Effects of Climate Hazards on the Suitability of Selected Crops in Cotabato Province

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Abstract –*Studies of climate change in the Philippines are immensely important as the country is stricken by various climate change hazards. As climate hazards affect agricultural sector, changes in the suitability of crops, alter cropping patterns and shift in cropping calendar. Hence, an examination on the effect of climate hazards to crop suitability is needed to develop a site-specific recommendation vis-à-vis crop suitability. Applying the concept of crop climatic suitability modelling to assess the spatial changes in crop suitability through descriptive-exploratory investigation, data on elevation, land cover, soil texture, temperature and rainfall at provincial level were used to map the suitability of Rubber, Coconut, Upland and Lowland Rice and Coffee in the province. Climate hazard maps were used to generate the final suitability map through ArcGIS. Results showed that coffee's moderately suitable areas increased from 19.78% to 72.07% as an effect of climate hazard replacing very high to high suitable areas. Coconut's highly suitable areas decreased by 56.84% while a decrease to around 8% for rubber and became only about 9% for upland rice. Sordid effect on wetland (lowland) rice has been observed as the province became very low suitable (84.04%) for lowland rice production; thereby only 7.72% remained to be moderately suitable for its production. Knowledge on the effects of climate hazards to crop suitability can be used for strategic planning in drafting climate change action plans both in the local and the national level which can aid in preparing farmers in the future scenarios. Local and national government can formulate framework for the adaptation and mitigation strategies and develop technologies that are site-specific to build a resilient agricultural community.*

Keywords –*ArcGIS, climate hazards, Cotabato, crop suitability*

INTRODUCTION

Agriculture, as a sector, has been exposed to climate variability, hence, it is considered to become the most vulnerable among the sectors in the economy especially for tropical countries [1] since yields and crop production depends on changes in weather patterns [2]. Climate change has a major impact on agriculture [3]. For example, radiation is essential for the production potential of the crop as well as the temperature and rainfall [4]. However, variability of these factors limits crop growth, development and yield [5-6]. Wide arrays of studies have addressed the impacts of climatic change on agriculture [7-9] specifically, the impact on crop productivity.

Climate hazards such as floods and landslide are the effects brought by changing climate and agricultural crops are severely affected. For the past years, Cotabato province, an agricultural province in Southern Philippines, was no exemption on these hazards. Agricultural sector of the province was devastated by flashfloods and landslides in both low- and high-lying areas. With this trend, climate change will superimpose itself increasing production risk especially those areas that are highly exposed to climatic extremes including droughts and flooding [10].

Change in the pattern of temperature and precipitation brought drastic changes in the suitability of crops, thereby, altering cropping pattern and cropping calendar [11-14]. For example, in West Africa there was seen a reduction and expansion of suitable areas for horticultural crops, legumes and cereals as well as planting season was affected [15]. Aside from this, climate change makes farmers vulnerable to various climate hazards. Further, current trend shows that there may be further decrease in yield due to changing crop suitability in the face of increasing warming and drought in the tropics [16-18]. There was also a study in Vietnam that revealed that Mekong delta has declined its suitability for rice and maize combined with high exposure to flooding, sea level rise and drought [19]. At the global trend, based on the Intergovernmental Panel on Climate Change (IPCC), yield are generally expected to decline especially in low latitude countries [20-21]. Studies have shown that there are projected losses in cacao [22] and coffee [23] which can affect both the regional and global supply chain of these respective industries [19]. It is further projected that in Africa and South Asia, wheat, maize and sorghum would suffer from a loss in the mean yield of 8% by 2050 [24]. Moreover, as climate change affect not only the tropics, the spatio-temporal variability of climate shift northward of central Europe and have been estimated for warmer season crops like grain maize and grapevine [25-26].

There were various climate-smart agricultural technologies that have been developed in recent years and have been practiced by some farmers. However, suitability assessment is essential for the utilization of these technologies. The land or crop suitability analysis for agriculture is an important piece of information for agricultural development and future planning [27].Thus, a crop suitability assessment is essential in order to help the decision makers as well as agricultural development planners. Moreover, crop modeling is vital to understanding the snowballing effects of climate change on agricultural sector across the region. Hence, information at regional scale offer framework to support building of adaptive capacity which is tailored to site-specific adaptation strategies.

OBJECTIVES OF THE STUDY

This study assessed the suitability of growing selected crops based on agro-climatic data and its potential climate risks to climate change hazards.

MATERIALS AND METHODS

The study made use of a descriptive-exploratory research design to describe the effect of climate hazards crop suitability in the province. Site scoping was done through examination of the available data in the province. Community-based participatory approach was also utilized in this study to locate the crops being studied.

Description of Study Site

Cotabato province (Figure 1) lies on the eastern part of Region XII and is strategically located in the central part of Mindanao. The province is bounded on the North of Bukidnon, northwest by Lanano del Sur, southwest by Davao del Sur, west by Manguindanao Province and southwest by Sultan Kudarat Province. It covers a total land area of 656,590 hectares or 36 per cent of the regional land area (1,815,500 hectares). The province is divided into three congressional districts consisting of 17 municipalities and 1 city. Its terrain varies from flat, fertile plains to irregular landscapes of wide valleys, scattered hills, and extensive mountain ranges.

Figure 1. Administrative Map of Cotabato Province

Based on the Bureau of Soils and Water Management (BSWM), a big portion of the land of Cotabato province is classified as upland with a topography ranging from level to nearly level (0-3%); nearly level to gently sloping (3-8%), gently sloping to undulating (8-18%); undulating to rolling (18-25%); rolling to moderately steep (25-50%); steep o very steep (50%-above). Levels to nearly level areas which constitute 124,727 hectares are best suited for lowland rice, corn, and sugarcane production. Areas with the slope of 3-8% comprise 48,100 hectares, are best for agricultural plantations and other high value crops such as oil palm, rubber, coconut, and banana as well as coffee and fruit trees. Gently sloping to undulating areas (8-18%) covers 227,145 hectares and has the same crop suitability as that of those areas within 3-8% slope range. Meanwhile, those areas above 18% slope comprising 156,618 hectares are considered in the steep and protection-oriented slope range. These areas are considered highly critical and protected. Production lands share 74.13% of the total lands area of the province.

Sources of Data

The suitability of various crops used in this study was determined based on existing data and on potential climate risks based on provincial report. Hence, upland and lowland rice, rubber, coconut and coffee were selected crops included in the analysis. These crops or commodities were considered as the high-value crops in the province. More so, these crops represented the topography of the province. Results of AMIA I GIS based hazards maps and other available maps in the region were used to determine the suitability of the site in producing specific commodities amidst the hazards. In generating crop suitability maps, temperature, rainfall, slope, soil texture, elevation and land cover were gathered.These source layers are generated from the criteria needed by each crop as presented in the next section. In each source layer, the scale values were interpreted as follows: 5 – Very High Suitability; 4 – High Suitability; 3 – Moderate Suitability; 2 – Low Suitability; 1 – Very Low Suitability

Data Analysis

The gathered data and maps were modeled using geographic information system (GIS) software which is the ArcGIS. The baseline suitability maps were created using the mentioned source layers. To ascertain the effects of climate hazards, hazard maps (i.e. flood and landslide) were combined with the baseline map. The crop suitability shift was computed and presented as a percent change (increment) from the baseline.

RESULTS AND DISCUSSION

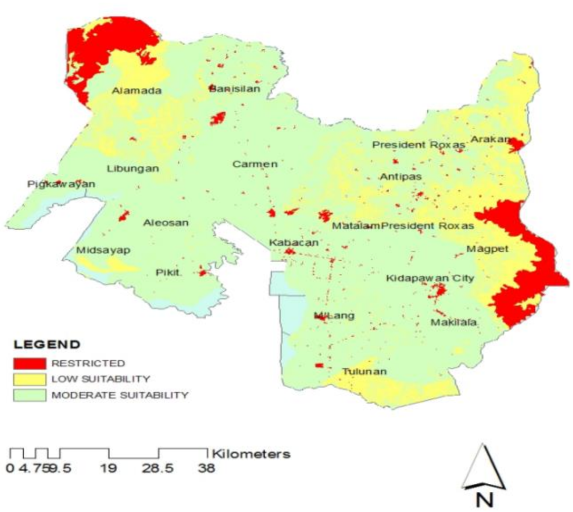

Figure 2. Baseline map of coffee suitability

Coffee. The area that is highly suitable for coffee in the province decreases from its baseline (Figure 2) making the province moderately suitable for coffee production due to climate hazards (i.e. flood and landslides). Municipalities of Kabacan, Mlang, Makilala, Matalam, Carmen, Aleosan, Pikit, Banisilan, Midsayap, Pigkawayan, and the city of Kidapawan (Figure 3)are moderately suitable while there are some areas in Alamada, Arakan, President Roxas, Magpet and Tulunan that are also moderately suitable and some of these are having low suitability for coffee. Generally, the province has 72.07% of its land area that is moderately suitable when there are climate hazards.

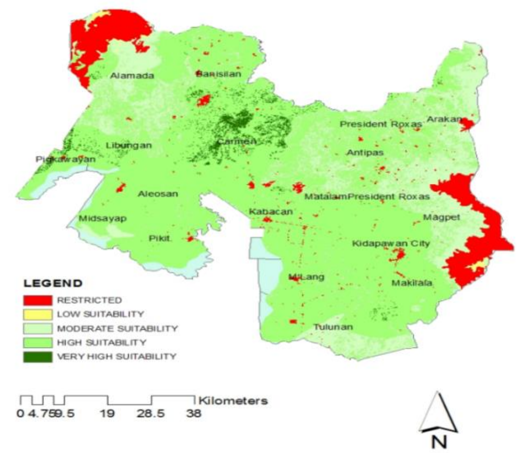

Figure 3. Coffee suitability map due to climate hazards

Coconut. Figure 4 shows the coconut suitability of the Province of Cotabato under normal climate conditions. Approximately, 58.79% of the total land area are highly suitable for coconut while an estimated 31.69% are moderately suitable. Only a small portion of the province has very high and low suitability for the crop.

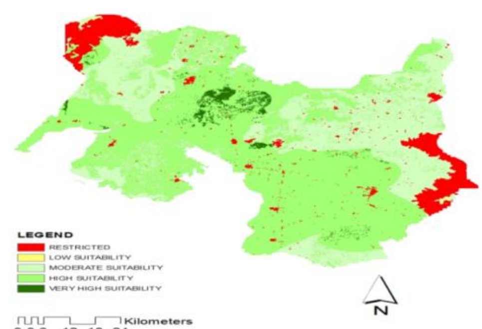

Figure 4. Baseline map of coconut suitability

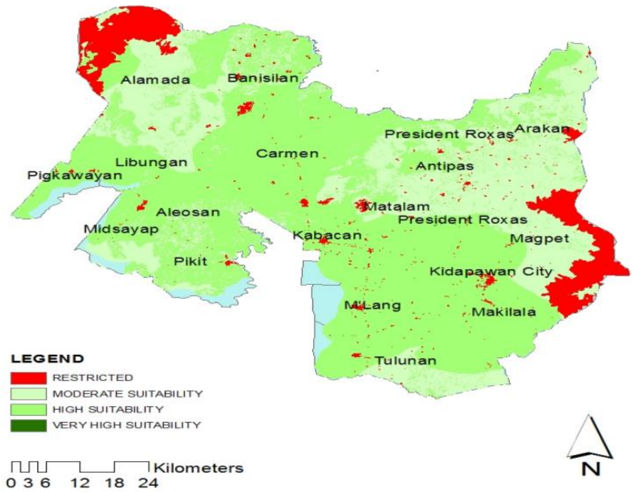

Figure 5. Coconut suitability map due to climate hazard

However, highly suitable areas decreased by approximately 56.84% while those areas with moderate suitability increased to 75.70% as climate hazards affect those areas (Figure 5). These municipalities that are highly suitable for coconut are Carmen (where Phil. Coconut Authority is located), Kabacan, Makilala, Midsayap, Mlang, Aleosan, Midsayap, Pikit, some parts of Libungan and Banisilan, Pigkawayan, parts of Antipas, President Roxas, some part of Alamada and Kidapawan city. Meanwhile, municipalities that are moderately suitable for coconut are Arakan, Antipas, Magpet, Tulunan, large portion of Alamada and Matalam.

Rubber. Rubber has been a contributor to the economy of the province since rubber plantation are being planted across municipalities of the province. Under the normal condition (Figure 6), an estimated 77.82% of the total area of the province is highly suitable for rubber. Approximately, 11.66% of its area are moderately suitable and 2.98% are very highly suitable. However, with the occurrence of hazards in the province, those highly suitable areas decreased to around 8%, a large decrease from its baseline situation. Meanwhile, those areas that are moderately suitable increased to 85.39% which is comparatively a high incremental increase from its baseline condition. This makes the province moderately suitable for rubber, in general, when there is an occurrence of hazards. As seen in Figure 7, only the municipalities of Midsayap, Pikit, Kabacan, Pigkawayan, some parts of Tulanan and Mlang are highly suitable for rubber given the occurrence of hazards while the rests remained moderately suitable.

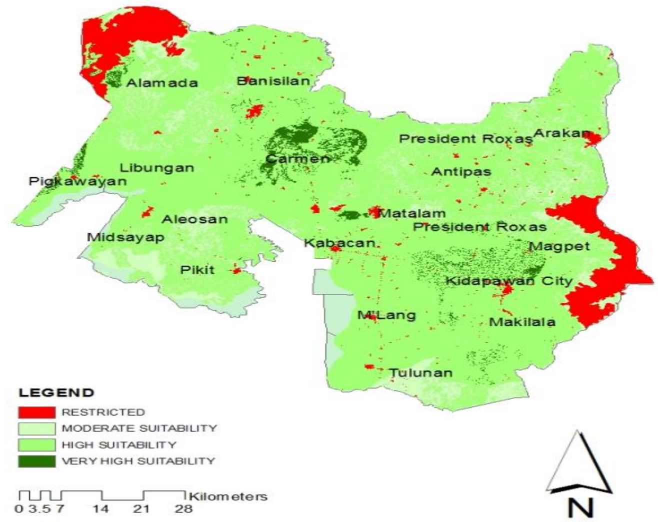

Figure 6. Baseline map of rubber suitability

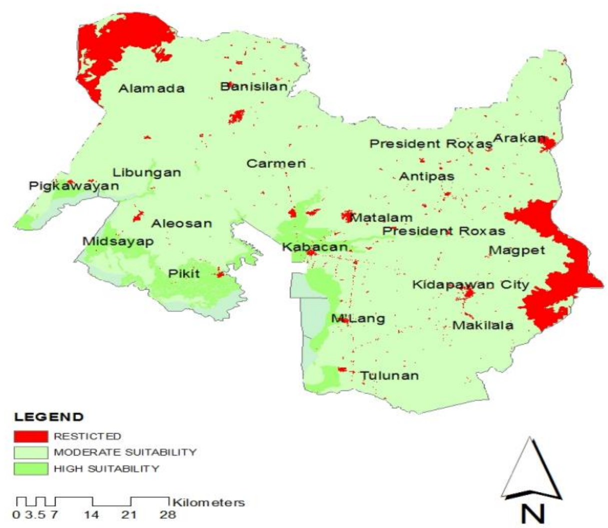

Figure 7. Rubber suitability due to climate hazards

Upland Rice. Being one of the rice producers in Region XII, the province of Cotabato leads among its neighboring provinces in term of its production. The province plants upland and lowland rice. For upland rice, the province is highly suitable accounting for about 86% of its total land area (Figure 8). With climate hazards, the optimal suitability of upland rice decreases to moderately suitable accounting for 84% of its total land area. Almost all municipalities are moderately suitable but there are portions of the Municipality of Pikit, Midsayap, Kabacan, Mlang, Tulunan and Pigkawayan are highly suitable for upland rice production as shown in Figure 9.

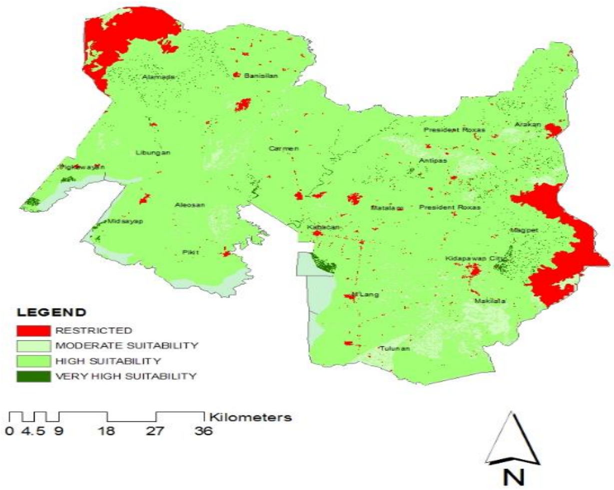

Figure 8. Baseline map of Upland Rice

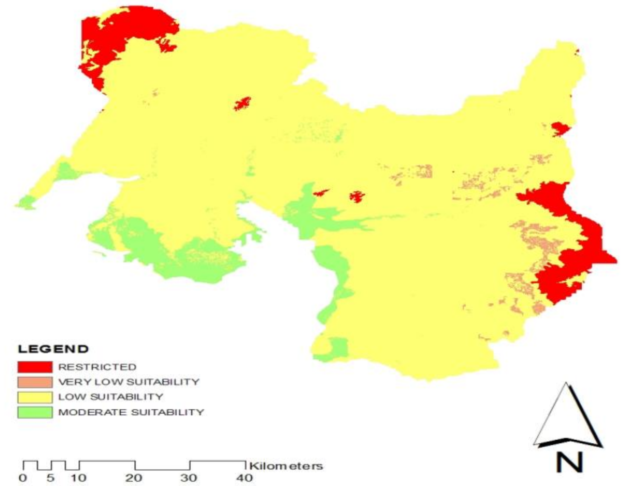

Figure 10. Baseline map of Lowland Rice

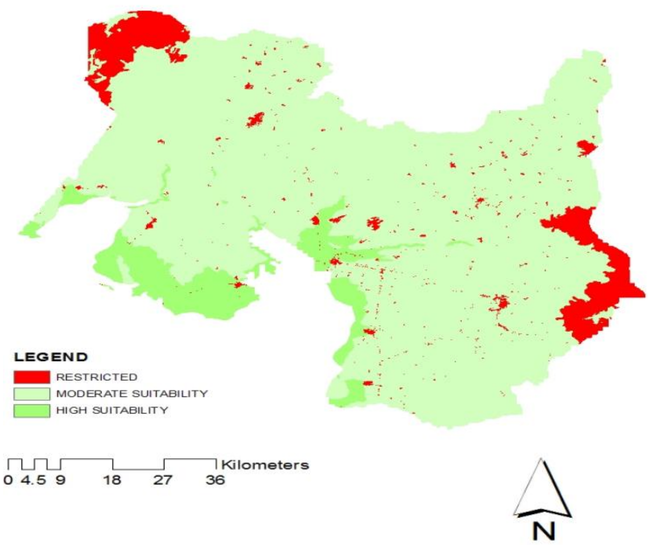

Figure 9. Upland rice suitability due to climate hazards

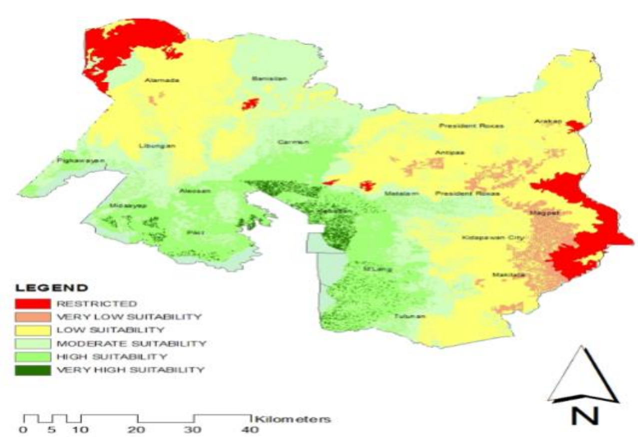

Figure 11. Lowland rice suitability due to climate hazards

Lowland Rice. As the province also produced lowland rice, larger portion of the province, however, are having low suitability for its production.But, there are municipalities that are having a moderate to very high suitability. These municipalities are the municipalities of Kabacan, Tulunan, Mlang, Aleosan, Carmen, Banisilan, Pigkawayan, Pikit, Midsayap, Libungan and Matalam. However, as climate hazards occur, only some parts of Kabacan, Mlang, Tulunan, Pigkawayan, Pikit and Aleosan are moderately suitable while the other municipalities are not suitable for lowland rice (Figure 10). Statistically, there are 84.04% of areas that are low in suitability for lowland rice and only 7.72% are moderate when climate hazard occurs (Figure 11).

CONCLUSION AND RECOMMENDATION

Climate hazards particularly floods and landslides had resulted to shift or change in the suitability of the selected crops in the province. Some areas that were highly suitable became moderate to low suitable areas. Hence, will cause change in cropping pattern as well as cropping calendar. The long run effect of this change in crop suitability will be change in productivity which may lead to change in consumption patterns, thereby, affecting food security in the province.

Sustainable Development Goal (SDG) 13 emphasized to take urgent action to combat climate change and its impact, it is recommended that improvement of early warning systems, contingency planning and integrated responses should be strengthened as this will promote effective community-based adaptation and risk reduction. In addition, proactive approach by local authorities to climate change adaptation can be done by integrating climate change adaptation and mitigation in their local climate change action plan (LCCAP). Further, enhancing the capacity of the farming community can take advantage of the scientific findings of the relevant research organizations. With this, they can be orientated and taught on the possibilities brought about by climate change and what can be done to address its impact to farmer's income. Finally, rain-fed area farmers are encouraged to avoid monoculture, instead plant a variety of heat and drought resistant low delta crops to reduce the risk of crop failure. Hence, by doing so, assessing agricultural potential through crop suitability can achieve various sustainable goals aside from SDG 13 as it can reduce poverty (SDG1), avert hunger (SDG2), enhancing good health and well-being (SDG3), responsible consumption and production (SDG12) and sustenance of life on land (SDG15).

As the study only include limited crops, future study can explore crop suitability of other crops especially to areas where there is a high risk of climate change. Further, to see specific effects of climate hazards (i.e, flood and landslide), future study can generate separate crop suitability maps for each hazards and identify which crops are suitable per area, hence, crop simulation can be done.

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