P. A. (2000). Linking climate change research with food security and poverty reduction in the tropics. *Agriculture, Ecosystems and Environment* , 371-383.

Sarris, A., andKarfakis, P. (2010).Vulnerability to Covariate and Idiosyncratic Shocks and Safety Net Targeting of Rural Households with an Application to Rural Tanzania.*ERD Conference on Social Safety Nets.*

Schmidhumber, J. and Tubiello, F. (2007). Global Food Security Under Climate Change. (http://www.pnas.org/content/104/50/19703.full.pdf.)

Sheather, Simon J. A. A Modern Approach to Regression with R. Springer Science+Business Media, LLC, New York, USA, 2009.

T. Hastie and R. Tibshirani. Generalized additive models. Statistical Science, 1(3):297{310, 1986..

Stata Press. Stata Base Reference Manual: Release 12. Stata release 12. StatacorpLp, 2011.

Sumner, G., Homar, V., and Ramis, C. (2001). Precipitation Seasonality In Eastern And Southern Coastal Spain. *International Journal Of Climatology, 21*, 219-247.

Webb, P., Coates, J., Frongillo, E. A., Rogers, B. L., Swindale, A., and Bilinsky, P. (2006). Measuring Household Food Insecurity: Why It's So Important and Yet So Difficult to Do. *The Journal of Nutrition* .

Wooldridge, J. (2002) Econometric Analysis of Cross Section and Panel Data. Econometric Analysis of Cross Section and Panel Data.Massachusetts Institute of Technology 2002.

Weismann, D., von Braun, J., andFeldbriigge, T. (2002). An International Nutrition Index: A Big Picture of Successes and Failures in Addressing Hunger and Malnutrition. *Quarterly Journal of International Agriculture, Vol.4,* No. 4, pp.277-296.

Ziervogel, G., Nyong, A., Osman, B. Conde, C. Cortes, S. and Downing, T. (2006). Climate variability and change: implications for household food security. *AIACC Working Paper No. 20.*

Ziervogel, G., and Ericksen, P. J. (2010). Adapting to climate change to sustain food security. *Advanced Review* , 525-540.

Annex 1. Models

Table 1. Rainfall model, FIES 2009

	2009					
	ln of income from farming			ln of food expenditure per capita		
	Coef.	**Sig.**	**Std. Err.**	**Coef.**	**Sig.**	**Std. Err.**
ln of income from farming				0.141	***	0.014
Age of HH	-0.004	***	0.001	0.006	***	0.000
Female Head	-0.360	***	0.032	0.118	***	0.012
Highest Educational Attainment of HH head						
No Grade						
Elem undergraduate_2	-0.205	***	0.044	0.103	***	0.016
Elem graduate_3	-0.147	***	0.046	0.163	***	0.016
HS undergraduate _4	-0.164	***	0.051	0.171	***	0.018
HS graduate_5	-0.174	***	0.051	0.242	***	0.018
College undergraduate_6	-0.137	**	0.061	0.288	***	0.021
College graduate_7	0.054		0.074	0.425	***	0.026
HH with cash received from abroad	-0.073	***	0.027	0.138	***	0.009
HH with strong construction materials of walls and roof	0.190	***	0.023	0.052	***	0.008
HH has safe water	-0.146	***	0.023	0.059	***	0.008
HH with radio	0.130	***	0.020	0.024	***	0.007
HH with TV sets	0.087	***	0.025	0.095	***	0.009
HH with telephones	0.132	***	0.023	0.028	***	0.008
HH with cars	0.512	***	0.054	0.167	***	0.020
HH with motorcycles	0.206	***	0.029	0.067	***	0.010
HH with cash loan payments	0.136	***	0.023	-0.010		0.008
HH with expenditure on insurance and premiums	-0.210	***	0.031	0.156	***	0.011
CPI of food	0.253		0.203	0.006		0.065
% change in rainfall						
-10% - <0%	0.166	***	0.015			
0%-<10%	0.031	***	0.012			
10% - <20%	-0.015	**	0.007			
>=20%	-0.005	***	0.001			
dummy % change in rainfall						
-10% - <0%	0.866	***	0.088			
0%-<10%	-0.261	***	0.093			
10% - <20%	-0.094		0.119			
FMR spending	0.001	***	0.000			
Irrigation spending on palay	0.026	***	0.002			
Urban	0.128	***	0.028			
Constant	8.861	***	0.290	4.893	***	0.155

Table 2. Seasonality model, FIES 2009

	2009					
	ln of income from farming			ln of food expenditure per capita		
	Coef.	Sig.	Std. Err.	Coef.	Sig.	Std. Err.
ln of income from farming				0.131	***	0.014
Age of HH	-0.004	***	0.001	0.006	***	0.000
Female Head	-0.355	***	0.032	0.114	***	0.012
Highest Educational Attainment of HH head						
No Grade						
Elem undergraduate_2	-0.266	***	0.044	0.099	***	0.016
Elem graduate_3	-0.222	***	0.046	0.160	***	0.016
HS undergraduate _4	-0.244	***	0.051	0.168	***	0.018
HS graduate_5	-0.255	***	0.050	0.240	***	0.018
College undergraduate_6	-0.217	***	0.061	0.285	***	0.021
College graduate_7	-0.050		0.074	0.424	***	0.025
HH with cash received from abroad	-0.083	***	0.027	0.138	***	0.009
HH with strong construction materials of walls and roof	0.178	***	0.023	0.055	***	0.008
HH has safe water	-0.144	***	0.022	0.057	***	0.008
HH with radio	0.137	***	0.020	0.026	***	0.007
HH with TV sets	0.070	***	0.025	0.096	***	0.009
HH with telephones	0.140	***	0.023	0.029	***	0.008
HH with cars	0.526	***	0.054	0.173	***	0.020
HH with motorcycles	0.204	***	0.029	0.070	***	0.010
HH with cash loan payments	0.132	***	0.023	-0.008		0.008
HH with expenditure on insurance and premiums	-0.184	***	0.031	0.153	***	0.011
CPI of food	1.839	***	0.214	0.016		0.064
% change in seasonality index						
<-20%	0.017	***	0.001			
<=2-0% - <-10%	-0.072		0.086			
-10% - <0%	0.047	***	0.011			
0%-<10%	-0.026	**	0.012			
10% - <20%	0.053	***	0.014			
>=20%	-0.026	.	0.017			
dummy % change in seasonality index						
<-20%	-0.058		0.530			
<=2-0% - <-10%	-1.992	*	1.195			
-10% - <0%	-0.614		0.533			

0%-<10%	-0.744		0.532			
10% - <20%	-1.651	***	0.566			
FMR spending	0.001	***	0.000			
Irrigation spending on palay	0.032	***	0.002			
Urban	0.097	***	0.028			
Constant	7.355	***	0.531	4.991	***	0.155

Table 3. Volatility model, FIES 2009

	2009					
	ln of income from farming			**ln of food expenditure per capita**		
	Coef.	**Sig.**	**Std. Err.**	**Coef.**	**Sig.**	**Std. Err.**
ln of income from farming				0.167	***	0.016
Age of HH	-0.005	***	0.001	0.006	***	0.000
Female Head	-0.364	***	0.033	0.128	***	0.013
Highest Educational Attainment of HH head						
No Grade						
Elem undergraduate_2	-0.271	***	0.043	0.111	***	0.016
Elem graduate_3	-0.219	***	0.045	0.170	***	0.016
HS undergraduate _4	-0.243	***	0.050	0.180	***	0.018
HS graduate_5	-0.244	***	0.050	0.250	***	0.018
College undergraduate_6	-0.201	***	0.060	0.295	***	0.022
College graduate_7	-0.042		0.074	0.428	***	0.026
HH with cash received from abroad	-0.069	***	0.027	0.139	***	0.010
HH with strong construction materials of walls and roof	0.187	***	0.023	0.047	***	0.009
HH has safe water	-0.139	***	0.023	0.062	***	0.008
HH with radio	0.132	***	0.020	0.020	***	0.008
HH with TV sets	0.078	***	0.025	0.092	***	0.009
HH with telephones	0.138	***	0.023	0.024	***	0.009
HH with cars	0.537	***	0.055	0.152	***	0.021
HH with motorcycles	0.189	***	0.029	0.063	***	0.011
HH with cash loan payments	0.123	***	0.023	-0.013	.	0.008
HH with expenditure on insurance and premiums	-0.195	***	0.031	0.162	***	0.012
CPI of food	1.538	***	0.209	-0.016		0.066
% change in volatility						
<-20%	0.014	***	0.001			
<=2-0% - <-10%	-0.016		0.015			
-10% - <0%	-0.014	*	0.007			
0%-<10%	0.043	***	0.012			

10% - <20%	-0.209	**	0.098			
>=20%	0.007		0.007			
dummy % change in volatility						
<-20%	0.932	***	0.262			
<=2-0% - <-10%	-0.215		0.330			
-10% - <0%	0.304		0.262			
0%-<10%	-0.038		0.266			
10% - <20%	3.328	**	1.536			
FMR spending	0.001	***	0.000			
Irrigation spending on palay	0.022	***	0.002			
Urban	0.115	***	0.028			
Constant	6.969	***	0.376	4.654	***	0.167

Table 4. Temperature model, FIES 2009

	2009.000					
	ln of income from farming			**ln of food expenditure per capita**		
	Coef.	**Sig.**	**Std. Err.**	**Coef.**	**Sig.**	**Std. Err.**
ln of income from farming				0.169	***	0.016
Age of HH	-0.005	***	0.001	0.006	***	0.000
Female Head	-0.360	***	0.033	0.129	***	0.013
Highest Educational Attainment of HH head						
No Grade						
Elem undergraduate_2	-0.308	***	0.043	0.112	***	0.016
Elem graduate_3	-0.264	***	0.045	0.171	***	0.016
HS undergraduate _4	-0.280	***	0.050	0.180	***	0.018
HS graduate_5	-0.293	***	0.050	0.251	***	0.018
College undergraduate_6	-0.257	***	0.060	0.295	***	0.022
College graduate_7	-0.082		0.074	0.429	***	0.026
HH with cash received from abroad	-0.088	***	0.027	0.139	***	0.010
HH with strong construction materials of walls and roof	0.193	***	0.023	0.046	***	0.009
HH has safe water	-0.172	***	0.022	0.063	***	0.008
HH with radio	0.145	***	0.020	0.020	***	0.008
HH with TV sets	0.057	***	0.025	0.092	***	0.009
HH with telephones	0.149	***	0.023	0.024	***	0.009
HH with cars	0.537	***	0.054	0.152	***	0.021
HH with motorcycles	0.186	***	0.029	0.062	***	0.011
HH with cash loan payments	0.121	***	0.023	-0.013	.	0.008
HH with expenditure on insurance and premiums	-0.175	***	0.031	0.162	***	0.012

CPI of food	0.018	***	0.002	0.000		0.001
Temperature						
Decrease in min temp	0.990	***	0.338			
Increase in max temp	-0.249	***	0.064			
Dummy Temperature						
Decrease in min temp	0.728	***	0.078			
Increase in max temp	0.028		0.029			
FMR spending	0.001	***	0.000			
Irrigation spending on palay	0.021	***	0.002			
Urban	0.108	***	0.028			
Constant	7.156	***	0.271	4.638	***	0.169

Table 5. IV validation tests, FIES 2009

Adjusted model	**Rainfall**		**Seasonality**		**Volatility**		**Temperature**	
Normality								
	z	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**
Swilk	9.046	0	8.734	0	9.223	0	9.341	0
	chi2(2)	**Prob>chi2**	**chi2(2)**	**Prob>chi2**	**chi2(2)**	**Prob>chi2**	**chi2(2)**	**Prob>chi2**
Sktest	203.8	0	179.9	0	218.7	0	229.2	0
	z	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**
Sfrancia	0.658	0.255	0.635	0.263	0.67	0.251	0.677	0.249
	Test Statistic	**p-value**	**Test Statistic**	**p-value**	**Test Statistic**	**p-value**	**Test Statistic**	**p-value**
Underidentification								
Anderson	Chi-sq(10)=550.33	0	Chi-sq(14)=551.94	0	Chi-sq(14)=500.78	0	Chi-sq(7)=475.42	0
Cragg-Donald	Chi-sq(10)=575.34	0	Chi-sq(14)=577.10	0	Chi-sq(14)=521.40	0	Chi-sq(7)=493.97	0
Weak Instrument								
Cragg-Donald Wald	57.4		41.11		37.14		70.42	
Anderson-Rubin Wald	F(10,12631)=33.33	0	F(14,12627)=27.39	0	F(14,12627)=26.50	0	F(7,12634)=44.31	0

Anderson-Rubin Wald	Chi-sq(10)=334.09	0	Chi-sq(14)=384.46	0	Chi-sq(14)=372.06	0	Chi-sq(7)=310.81	0
Overidentification								
Sargan	Chi-sq(9)=191.7	0	Chi-sq(13)=259.1	0	Chi-sq(13)=222.4	0	Chi-sq(6)=166.6	0
Ivendog								
Wu-Hausman	F(1,12639) =62.12	0	F(1,12639) =44.8	0	F(1,12639) =60.14	0	F(1,12639) =62.12	0
Durbin-Wu-Hausman	Chi-sq(1)=61.92	0	Chi-sq(1)=44.4	0	Chi-sq(1)=59.96	0	Chi-sq(1)=61.92	0

Table 6. Rainfall model, CBMS 2007-2010

Variable	Income from crop farming (log)					With malnourished				
	Coef.	**Std. Err.**	**Sig code**	**Robust SE**	**Robust Sig**	**Coef.**	**Std. Err.**	**Sig code**	**Robust SE**	**Robust Sig**
Income from crop farming (log)						-0.248	0.011	***	0.012	***
Female head	-0.213	0.011	***	0.012	***	-0.057	0.022	***	0.022	***
Age of head	0.006	0.000	***	0.000	***	-0.007	0.000	***	0.000	***
Household size	0.026	0.001	***	0.001	***	0.054	0.002	***	0.002	***
IP indicator	-0.263	0.008	***	0.008	***	0.096	0.011	***	0.011	***
With OFW	-0.014	0.010		0.011		-0.086	0.022	***	0.022	***

With safe water	0.056	0.006	***	0.006	***	-0.033	0.011	***	0.011	***
With radio	0.109	0.006	***	0.006	***	-0.048	0.010	***	0.010	***
With telephone	0.250	0.018	***	0.021	***	-0.172	0.045	***	0.046	***
With cellphone	0.182	0.006	***	0.006	***	-0.132	0.012	***	0.013	***
Availed govt prog	-0.049	0.006	***	0.006	***	0.141	0.010	***	0.010	***
Illness shock	-0.065	0.005	***	0.005	***	0.132	0.010	***	0.010	***
Urban	0.000	0.008		0.009		-0.149	0.017	***	0.017	***
CPI - food	4.560	0.092	***	0.095	***	0.105	0.057	*	0.057	*
Education of head										
Below elementary	base									
Elem level	0.142	0.012	***	0.012	***	-0.162	0.018	***	0.018	***
Elem grad	0.201	0.013	***	0.013	***	-0.206	0.021	***	0.020	***
HS level	0.173	0.014	***	0.013	***	-0.230	0.022	***	0.021	***

HS Grad	0.200	0.014	***	0.013	***	-0.293	0.022	***	0.022	***
Coll level	0.275	0.015	***	0.015	***	-0.288	0.027	***	0.026	***
Coll grad	0.371	0.019	***	0.020	***	-0.343	0.039	***	0.039	***
With agri org	0.136	0.016	***	0.015	***					
With thresher	0.313	0.007	***	0.007	***					
With dryer	0.212	0.011	***	0.010	***					
With irrigation pump	0.278	0.010	***	0.009	***					
Relative change in rainfall										
<-20%	-0.070	0.006	***	0.006	***					
<=-20% - <-10%	0.027	0.004	***	0.004	***					
-10% - <0%	0.031	0.004	***	0.004	***					
0%-<10%	0.011	0.003	***	0.004	***					
10% - <20%	0.025	0.003	***	0.003	***					
>=20%	0.013	0.001	***	0.001	***					

Relative change in rainfall (dummies)										
<-20%	base									
<=-20% - <-10%	1.697	0.155	***	0.157	***					
-10% - <0%	1.520	0.146	***	0.148	***					
0%-<10%	1.569	0.145	***	0.146	***					
10% - <20%	1.315	0.148	***	0.149	***					
>=20%	1.420	0.149	***	0.151	***					
Cost of fertilizer	-1.418	0.036	***	0.040	***					
Expenditure on farm to market road	0.0572	0.0127	***	0.0138	***					
Road density category										
4.25-6.31	base									
6.31-6.37	-0.6550	0.0182	***	0.0186	***					
6.37-7.51	-1.3110	0.0227	***	0.0230	***					
7.51-7.62	-0.7920	0.0188	***	0.0194	***					
7.62-9.42	-1.6360	0.0344	***	0.0380	***					

9.42-10.32	-0.3660	0.0184	***	0.0187	***					
10.32-12.75	-0.6900	0.0250	***	0.0258	***					
>12.75	-1.6250	0.0303	***	0.0322	***					
Time control (quarter)										
20072	-0.0387	0.0287		0.0292						
20073	0.2510	0.0331	***	0.0330	***					
20074	0.1200	0.0455	***	0.0451	***					
20081	0.2930	0.0365	***	0.0383	***					
20082	0.2130	0.0359	***	0.0379	***					
20083	0.1920	0.0372	***	0.0396	***					
20084	0.1590	0.0396	***	0.0418	***					
20091	0.0466	0.0368		0.0376						
20092	-0.0556	0.0347	.	0.0359	.					
20093	-0.2320	0.0360	***	0.0374	***					

20094	-0.2180	0.0392	***	0.0408	***					
20101	-0.5200	0.0419	***	0.0436	***					
20102	-0.3120	0.0407	***	0.0421	***					
20103	-0.3980	0.0412	***	0.0431	***					
20104	-0.1980	0.0423	***	0.0447	***					
adjustment	-0.0316	0.0163	*	0.0173	*					
Intercept	4.1060	0.1790	***	0.1810	***	0.705	0.103	***	0.114	***
Wald's Chi-test for exogeneity							315.9	***	249.1	***
Sig. codes *** 2.5% ** 5% * 10% . 15%										

Table 7. Rainfall seasonality model, CBMS 2007-2010

Variable	**Income from crop farming (log)**					**With malnourished**				
	Coef.	**Std. Err.**	**Sig code**	**Robust SE**	**Robust Sig**	**Coef.**	**Std. Err.**	**Sig code**	**Robust SE**	**Robust Sig**
Income from crop farming (log)						-0.258	0.011	***	0.012	***

Female head	-0.217	0.011	***	0.012	***	-0.060	0.022	***	0.022	***
Age of head	0.006	0.000	***	0.000	***	-0.007	0.000	***	0.000	***
Household size	0.025	0.001	***	0.001	***	0.054	0.002	***	0.002	***
IP indicator	-0.239	0.008	***	0.008	***	0.099	0.011	***	0.011	***
With OFW	-0.018	0.010	*	0.011	.	-0.087	0.022	***	0.022	***
With safe water	0.060	0.006	***	0.006	***	-0.032	0.011	***	0.011	***
With radio	0.118	0.006	***	0.006	***	-0.046	0.010	***	0.010	***
With telephone	0.246	0.018	***	0.021	***	-0.169	0.045	***	0.045	***
With cellphone	0.193	0.006	***	0.006	***	-0.129	0.012	***	0.013	***
Availed govt prog	-0.054	0.006	***	0.006	***	0.140	0.010	***	0.010	***
Illness shock	-0.064	0.005	***	0.005	***	0.131	0.010	***	0.010	***
Urban	-0.001	0.008		0.009		-0.148	0.017	***	0.017	***

CPI - food	4.232	0.092	***	0.095	***	0.123	0.057	**	0.057	**
Education of head										
Below elementary	base									
Elem level	0.140	0.012	***	0.012	***	-0.159	0.018	***	0.018	***
Elem grad	0.200	0.013	***	0.013	***	-0.203	0.021	***	0.020	***
HS level	0.169	0.014	***	0.013	***	-0.227	0.022	***	0.021	***
HS Grad	0.194	0.014	***	0.013	***	-0.289	0.022	***	0.022	***
Coll level	0.265	0.015	***	0.015	***	-0.282	0.027	***	0.026	***
Coll grad	0.354	0.019	***	0.020	***	-0.336	0.039	***	0.039	***
With agri org	0.153	0.016	***	0.016	***					
With thresher	0.325	0.007	***	0.007	***					
With dryer	0.212	0.011	***	0.010	***					
With irrigation pump	0.281	0.010	***	0.009	***					
Relative change in rainfall seasonality										

<-20%	0.003	0.001	***	0.001	***					
<=-20% - <-10%	0.023	0.005	***	0.005	***					
-10% - <0%	-0.003	0.003		0.003						
0%-<10%	0.001	0.004		0.004						
10% - <20%	0.003	0.004		0.004						
>=20%	0.012	0.001	***	0.001	***					
Relative change in rainfall seasonality (dummies)										
<-20%	base									
<=-20% - <-10%	0.228	0.069	***	0.069	***					
-10% - <0%	0.020	0.034		0.035						
0%-<10%	0.016	0.035		0.036						
10% - <20%	0.055	0.064		0.067						
>=20%	-0.078	0.044	*	0.045	*					
Cost of fertilizer	-1.238	0.032	***	0.035	***					
Road density category										

4.25-6.31	base									
6.31-6.37	-0.791	0.022	***	0.023	***					
6.37-7.51	-1.420	0.024	***	0.024	***					
7.51-7.62	-0.788	0.020	***	0.020	***					
7.62-9.42	-1.773	0.035	***	0.039	***					
9.42-10.32	-0.449	0.020	***	0.020	***					
10.32-12.75	-0.828	0.025	***	0.025	***					
>12.75	-1.551	0.023	***	0.024	***					
Time control (quarter)										
20072	-0.1360	0.0284	***	0.0290	***					
20073	0.0880	0.0322	***	0.0322	***					
20074	-0.0745	0.0447	*	0.0444	*					
20081	0.1720	0.0367	***	0.0377	***					

20082	0.1800	0.0361	***	0.0374	***					
20083	0.1610	0.0375	***	0.0389	***					
20084	0.0457	0.0406		0.0419						
20091	0.1570	0.0382	***	0.0389	***					
20092	0.0003	0.0385		0.0395						
20093	-0.0682	0.0357	*	0.0366	*					
20094	0.0619	0.0370	*	0.0380	.					
20101	-0.3280	0.0416	***	0.0431	***					
20102	-0.2990	0.0412	***	0.0426	***					
20103	-0.5060	0.0396	***	0.0415	***					
20104	-0.1680	0.0399	***	0.0420	***					
adjustment	-0.0079	0.0167		0.0177						
Intercept	5.9310	0.1020	***	0.1050	***	0.768	0.103	***	0.115	***

Wald's Chi-test for exogeneity							336.7	***	259.9	***
Sig. codes *** 2.5% ** 5% * 10% . 15%										

Table 8. Rainfall volatility model, CBMS 2007-2010

Variable	Income from crop farming (log)					With malnourished				
	Coef.	Std. Err.	Sig code	Robust SE	Robust Sig	Coef.	Std. Err.	Sig code	Robust SE	Robust Sig
Income from crop farming (log)						-0.256	0.011	***	0.012	***
Female head	-0.216	0.011	***	0.012	***	-0.060	0.022	***	0.022	***
Age of head	0.006	0.000	***	0.000	***	-0.007	0.000	***	0.000	***
Household size	0.024	0.001	***	0.001	***	0.054	0.002	***	0.002	***
IP indicator	-0.211	0.008	***	0.008	***	0.102	0.011	***	0.011	***
With OFW	-0.020	0.010	*	0.011	*	-0.087	0.022	***	0.022	***
With safe water	0.048	0.006	***	0.006	***	-0.033	0.011	***	0.011	***
With radio	0.125	0.006	***	0.006	***	-0.046	0.010	***	0.010	***

With telephone	0.240	0.018	***	0.021	***	-0.169	0.045	***	0.046	***
With cellphone	0.204	0.006	***	0.006	***	-0.129	0.012	***	0.013	***
Availed govt prog	-0.059	0.006	***	0.006	***	0.140	0.010	***	0.010	***
Illness shock	-0.067	0.005	***	0.005	***	0.131	0.010	***	0.010	***
Urban	0.011	0.008		0.009		-0.148	0.017	***	0.017	***
CPI - food	3.982	0.095	***	0.098	***	0.127	0.058	**	0.057	**
Education of head										
Below elementary	base									
Elem level	0.153	0.012	***	0.012	***	-0.158	0.018	***	0.018	***
Elem grad	0.217	0.013	***	0.013	***	-0.201	0.021	***	0.020	***
HS level	0.184	0.014	***	0.013	***	-0.225	0.022	***	0.021	***
HS Grad	0.209	0.014	***	0.013	***	-0.288	0.022	***	0.022	***
Coll level	0.276	0.015	***	0.015	***	-0.282	0.027	***	0.026	***

Coll grad	0.361	0.019	***	0.020	***	-0.336	0.039	***	0.039	***
With agri org	0.155	0.016	***	0.016	***					
With thresher	0.323	0.007	***	0.007	***					
With dryer	0.203	0.011	***	0.010	***					
With irrigation pump	0.260	0.010	***	0.009	***					
Relative change in rainfall volatility										
<-20%	0.015	0.001	***	0.001	***					
<=-20% - <-10%	0.020	0.002	***	0.002	***					
-10% - <0%	0.014	0.002	***	0.002	***					
0%-<10%	0.030	0.003	***	0.003	***					
10% - <20%	0.005	0.004		0.004						
>=20%	0.012	0.003	***	0.003	***					
Relative change in rainfall volatility (dummies)										
<-20%	base									
<=-20% - <-10%	-0.163	0.043	***	0.042	***					

-10% - <0%	-0.373	0.031	***	0.032	***					
0%-<10%	-0.708	0.034	***	0.036	***					
10% - <20%	-0.534	0.068	***	0.068	***					
>=20%	-0.736	0.085	***	0.081	***					
Cost of fertilizer	-1.335	0.032	***	0.034	***					
Road density category										
4.25-6.31	base									
6.31-6.37	-0.568	0.020	***	0.021	***					
6.37-7.51	-1.419	0.023	***	0.024	***					
7.51-7.62	-0.887	0.017	***	0.018	***					
7.62-9.42	-1.883	0.034	***	0.038	***					
9.42-10.32	-0.474	0.018	***	0.018	***					

10.32-12.75	-0.905	0.021	***	0.021	***					
>12.75	-1.715	0.022	***	0.022	***					
Time control (quarter)										
20072	-0.2070	0.0295	***	0.0302	***					
20073	0.1330	0.0352	***	0.0358	***					
20074	-0.0590	0.0461		0.0458						
20081	0.3650	0.0390	***	0.0402	***					
20082	0.3220	0.0385	***	0.0399	***					
20083	0.3770	0.0396	***	0.0412	***					
20084	0.2420	0.0418	***	0.0433	***					
20091	0.4050	0.0387	***	0.0392	***					
20092	0.4210	0.0388	***	0.0398	***					
20093	0.2080	0.0381	***	0.0390	***					
20094	0.4220	0.0376	***	0.0384	***					

20101	0.0656	0.0442	.	0.0455	.					
20102	-0.0046	0.0448		0.0461						
20103	-0.2310	0.0457	***	0.0477	***					
20104	0.0678	0.0436	.	0.0454	.					
adjustment	-0.0827	0.0161	***	0.0171	***					
Intercept	6.6740	0.1070	***	0.1110	***	0.745	0.102	***	0.114	***
Wald's Chi-test for exogeneity							330.8	***	255.9	***
Sig. codes *** 2.5% ** 5% * 10% . 15%										

Table 9. Temperature model, CBMS 2007-2010

Variable	Income from crop farming (log)					With malnourished				
	Coef.	**Std. Err.**	**Sig code**	**Robust SE**	**Robust Sig**	**Coef.**	**Std. Err.**	**Sig code**	**Robust SE**	**Robust Sig**
Income from crop farming (log)						-0.253	0.011	***	0.012	***
Female head	-0.216	0.011	***	0.012	***	-0.059	0.022	***	0.022	***

Age of head	0.006	0.000	***	0.000	***	-0.007	0.000	***	0.000	***
Household size	0.025	0.001	***	0.001	***	0.054	0.002	***	0.002	***
IP indicator	-0.275	0.008	***	0.008	***	0.099	0.011	***	0.011	***
With OFW	-0.015	0.010		0.011		-0.086	0.022	***	0.022	***
With safe water	0.043	0.006	***	0.006	***	-0.034	0.011	***	0.011	***
With radio	0.114	0.006	***	0.006	***	-0.047	0.010	***	0.010	***
With telephone	0.248	0.018	***	0.021	***	-0.170	0.045	***	0.046	***
With cellphone	0.197	0.006	***	0.006	***	-0.130	0.012	***	0.013	***
Availed govt prog	-0.052	0.006	***	0.006	***	0.141	0.010	***	0.010	***
Illness shock	-0.076	0.005	***	0.005	***	0.131	0.010	***	0.010	***
Urban	0.003	0.008		0.009		-0.149	0.017	***	0.017	***
CPI - food	4.186	0.093	***	0.095	***	0.117	0.058	**	0.057	**
Education of head										

Below elementary	base									
Elem level	0.149	0.012	***	0.012	***	-0.160	0.018	***	0.018	***
Elem grad	0.208	0.013	***	0.013	***	-0.203	0.021	***	0.020	***
HS level	0.171	0.014	***	0.013	***	-0.227	0.022	***	0.021	***
HS Grad	0.200	0.014	***	0.013	***	-0.290	0.022	***	0.022	***
Coll level	0.264	0.015	***	0.015	***	-0.284	0.027	***	0.026	***
Coll grad	0.349	0.019	***	0.020	***	-0.338	0.039	***	0.039	***
With agri org	0.146	0.016	***	0.016	***					
With thresher	0.302	0.007	***	0.007	***					
With dryer	0.205	0.011	***	0.010	***					
With irrigation pump	0.245	0.010	***	0.009	***					
Change in temperatures										
Change in minimum temperature	0.639	0.042	***	0.044	***					

Increase in minimum temperature	-0.333	0.047	***	0.049	***					
Change in maximum temperature	-0.093	0.022	***	0.021	***					
Increase in maximum temp	0.089	0.028	***	0.027	***					
Cost of fertilizer	-1.222	0.033	***	0.035	***					
Expenditure on farm to market road	0.019	0.013		0.014						
Road density category										
4.25-6.31	base									
6.31-6.37	-0.538	0.018	***	0.019	***					
6.37-7.51	-1.167	0.021	***	0.021	***					
7.51-7.62	-0.883	0.018	***	0.019	***					
7.62-9.42	-1.658	0.035	***	0.038	***					
9.42-10.32	-0.555	0.019	***	0.019	***					
10.32-12.75	-0.673	0.024	***	0.026	***					

>12.75	-1.723	0.032	***	0.034	***						
Time control (quarter)											
20072	0.060	0.028	**	0.028	**						
20073	0.339	0.031	***	0.030	***						
20074	0.219	0.044	***	0.042	***						
20081	0.550	0.035	***	0.036	***						
20082	0.513	0.034	***	0.036	***						
20083	0.441	0.036	***	0.038	***						
20084	0.270	0.039	***	0.040	***						
20091	0.361	0.035	***	0.035	***						
20092	0.228	0.033	***	0.034	***						
20093	0.202	0.033	***	0.034	***						
20094	0.519	0.033	***	0.034	***						
20101	0.248	0.038	***	0.039	***						
20102	0.398	0.040	***	0.041	***						

20103	0.156	0.041	***	0.042	***					
20104	0.476	0.038	***	0.039	***					
adjustment	-0.093	0.017	***	0.018	***					
Intercept	5.467	0.099	***	0.100	***	0.732	0.103	***	0.114	***
Wald's Chi-test for exogeneity							320.6	***	253.6	***

Table 10. Integrated (PCR) model, CBMS 2007-2010

Variable	Income from crop farming (log)					With malnourished				
	Coef.	Std. Err.	Sig code	Robust SE	Robust Sig	Coef.	Std. Err.	Sig code	Robust SE	Robust Sig
Income from crop farming (log)						-0.242	0.011	***	0.012	***
Female head	-0.235	0.011	***	0.012	***	-0.113	0.022	***	0.022	***
Age of head	0.005	0.000	***	0.000	***	-0.001	0.000	*	0.000	*
Share of dependents	-0.025	0.017	.	0.017	.	0.702	0.032	***	0.031	***
IP indicator	-0.282	0.009	***	0.009	***	0.087	0.012	***	0.012	***

With strong dwelling	-0.075	0.010	***	0.011	***	-0.078	0.022	***	0.023	***
Owned dwelling	0.186	0.007	***	0.007	***	-0.061	0.012	***	0.013	***
With electricity	0.112	0.006	***	0.006	***	-0.045	0.010	***	0.010	***
With OFW	0.095	0.007	***	0.007	***	-0.125	0.012	***	0.011	***
With safe water	0.067	0.006	***	0.006	***	-0.023	0.010	**	0.011	**
With radio	0.144	0.018	***	0.021	***	-0.105	0.045	***	0.046	***
With telephone	0.060	0.007	***	0.007	***	-0.034	0.013	***	0.013	***
With cellphone	0.295	0.008	***	0.009	***	-0.025	0.018		0.019	
Availed govt prog	-0.040	0.006	***	0.006	***	0.147	0.010	***	0.010	***
Illness shock	-0.069	0.005	***	0.005	***	0.135	0.010	***	0.010	***
Urban	-0.012	0.008	.	0.009		0.017	-8.410	***	-8.400	***
CPI - food	4.634	0.091	***	0.095	***	0.058	3.370	*	3.430	*
Education of head										

Below elementary	base									
Elem level	0.127	0.012	***	0.012	***	-0.141	0.018	***	0.018	***
Elem grad	0.160	0.013	***	0.160		-0.171	0.021	***	0.020	***
HS level	0.110	0.014	***	0.110		-0.196	0.022	***	0.021	***
HS Grad	0.109	0.014	***	0.109		-0.259	0.022	***	0.022	***
Coll level	0.129	0.015	***	0.129		-0.251	0.027	***	0.026	***
Coll grad	0.165	0.019	***	0.165		-0.303	0.039	***	0.039	***
With agri org	0.123	0.016	***	0.015	***					
With thresher	0.296	0.007	***	0.007	***					
With dryer	0.191	0.011	***	0.010	***					
With irrigation pump	0.235	0.010	***	0.009	***					
Principal Components										
1	0.043	0.002	***	0.002	***					
2	0.080	0.003	***	0.003	***					

3	-0.033	0.003	***	0.003	***					
4	-0.065	0.003	***	0.003	***					
5	-0.030	0.003	***	0.003	***					
Cost of fertilizer	-1.271	0.034	***	0.037	***					
Expenditure on farm to market road	0.046	0.013	***	0.014	***					
Irrigation expenditure	0.004	0.001	***	0.001	***					
Road density category										
4.25-6.31	base									
6.31-6.37	-0.762	0.021	***	0.021	***					
6.37-7.51	-1.377	0.023	***	0.023	***					
7.51-7.62	-0.791	0.018	***	0.018	***					
7.62-9.42	-1.666	0.033	***	0.037	***					
9.42-10.32	-0.542	0.023	***	0.024	***					
10.32-12.75	-0.685	0.024	***	0.025	***					
>12.75	-1.669	0.032	***	0.034	***					
Time control (quarter)										

20072	-0.021	0.028		0.029						
20073	0.274	0.031	***	0.031	***					
20074	0.111	0.044	***	0.044	***					
20081	0.114	0.037	***	0.038	***					
20082	0.058	0.036	.	0.037	.					
20083	-0.022	0.037		0.039						
20084	-0.099	0.040	***	0.041	***					
20091	-0.106	0.037	***	0.038	***					
20092	-0.209	0.037	***	0.038	***					
20093	-0.328	0.036	***	0.037	***					
20094	-0.220	0.039	***	0.040	***					
20101	-0.502	0.043	***	0.044	***					
20102	-0.251	0.043	***	0.045	***					
20103	-0.365	0.044	***	0.045	***					
20104	-0.158	0.046	***	0.049	***					
adjustment	-0.016	0.016		0.017						

Intercept	5.694	0.097	***	0.100	***	0.291	0.110	***	0.121	***
Wald's Chi-test for exogeneity							316.8	***	254.7	***
Sig. codes *** 2.5% ** 5% * 10% . 15%										

Table 11. Summary of diagnostics checking for FIES Data, 2009

Without Outliers	**Original data**	**Rainfall**		**Seasonality**		**Volatility**		**Temperature**	
Number of Provinces									
1st stage	80	72		66		60		74	
2nd stage	80	78		78		78		78	
Number of Observations									
1st stage	12675	10768		10251		9448		10953	
2nd stage	12675	11690		11,043		11671		11011	
Normality									
Swilk		**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**
1st stage		14.62	0	14.66	0	14.63	0	14.55	0
2nd stage		9.379	0	8.643	0	9.486	0	8.755	0
Sktest		**chi2(2)**	**Prob>chi2**	**chi2(2)**	**Prob>chi2**	**chi2(2)**	**Prob>chi2**	**chi2(2)**	**Prob>chi2**
1st stage		1593	0	1601	0	1571	0	1537	0
2nd stage		232.9	0	173.7	0	243	0	181.6	0
Sfrancia		**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**
1st stage		0.824	0.205	0.824	0.205	0.824	0.205	0.823	0.205
2nd stage		0.68	0.248	0.628	0.265	0.686	0.246	0.637	0.262
IVVIF									
2nd stage									
Variable		**VIF**							
IVHETTEST									
		Pagan-Hall TS	**p-value**	**Pagan-Hall TS**	**p-value**	**Pagan-Hall TS**	**p-value**	**Pagan-Hall TS**	**p-value**
Initial Model		Chi-sq(30)=268.7	0	Chi-sq(34)=244.1	0	Chi-sq(34)=175.3	0	Chi-sq(27)=159.6	0
NORMALITY									
		Test Statistic	**p-value**	**Test Statistic**	**p-value**	**Test Statistic**	**p-value**	**Test Statistic**	**p-value**
Underidentification									
Anderson		Chi-sq(10)=513.14	0	Chi-sq(14)=502.48	0	Chi-sq(14)=457.18	0	Chi-sq(7)=437.37	0
Cragg-Donald		Chi-sq(10)=534.82	0	Chi-sq(14)=523.25	0	Chi-sq(14)=474.31	0	Chi-sq(7)=453.02	0
Weak Instrument									
Cragg-Donald Wald		53.36		37.27		33.79		64.58	
Anderson-Rubin Wald		F(10,12631)=44.90	0	F(14,12627)=31.78	0	F(14,12627)=32.99	0	F(7,12634)=54.14	0
Anderson-		Chi-sq(10)=450.10	0	Chi-sq(14)=446.18	0	Chi-sq(14)=463.17	0	Chi-sq(7)=379.77	0

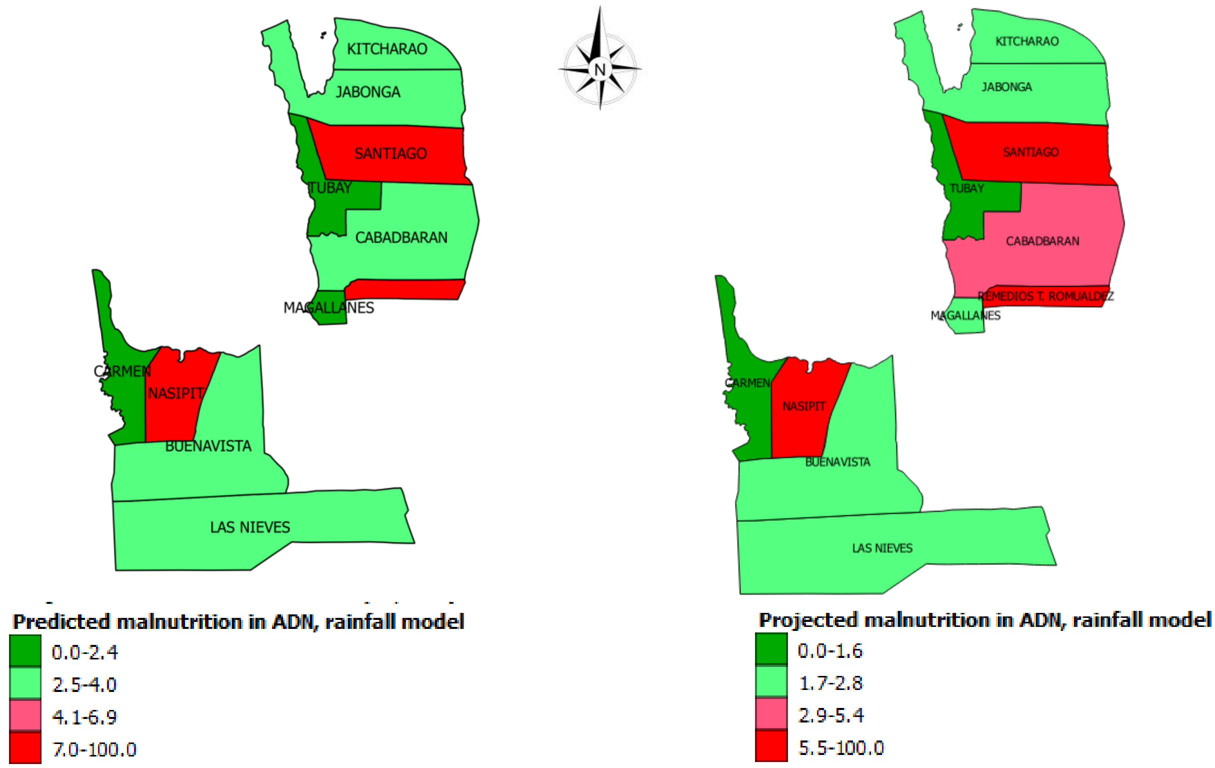
Rubin Wald									
Overidentification									
Sargan		Chi-sq(9)=269.4	0	Chi-sq(13)=326	0	Chi-sq(13)=286.7	0	Chi-sq(6)=271.2	0
IVENDOG									
Wu-Hausman		F(1,12639)=72.67	0	F(1,12639)=38.95	0	F(1,12639)=68.50	0	F(1,12639)=37.03	0
Durbin-Wu-Hausman		Chi-sq(1)=72.39	0	Chi-sq(1)=38.90	0	Chi-sq(1)=68.25	0	Chi-sq(1)=36.99	0
NORMALITY									
Adjusted model									
Swilk		**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**
		10.12	0	8.951	0	9.808	0	9.102	0
Sktest		**chi2(2)**	**Prob>chi2**	**chi2(2)**	**Prob>chi2**	**chi2(2)**	**Prob>chi2**	**chi2(2)**	**Prob>chi2**
		309.7	0	195.7	0	274.8	0	207.8	0
Sfrancia		**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**	**z**	**Prob>z**
		0.720	0.236	0.651	0.257	0.704	0.241	0.662	0.254
		Test Statistic	**p-value**	**Test Statistic**	**p-value**	**Test Statistic**	**p-value**	**Test Statistic**	**p-value**
Underidentification									
Anderson		Chi-sq(10)=514.26	0	Chi-sq(14)=508.56	0	Chi-sq(14)=455.92	0	Chi-sq(7)=429.52	0
Cragg-Donald		Chi-sq(10)=536.03	0	Chi-sq(14)=529.84	0	Chi-sq(14)=472.95	0	Chi-sq(7)=444.60	0
Weak Instrument									
Cragg-Donald Wald		53.48		37.74		33.69		63.38	
Anderson-Rubin Wald		F(10,12631)=7.26	0	F(14,12627)=3.43	0	F(14,12627)=2.40	0.0024	F(7,12634)=3.99	0.0002
Anderson-Rubin Wald		Chi-sq(10)=72.80	0	Chi-sq(14)=48.21	0	Chi-sq(14)=33.63	0.0023	Chi-sq(7)=27.98	0.0002
Overidentification									
Sargan		Chi-sq(9)=58.76	0	Chi-sq(13)=46.50	0	Chi-sq(13)=30.83	0.0036	Chi-sq(6)=27.08	0.0001
IVENDOG									
Wu-Hausman		F(1,12639)	0.708	F(1,12639)	0.261	F(1,12639)	0.741	F(1,12639)	0.579
Durbin-Wu-Hausman		Chi-sq(1)	0.708	Chi-sq(1)	0.261	Chi-sq(1)	0.741	Chi-sq(1)	0.579

Table 12. Variance Inflation Factors, CBMS 2007-2010 model

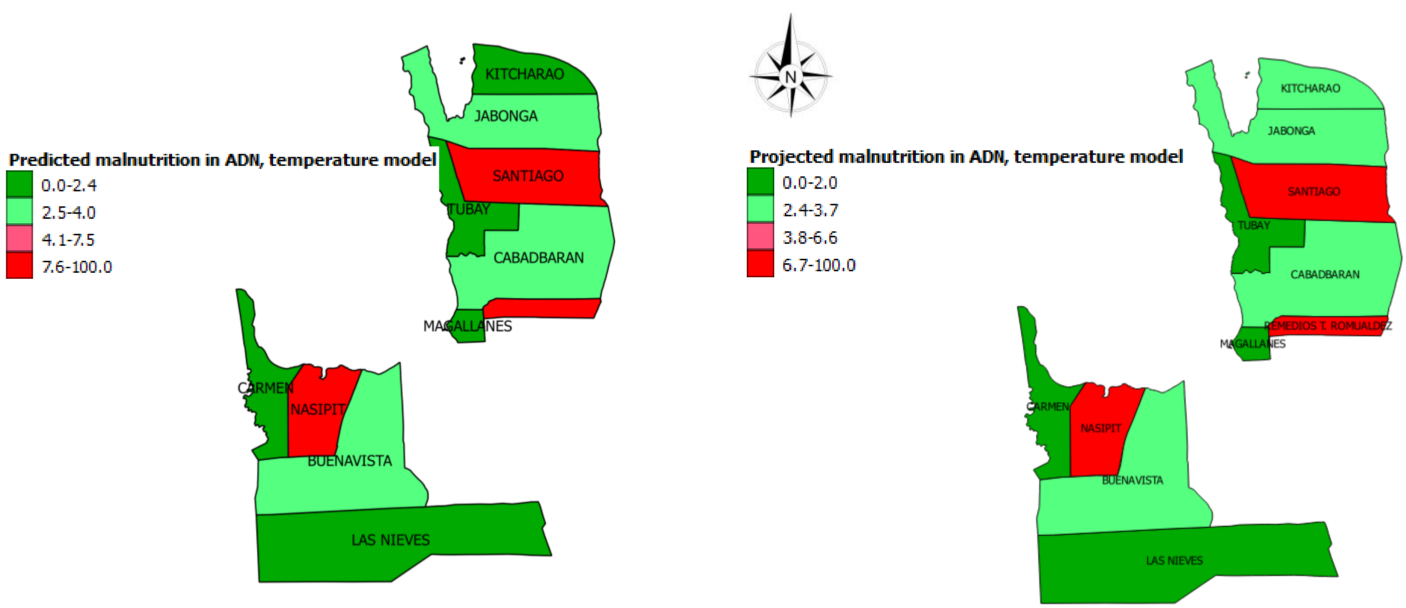
Variable	Rainfall		Rainfall seasonality		Rainfall volatility		Temperature	
	VIF	*1/VIF*	*VIF*	*1/VIF*	*VIF*	*1/VIF*	*VIF*	*1/VIF*
Female head	1.08	0.93	1.08	0.93	1.08	0.93	1.08	0.93
Age of head	1.44	0.70	1.43	0.70	1.43	0.70	1.43	0.70
Household size	1.23	0.81	1.23	0.82	1.23	0.81	1.23	0.82
IP indicator	1.62	0.62	1.50	0.67	1.47	0.68	1.70	0.59
With OFW	1.12	0.89	1.12	0.89	1.12	0.89	1.12	0.90
With safe water	1.15	0.87	1.14	0.87	1.14	0.87	1.14	0.88
With radio	1.11	0.90	1.11	0.90	1.10	0.91	1.11	0.90
With telephone	1.04	0.97	1.04	0.97	1.04	0.97	1.04	0.97
With cellphone	1.35	0.74	1.33	0.75	1.32	0.76	1.33	0.75
Availed govt prog	1.10	0.91	1.11	0.90	1.11	0.90	1.10	0.91
Illness shock	1.03	0.97	1.04	0.96	1.04	0.96	1.03	0.97
Urban	1.07	0.94	1.06	0.94	1.07	0.94	1.06	0.94
CPI - food	4.23	0.24	4.09	0.24	3.81	0.26	3.75	0.27
Education of head	1.09	0.91	1.10	0.91	1.10	0.91	1.09	0.92
Below elementary	(base)							
Elem level	4.83	0.21	4.77	0.21	4.75	0.21	4.80	0.21
Elem grad	4.10	0.24	4.04	0.25	4.02	0.25	4.08	0.25
HS level	3.46	0.29	3.41	0.29	3.39	0.30	3.43	0.29
HS Grad	3.92	0.25	3.86	0.26	3.84	0.26	3.89	0.26
Coll level	2.61	0.38	2.57	0.39	2.56	0.39	2.59	0.39
Coll grad	1.74	0.57	1.72	0.58	1.72	0.58	1.73	0.58
With agri org	1.02	0.98	1.02	0.98	1.02	0.98	1.02	0.98
With thresher	1.30	0.77	1.29	0.78	1.29	0.77	1.29	0.78
With dryer	1.32	0.76	1.32	0.76	1.32	0.76	1.32	0.76
With irrigation pump	1.44	0.69	1.45	0.69	1.44	0.69	1.44	0.69
<-20%	1.48	0.68	5.44	0.18	3.55	0.28		
<=-20% - <-10%	1.65	0.61	1.56	0.64	1.71	0.58		
-10% - <0%	2.72	0.37	4.15	0.24	2.04	0.49		
0%-<10%	3.26	0.31	1.97	0.51	1.48	0.68		
10% - <20%	3.52	0.28	2.69	0.37	1.33	0.75		
>=20%	2.73	0.37	2.98	0.34	1.40	0.71		
Decrease in TMIN							1.30	0.77
Increase in TMAX							1.46	0.68
Irrigation	3.58	0.28	1.76	0.57	2.28	0.44	1.80	0.55
Expenditure on farm to market road	1.66	0.60	2.17	0.46	2.17	0.46	1.58	0.63
Mean VIF	2.15		2.19		1.99		1.90	

Annex 2 – CBMS poverty maps based on predicted and projected malnutrition, rainfall and temperature models

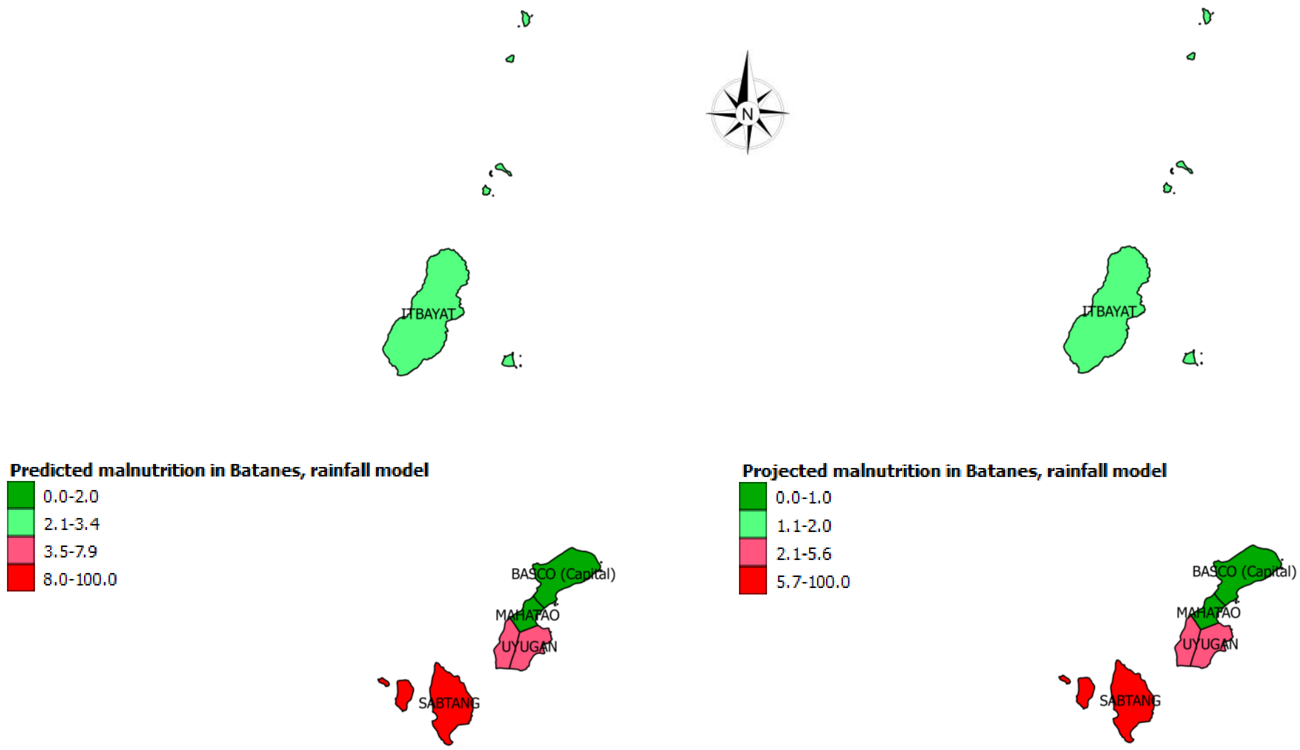
Map 7. Predicted and projected malnutrition using the rainfall model, Agusan del Norte



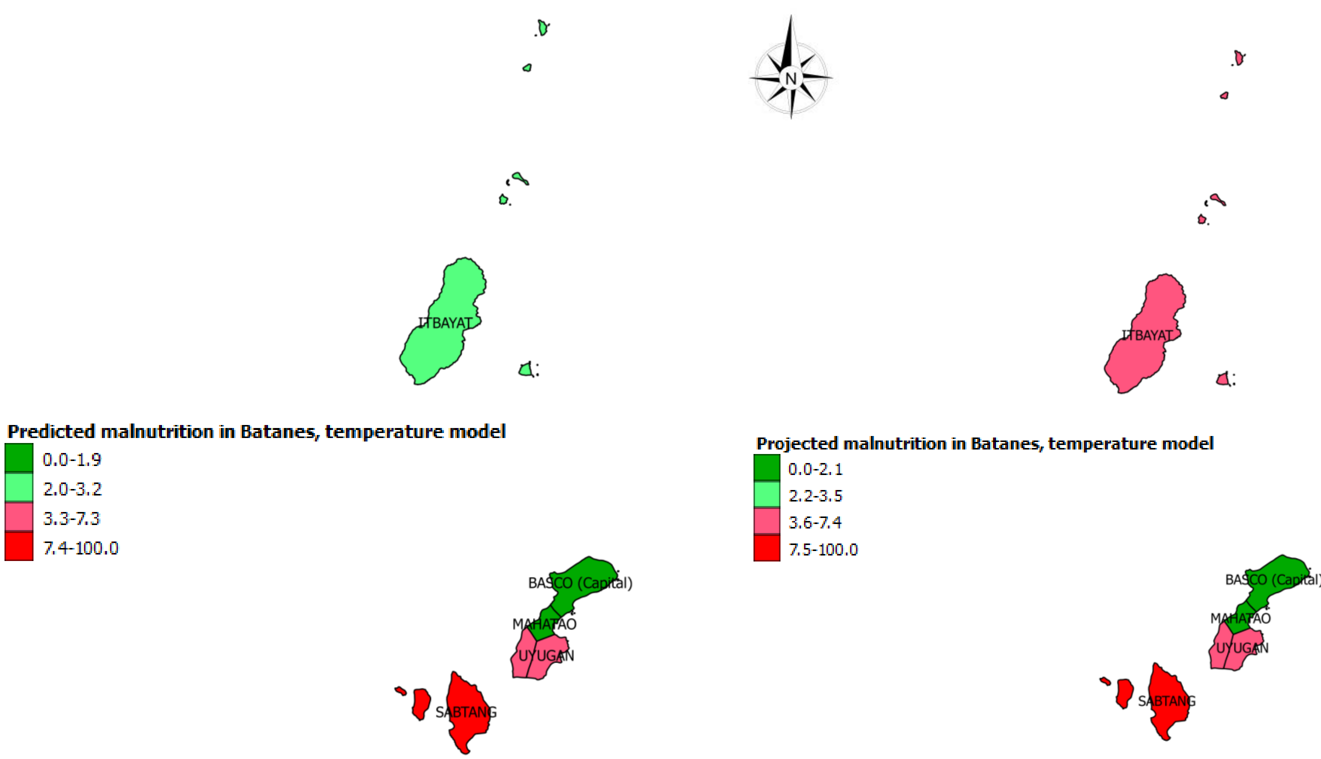
Map 8. Predicted and projected malnutrition using the temperature model, Agusan del Norte



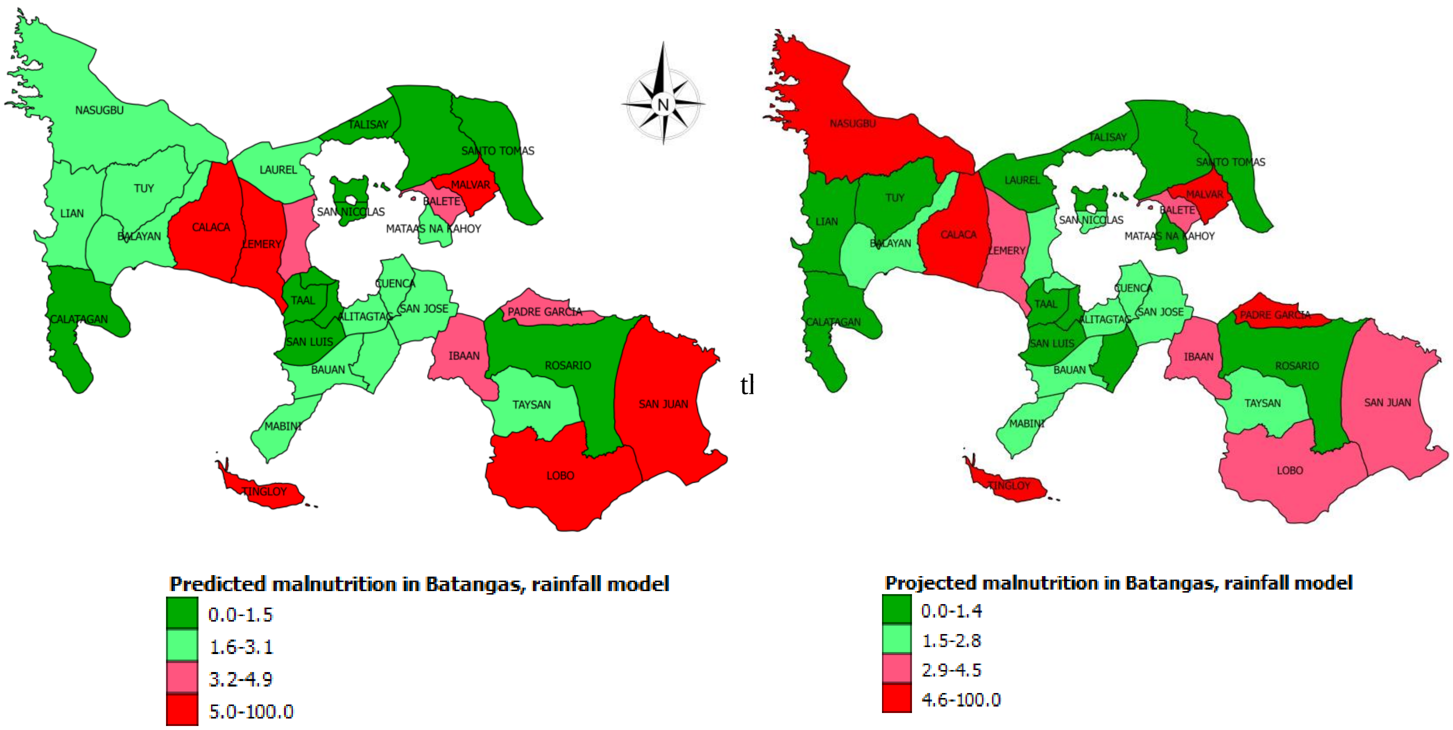
Map 9. Predicted and projected malnutrition using the rainfall model, Batanes



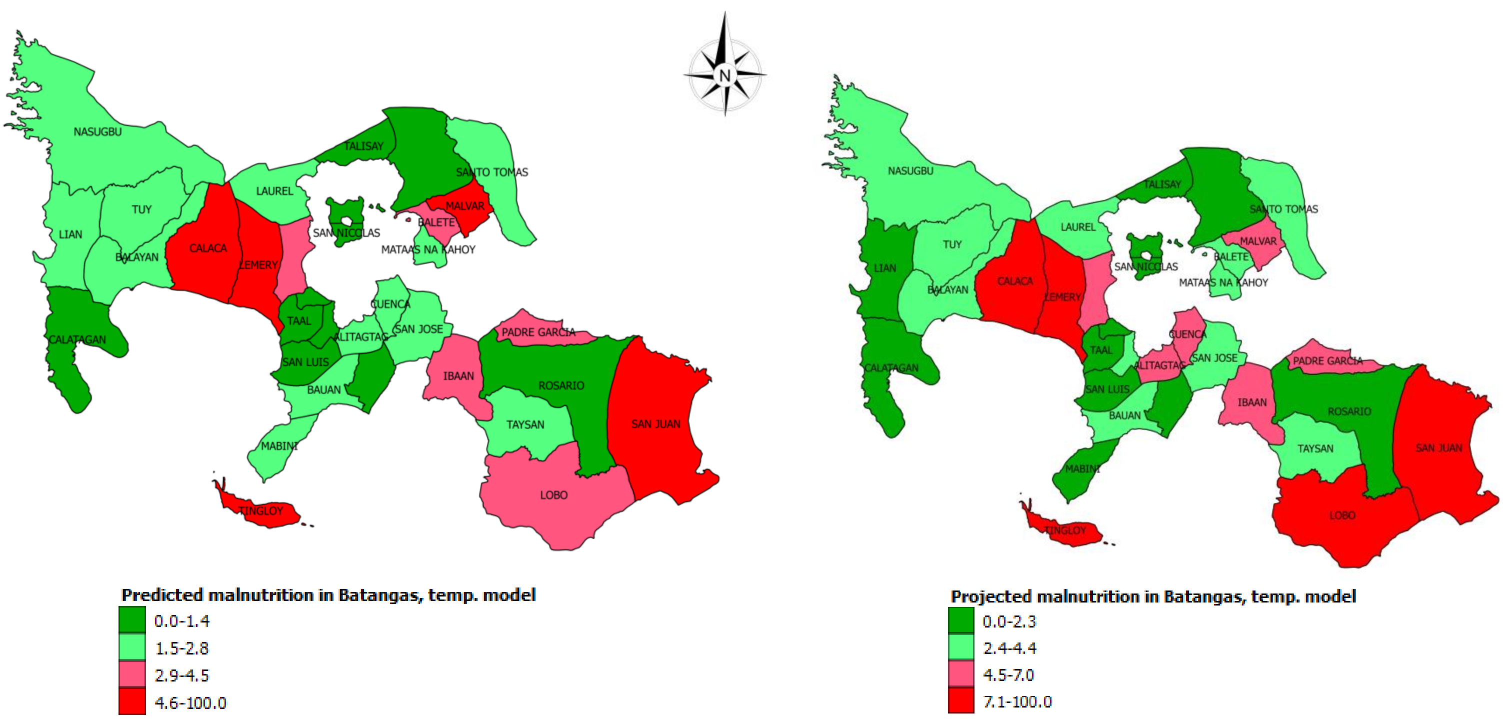
Map 10. Predicted and projected malnutrition using the temperature model, Batanes



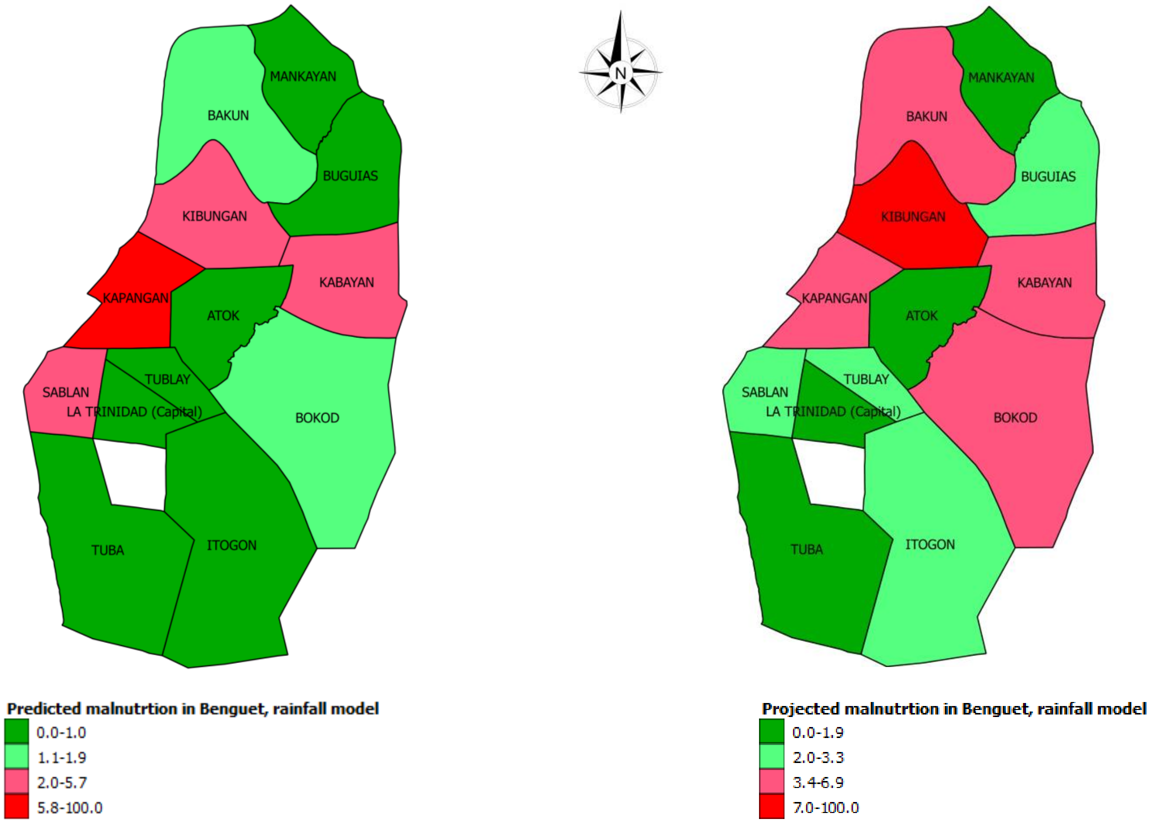
Map 11. Predicted and projected malnutrition using the rainfall model, Batangas



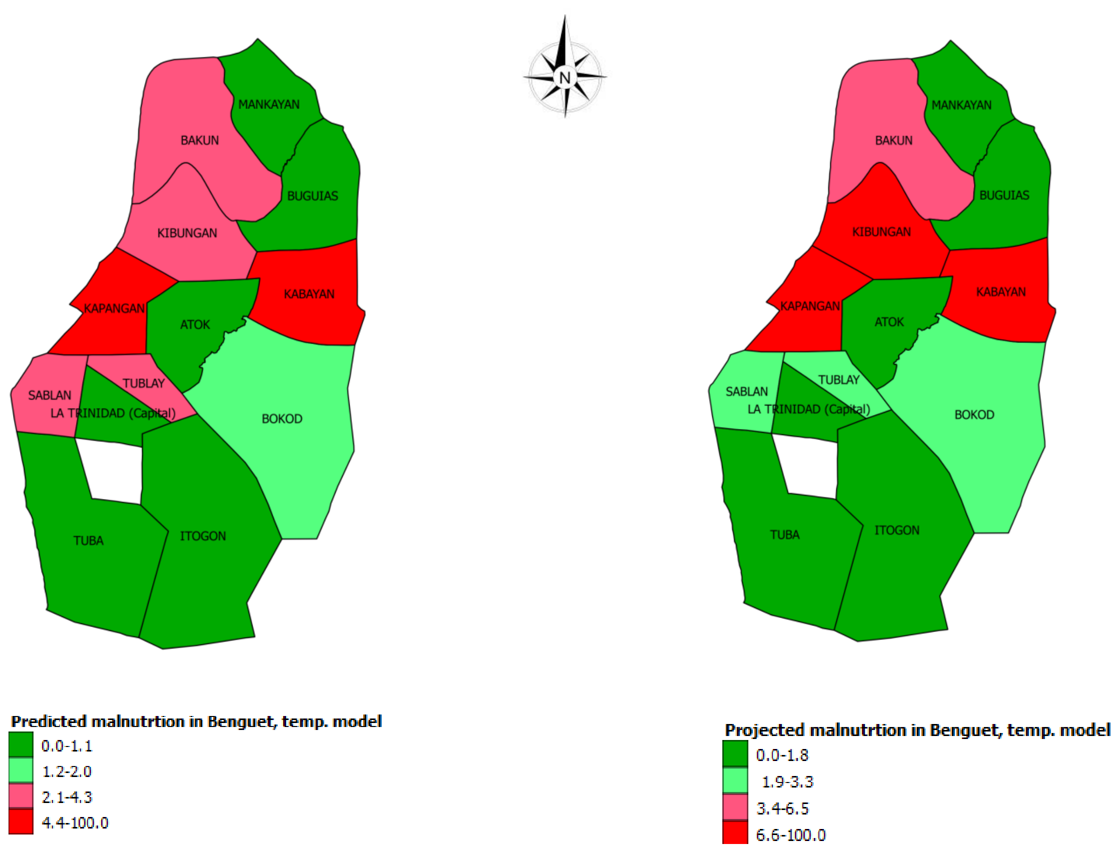
Map 12. Predicted and projected malnutrition using the temperature model, Batangas



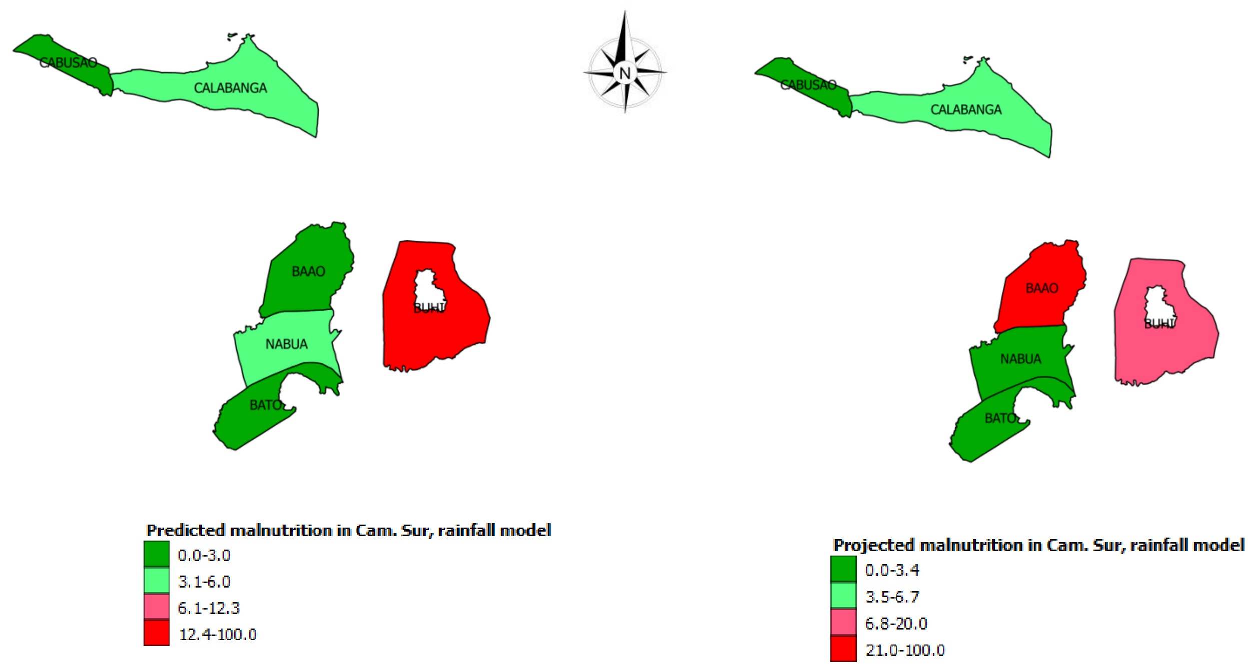
Map 13. Predicted and projected malnutrition using the rainfall model, Benguet



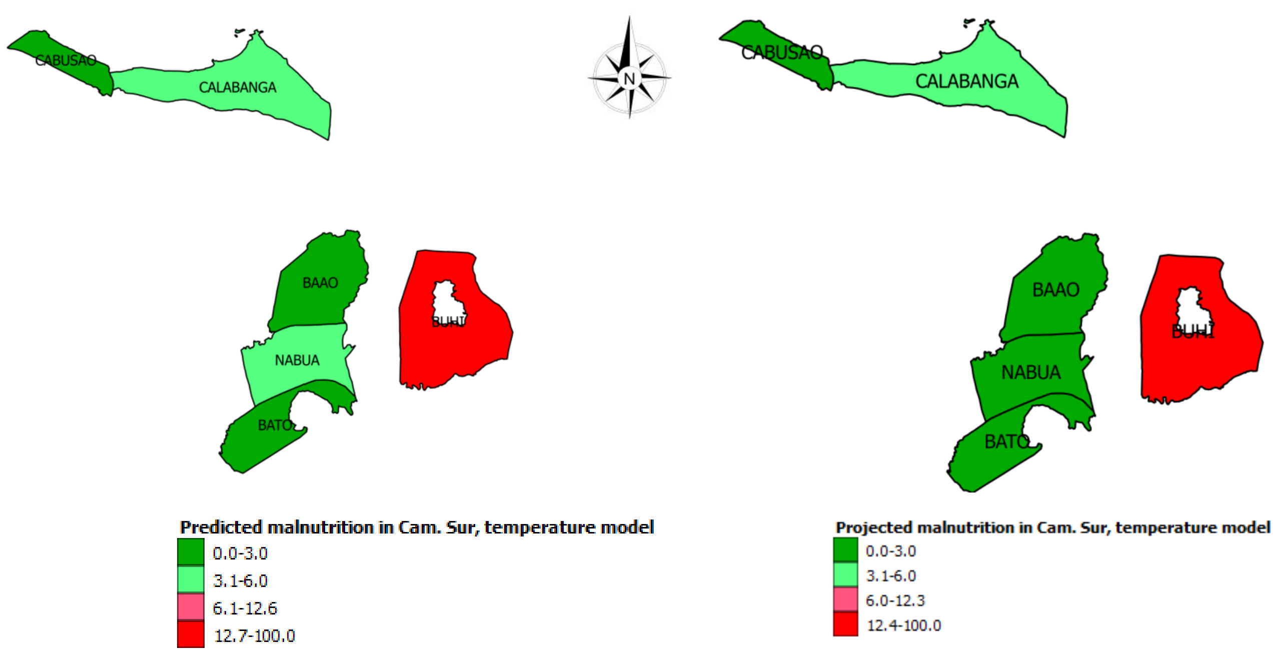
Map 14. Predicted and projected malnutrition using the temperature model, Benguet



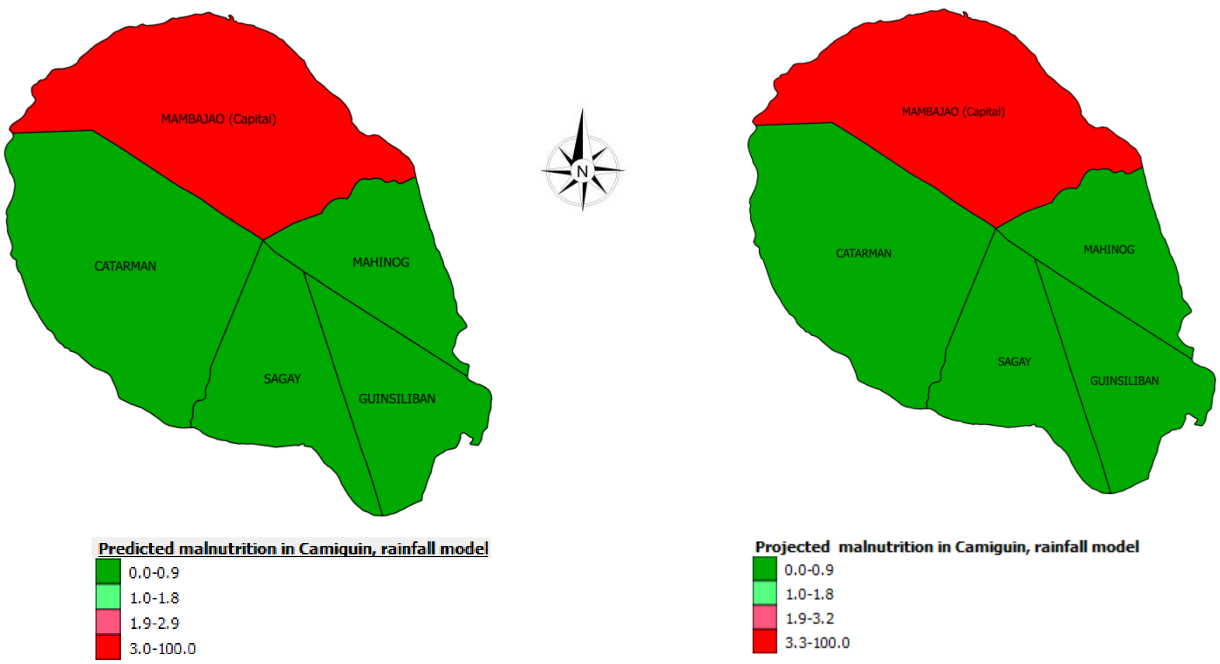
Map 15. Predicted and projected malnutrition using the rainfall model, Camarines Sur



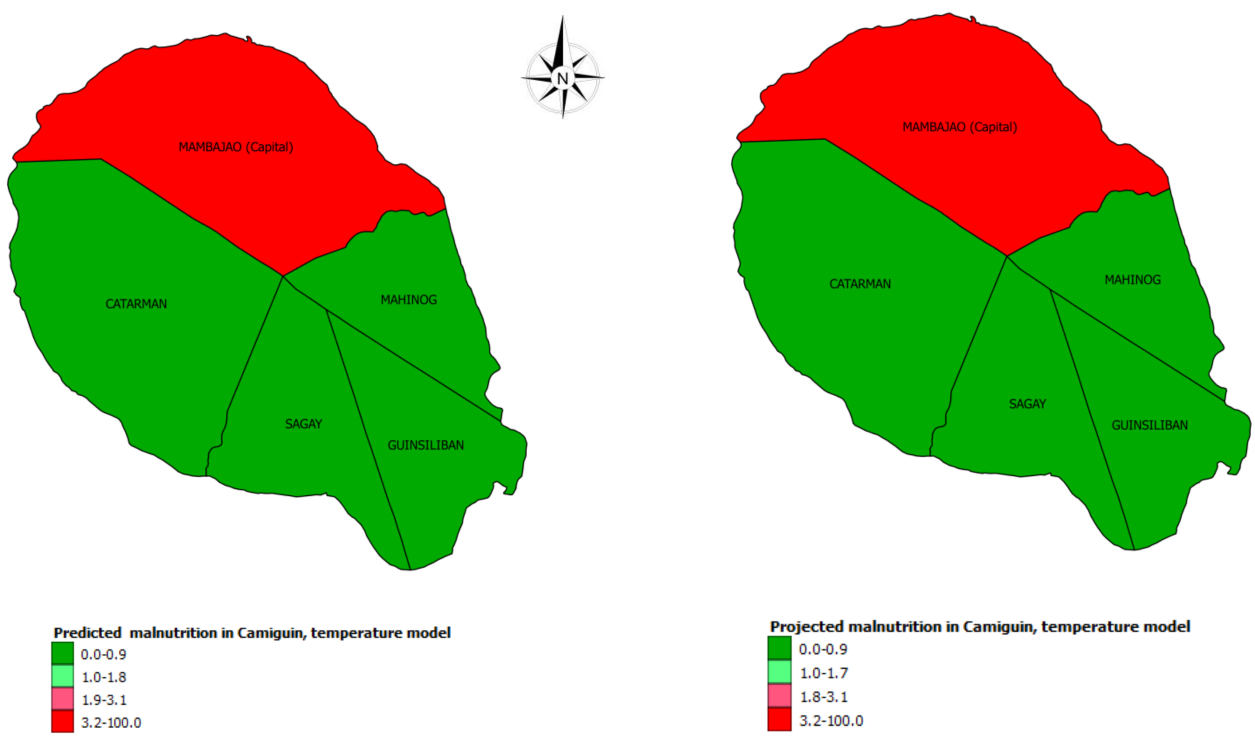
Map 16. Predicted and projected malnutrition using the rainfall model, Camarines Sur



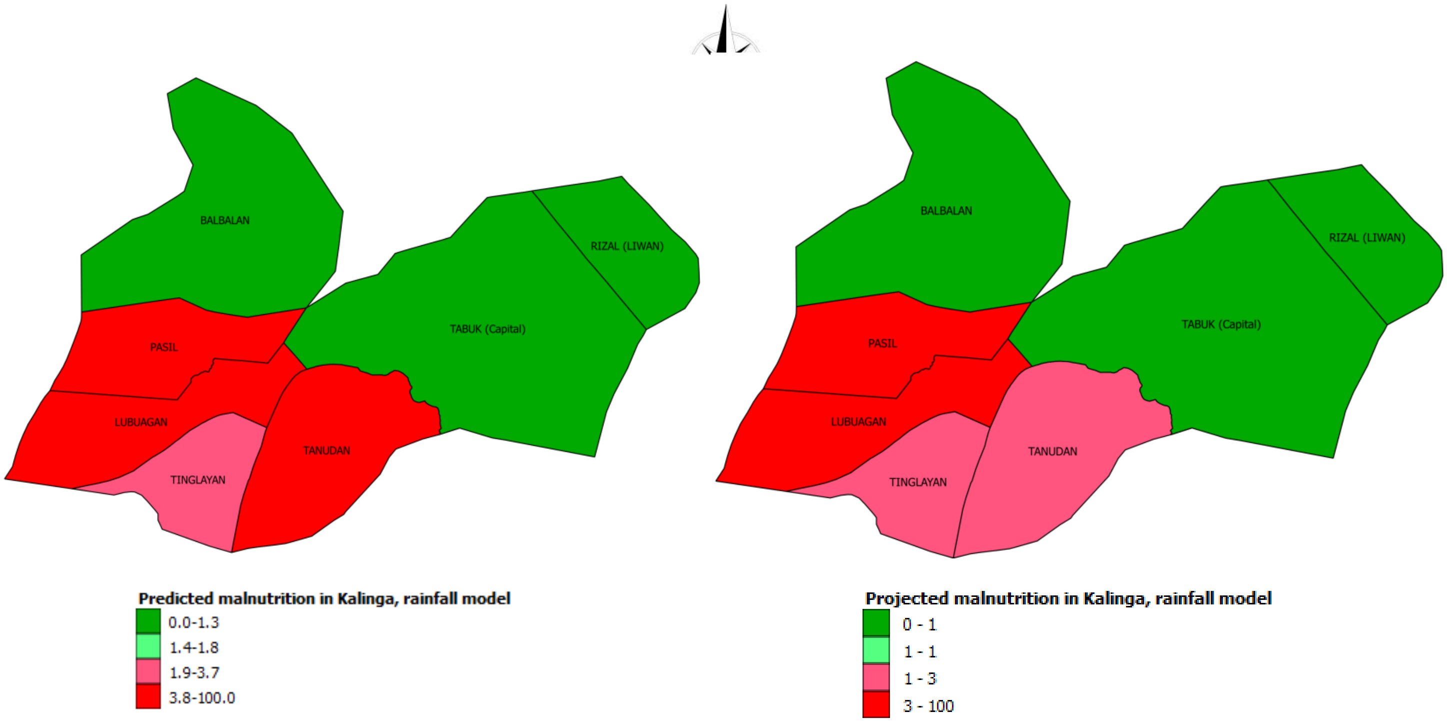
Map 17. Predicted and projected malnutrition using rainfall model, Camiguin



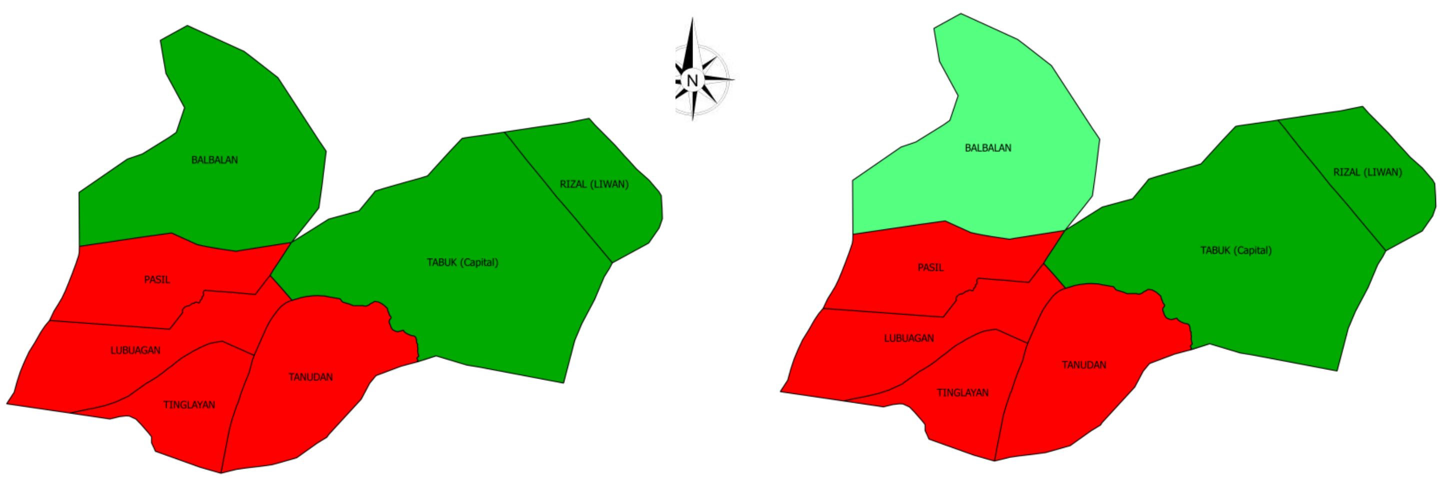
Map 18. Predicted and projected malnutrition using temperature model, Camiguin



Map 19. Predicted and projected malnutrition using rainfall model, Kalinga



Map 20. Predicted and projected malnutrition using temperature model, Kalinga



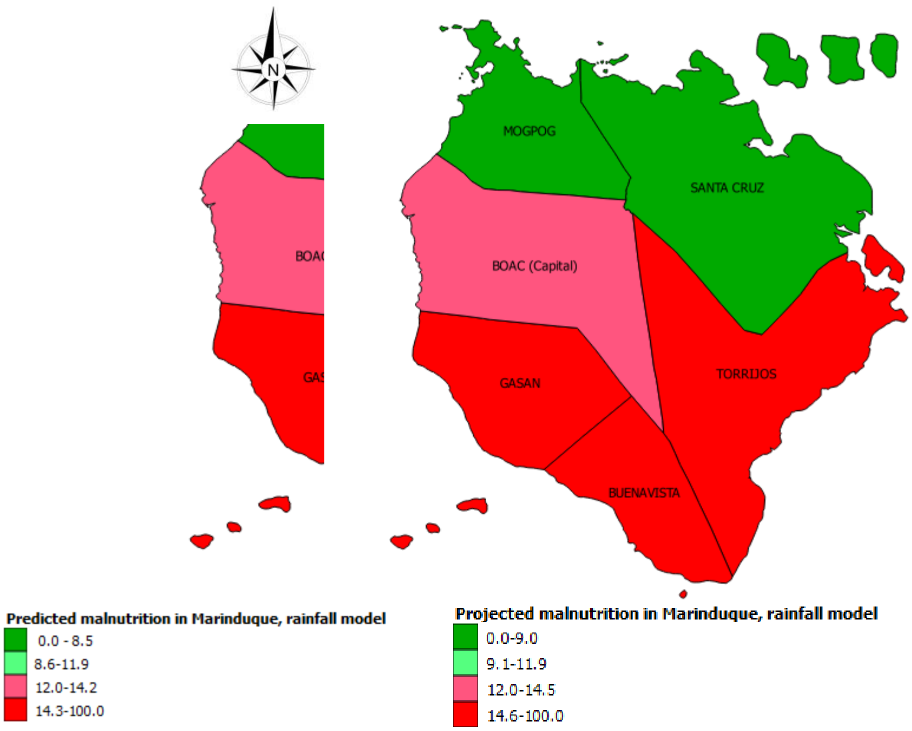
Predicted malnutrition in Kalinga, temperature model

0.0-1.3
1.4-1.8
1.9-3.3
3.4-100.0

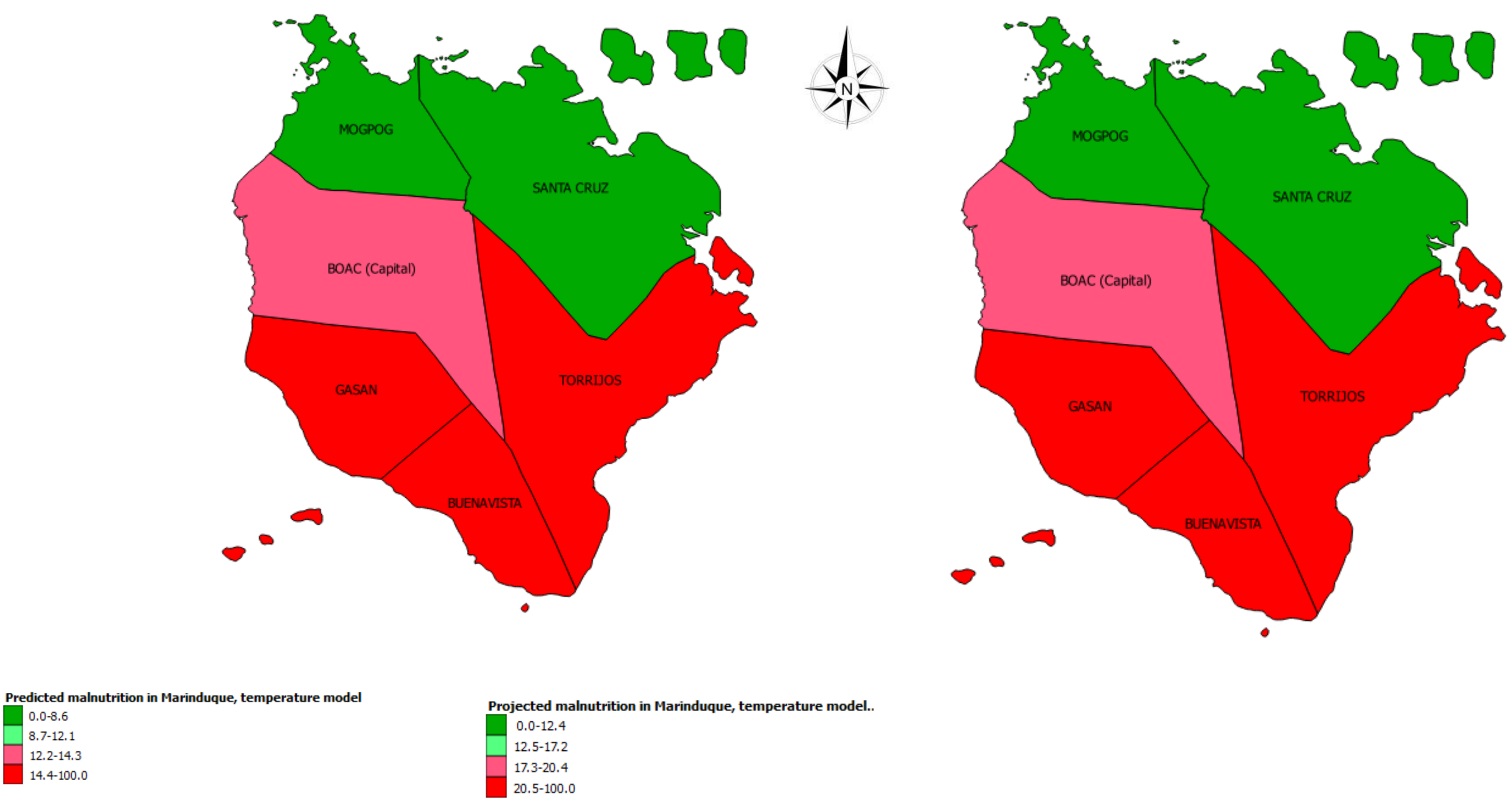
Predicted malnutrition in Kalinga, temperature model

0-1.5
1.6-2.1
2.2-3.5
3.6-100.0

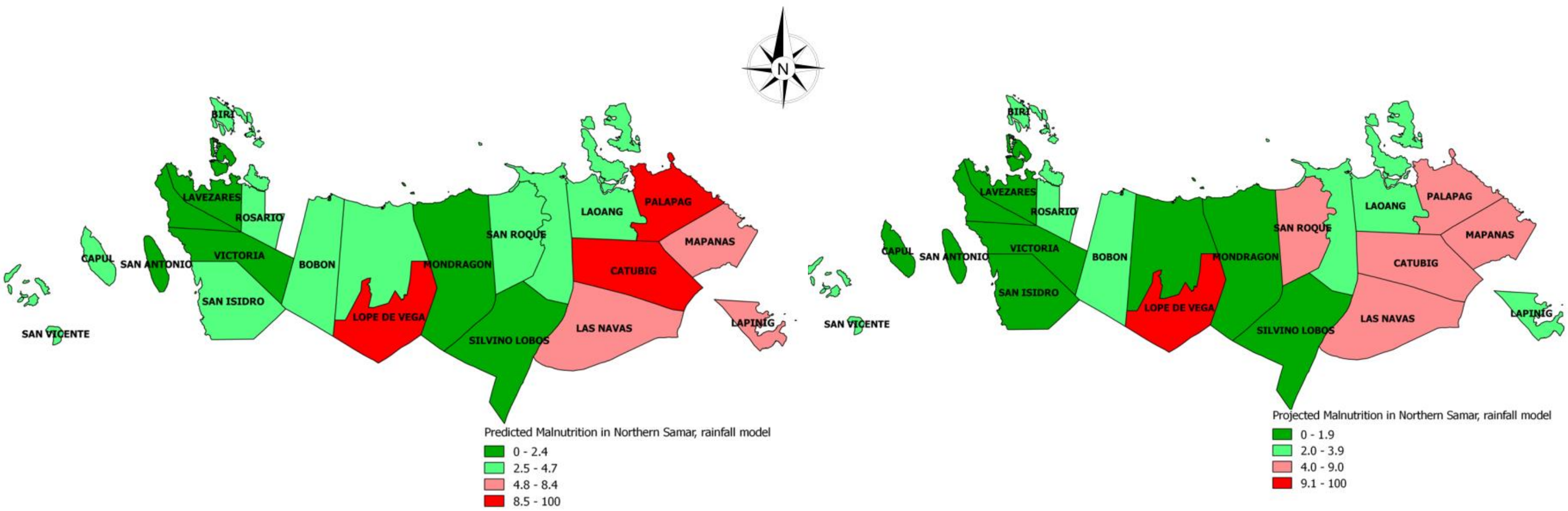
Map 21. Predicted and projected malnutrition using rainfall model, Marinduque



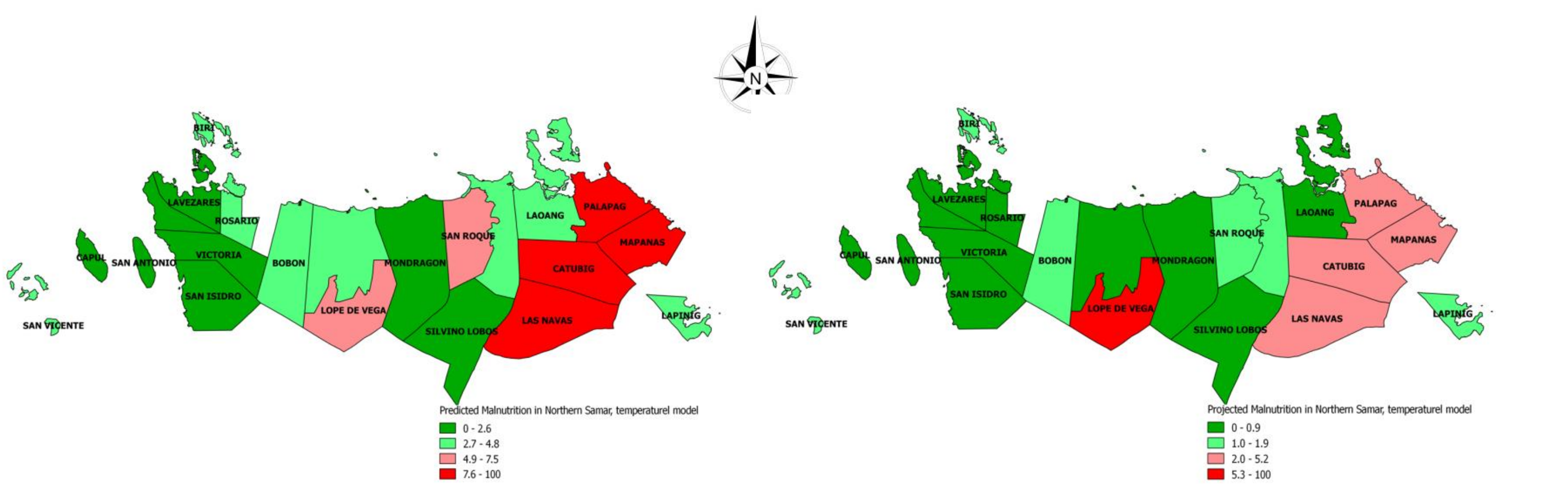
Map 22. Predicted and projected malnutrition using temperature model, Marinduque



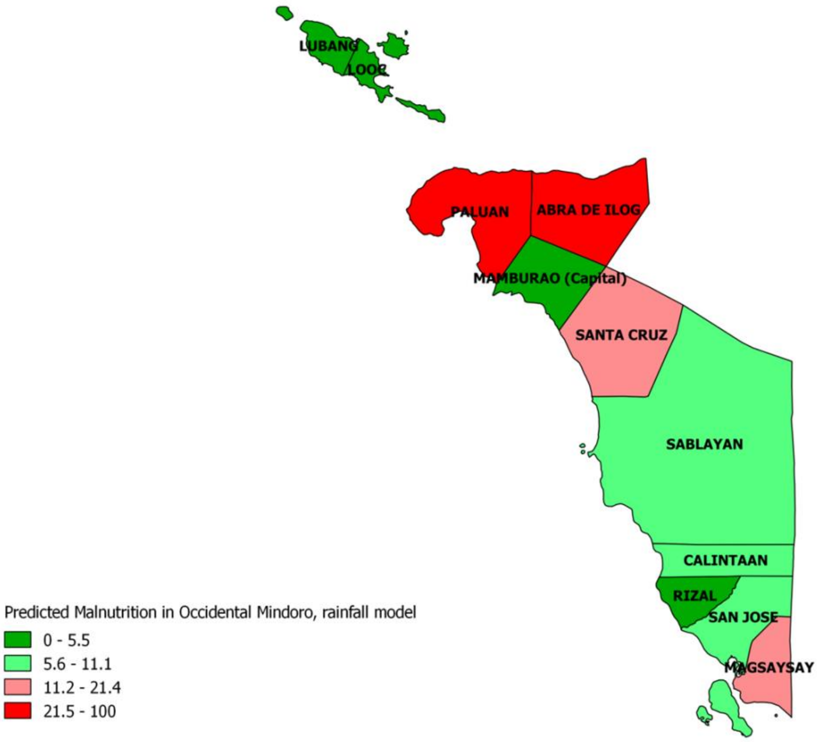
Map 23. Predicted and projected malnutrition using rainfall model, Northern Samar

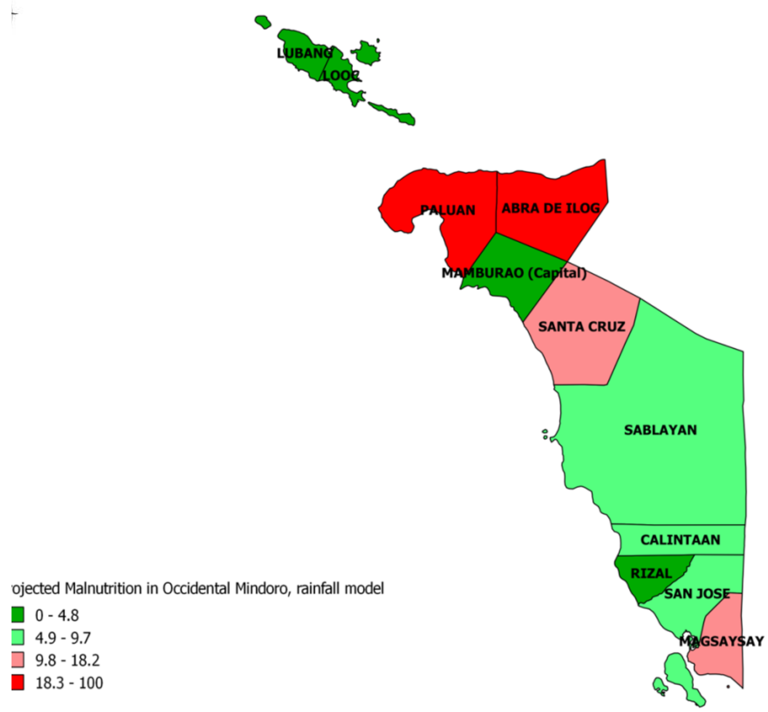


Map 24. Predicted and projected malnutrition using temperature model, Northern Samar

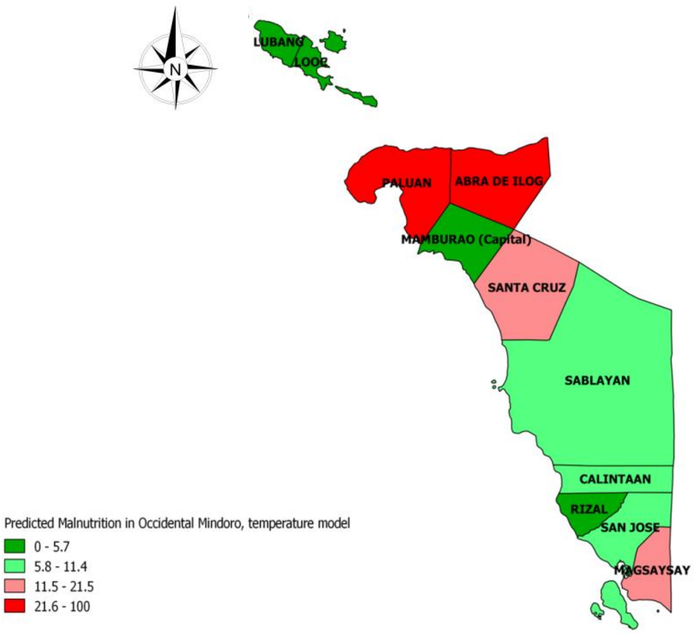


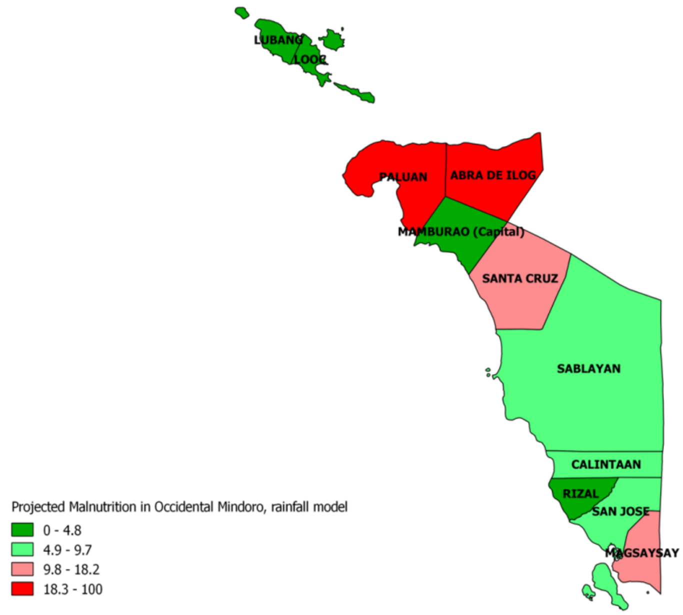
Map 25. Predicted and projected malnutrition using rainfall model, Occidental Mindoro



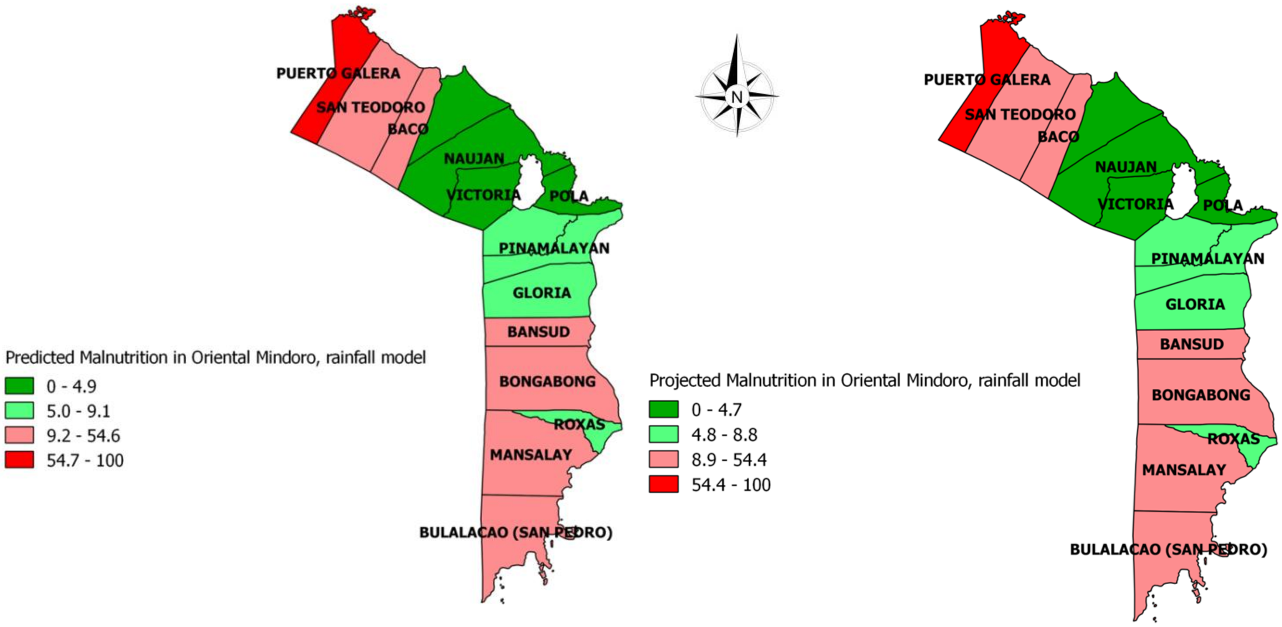


Map 26. Predicted and projected malnutrition using temperature model, Occidental Mindoro

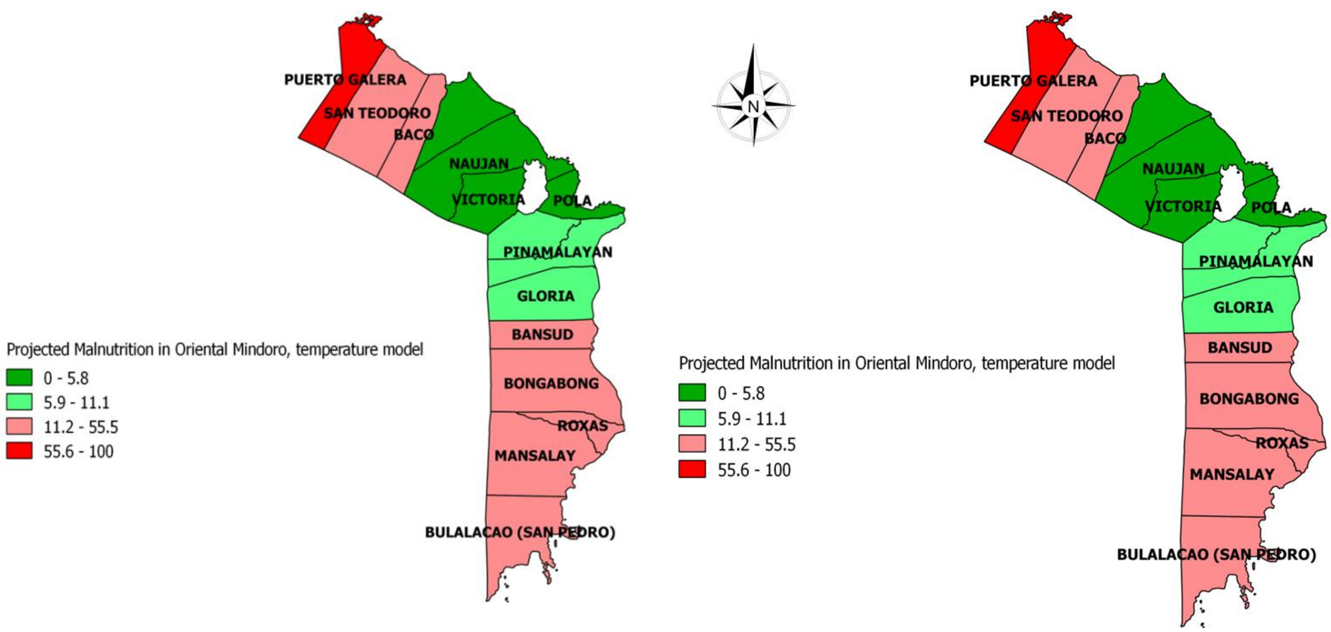




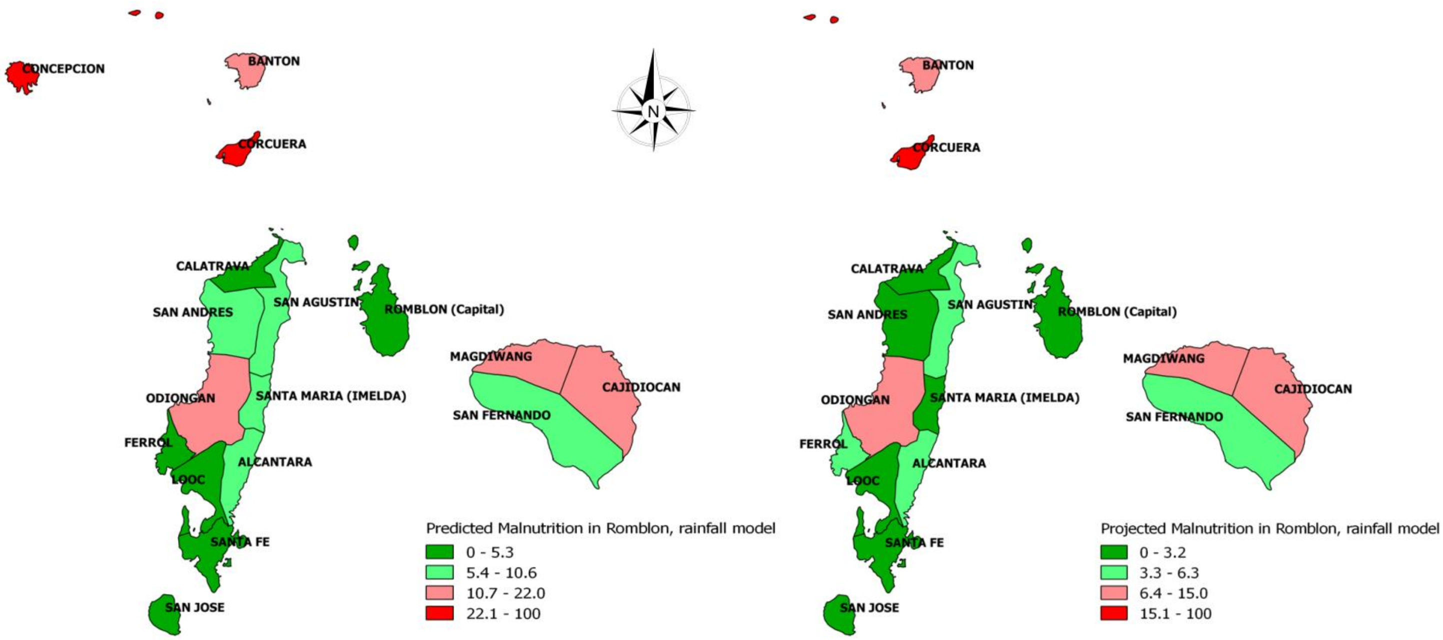
Map 27. Predicted and projected malnutrition using rainfall model, Oriental Mindoro



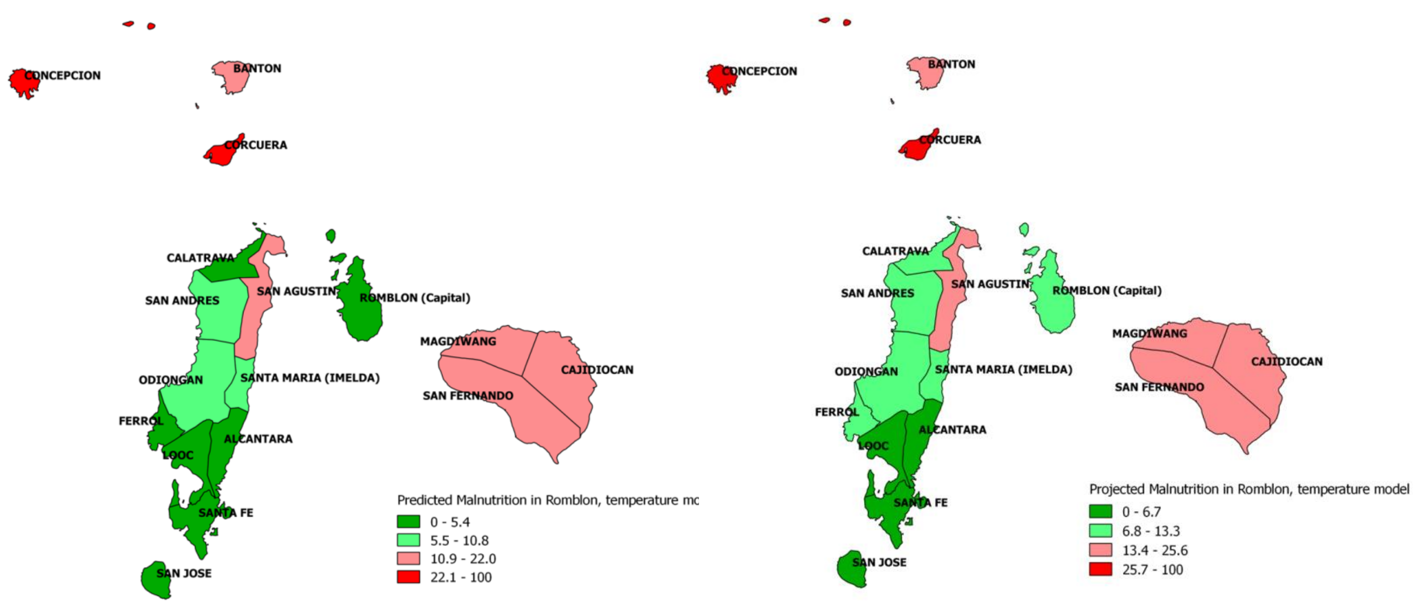
Map 28. Predicted and projected malnutrition using temperature model, Oriental Mindoro



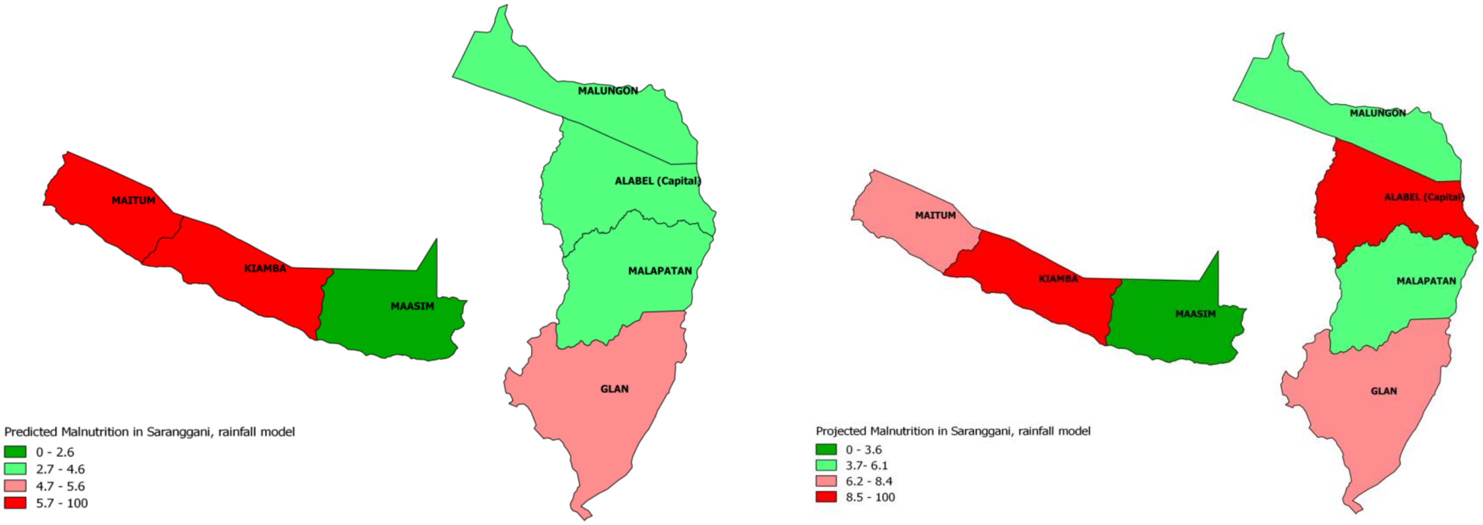
Map 29. Predicted and projected malnutrition using rainfall model, Romblon



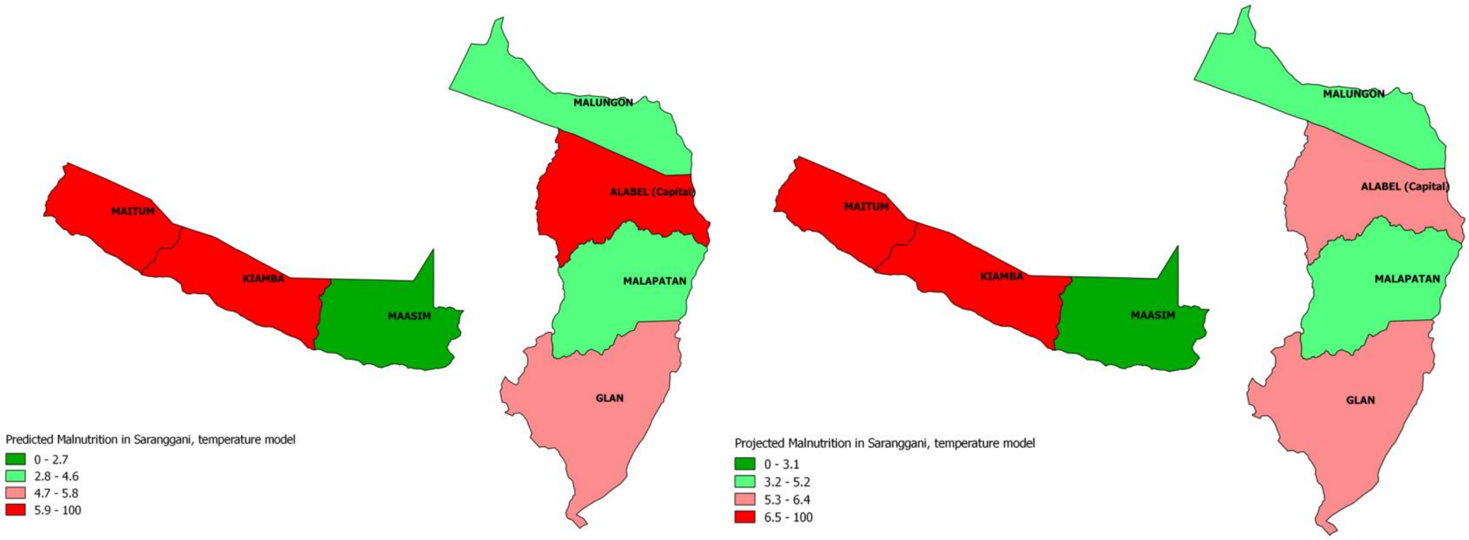
Map 30. Predicted and projected malnutrition using temperature model, Romblon



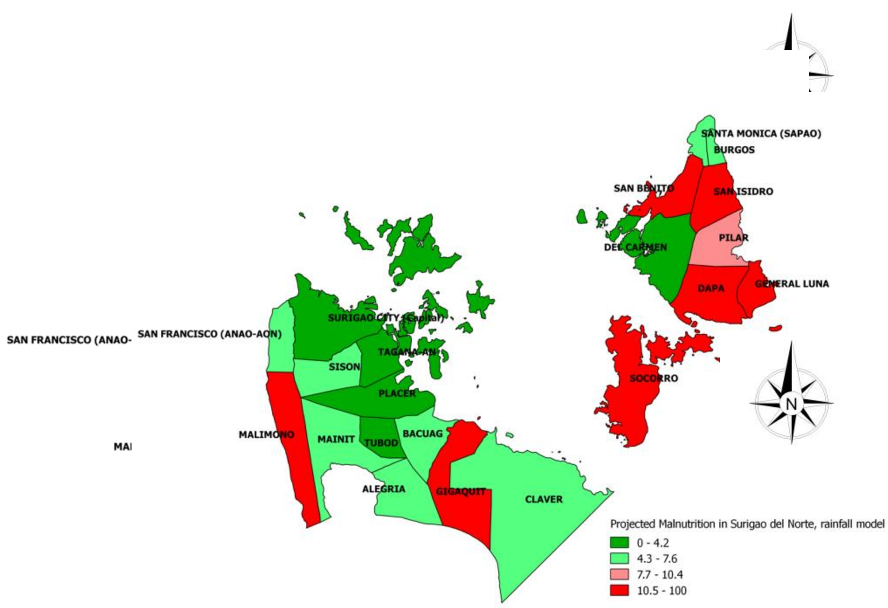
Map 31. Predicted and projected malnutrition using rainfall model, Saranggani



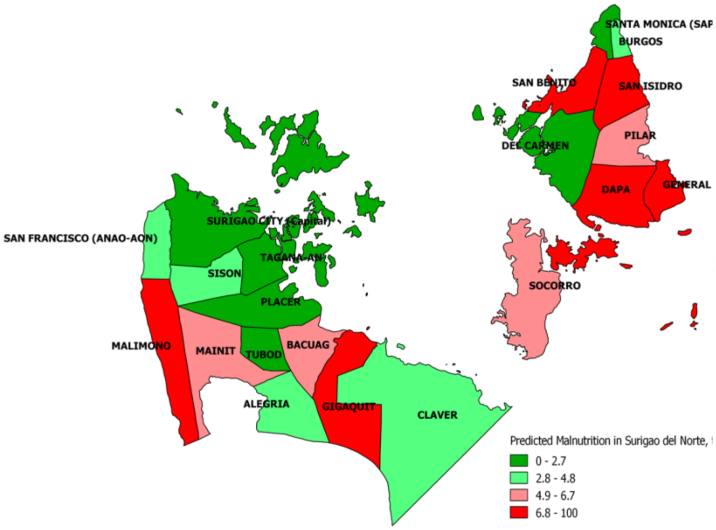
Map 32. Predicted and projected malnutrition using temperature model, Saranggani

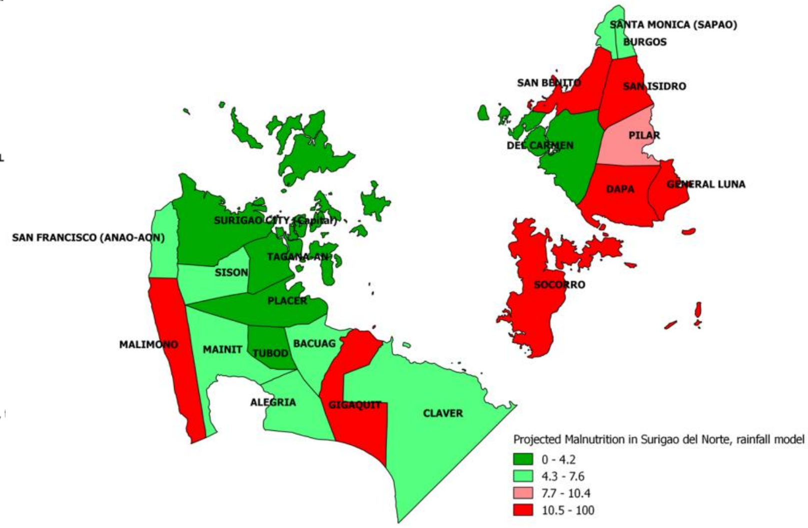


Map 33. Predicted and projected malnutrition using rainfall model, Surigao del Norte

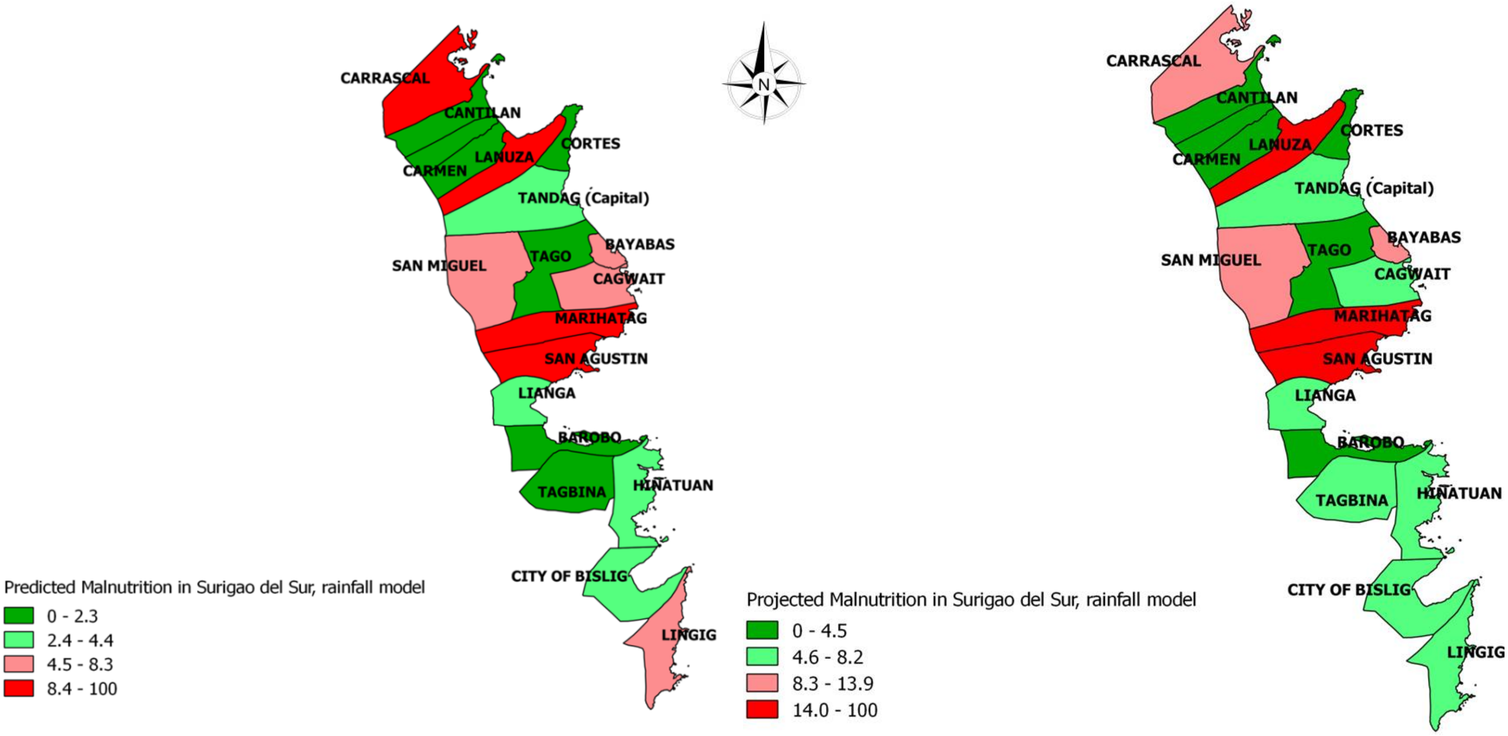


Map 34. Predicted and projected malnutrition using temperature model, Surigao del Norte

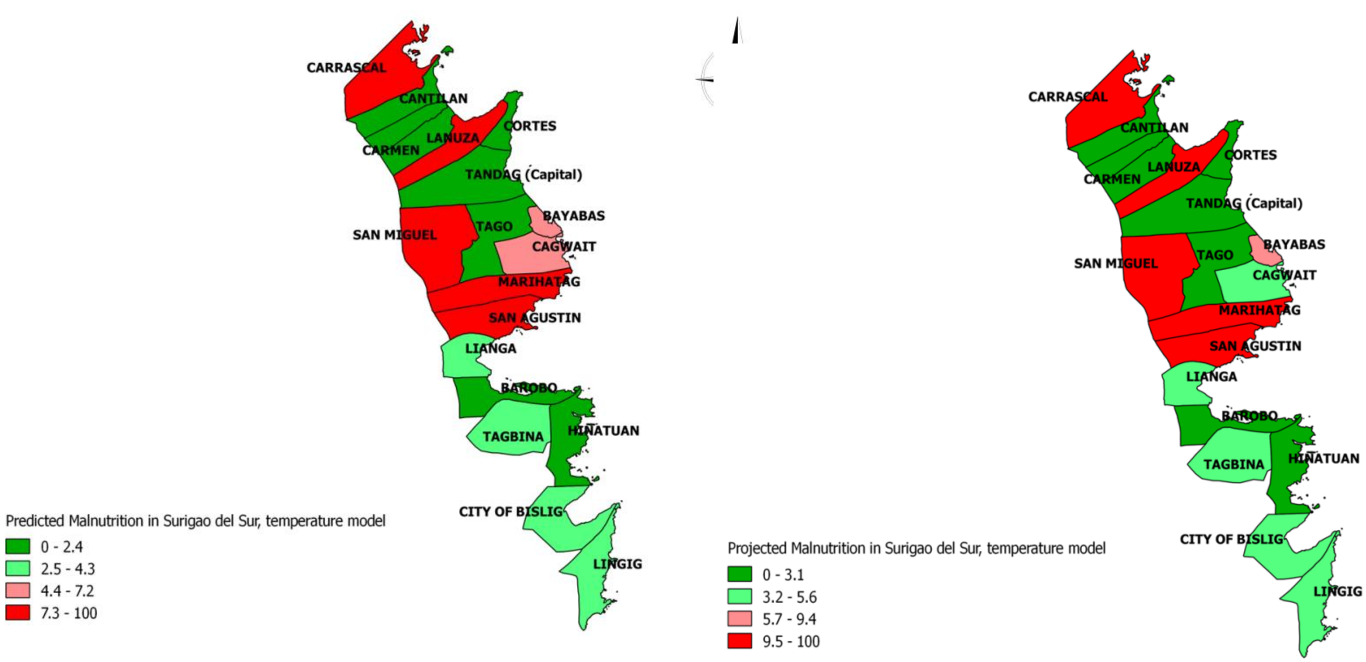

SANTA MONICA (SAP
BURGOS
SAN BENITO
SAN ISIDRO
DEL CARMEN
PILAR
DAPA
GENERAL
SURIGAO CITY (Capital)
SAN FRANCISCO (ANAO-AON)
TAGANA-AN
SISON
SOCORRO
PLACER
MALIMONO
MAINIT
TUBOD
BACUAG
ALEGRIA
GIGAQUIT
CLAVER
Predicted Malnutrition in Surigao del Norte,
0 - 2.7
2.8 - 4.8
4.9 - 6.7
6.8 - 100


SANTA MONICA (SAPAO)
BURGOS
SAN BENITO
SAN ISIDRO
DEL CARMEN
PILAR
DAPA
GENERAL LUNA
SURIGAO CITY (Capital)
SAN FRANCISCO (ANAO-AON)
TAGANA-AN
SISON
SOCORRO
PLACER
MALIMONO
MAINIT
TUBOD
BACUAG
ALEGRIA
GIGAQUIT
CLAVER
Projected Malnutrition in Surigao del Norte, rainfall model
0 - 4.2
4.3 - 7.6
7.7 - 10.4
10.5 - 100

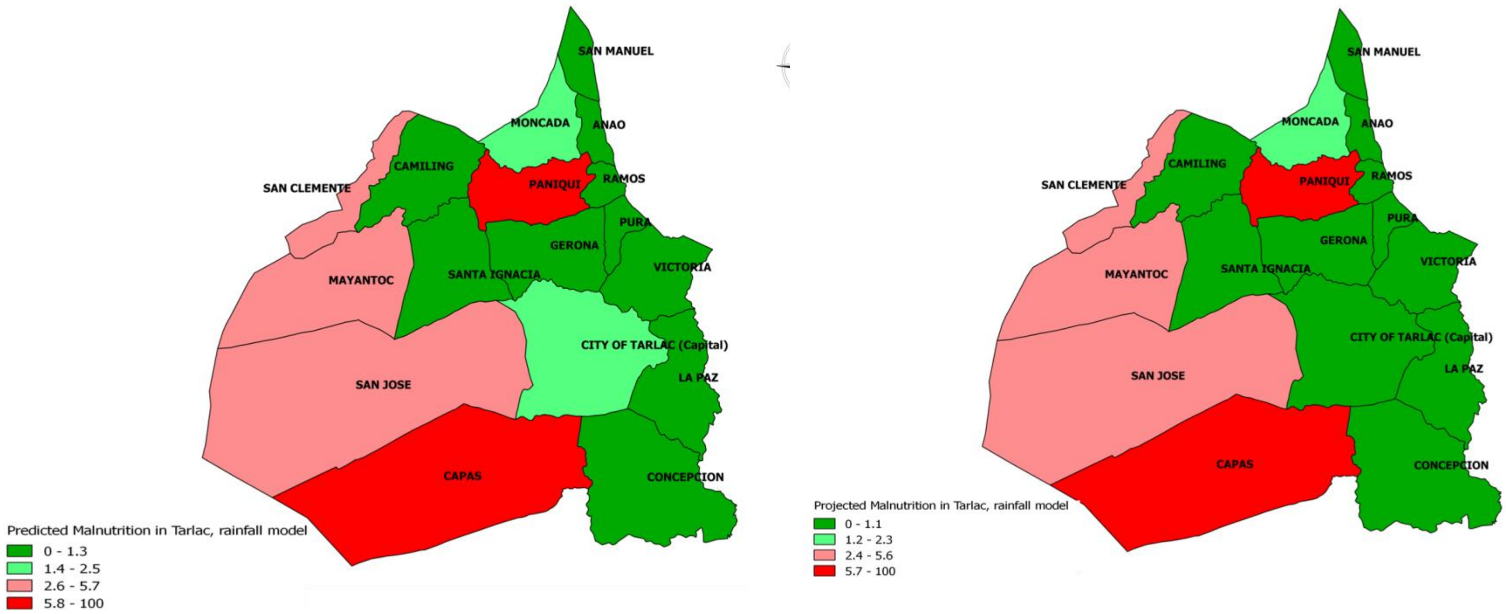
Map 35. Predicted and projected malnutrition using rainfall model, Surigao del Sur



Map 36. Predicted and projected malnutrition using temeprature model, Surigao del Sur



Map 37. Predicted and projected malnutrition using rainfall model, Tarlac



Map 38. Predicted and projected malnutrition using temperature model, Tarlac