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Crops and Cropping Strategies to Maintain Food Security under Changing Weather Conditions in Papua New Guinea

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Abstract

Papua New Guinea's climate varies considerably from year to year due to the effect of the El Niño-Southern Oscillation (ENSO). This cyclic variation leads to two extreme climatic conditions; the El Niño and La Niña. El Niño can lead to severe drought conditions and La Niña is associated with excessive rainfall causing flooding, water logging and erosion of food gardens. El Niño conditions occur approximately every 10 to 15 years resulting in reduction of almost 75% of mean annual precipitation. Thus, important tuber crops such as sweet potato, yam and taro which provide almost 80% of food energy for PNG's population, produce low yields and/or even fail to yield, leaving affected communities food insecure. Currently, there is lack of information on soil available water capacity for PNG soil types and crop water requirement (ETc) under different climatic extremes, which would form the basis for recommendations on suitable crop management practices. This study addressed the lack of availability of weather data in PNG and investigated potential impacts of ENSO events and future climate change on crop production through generation of past, current and future climatic scenarios, determination of soil moisture retention characteristic curves, and calculation of ETc for the main staple crops across different agro-ecological zones in PNG based on generated climatic scenarios. The tools and methods used for meteorological data generation and climate scenario development were evaluated for their applicability in the PNG context. The used tools for simulation of climatic and weather data clearly show that not all give accurate results. Results highly depend on the quality of downscaled climatic data based on selected emission scenarios of CSIRO-Mk3.6.0 GCM model, high topographic variations between interpolated data points and the type of tools used. Results showed that ETc for crops may increase in the future due to rising temperature; however this effect might be compensated through increased annual rainfall and cloud cover. Dry spells, droughts and changing weather patterns will make it necessary for farmers to adjust their cropping calendars and apply improved farming technologies to adapt to the changing conditions according to local soil water storage capacities and agro-ecological zones

Keywords: Climate change, crop water requirement, available water capacity

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Introduction

Almost 80% of PNG's population are subsistence farmers that mainly grow tuber crops and few tree crops such as sago and banana as staple food for consumption as well as alternative animal feed where protein is sourced. The country is categorized as the wettest area where it regularly receives 2000-4000 mm in many areas and few areas received more than 7000mm. Whereas drier areas receive below 1500mm annually (Bourke, and Harwood, (eds) (2009)). Hence, agricultural activities are mainly rainfed based system. Cropping practices are designed to suit the local climatic condition such as digging of deep drainage and mounds in water log areas or drainage along the slope to maintain field capacity and prevent soil erosion on poor drained soil. Flat beds with or without drainage are mainly done in lowlands. Under normal climatic scenario, farmers normally practice mix cropping system for sequential harvesting and/or involve in food preservation techniques in preparation for the unfavourable climatic seasons to maintain food security all throughout the year. However this pattern is not applicable nowadays due to climate change. Climate change leads to erratic, excessive and deficit rainfall that confuses farmers cropping calendar and provide unfavourable environment for crop production leading to yield decline and crop failure. This study came about to generate information on crop growing environment (different agro ecological zones vulnerable to climate change) under different climatic extremes. Hence, soil moisture retention characteristic curves generated and crop water requirement calculated under different climatic scenarios, to come up with suitable crop and cropping strategies that can maintain food security. Moreover the tools and methods used were evaluated for their suitability in PNG context.

Material and Methods

Tambul in the Western Highlands (2300masl) and Kopafo (1700masl) in Eastern Highlands province were selected as highlands dry and wet areas accordingly. Derin (52masl) and Murukanam (32masl) in Madang province were identified as lowland wet and dry sites in the Momase region. While Hisiu (30masl) and Yule Island (36masl) of Central Province represents the very drier areas in the Southern Region. These sites are hotspots to climate change impacts on food production in PNG. The study considered the interdependently linked system of soil moisture flow between soil, plant and atmosphere (Hillel.D.2004). Meteorological data were generated using PNG National Weather Service recorded data (from 1996-2014), NewLocClim software (local climatic estimator) and MarkSim (CSIRO-Mk3.6.0 Global Circulation Model selected) tool accordingly to past wet and dry scenario, current and future projected scenario. Moreover, soil moisture retention curves (SMC) for these sites were generated using Hyprop (a laboratory evaporative method using undisturbed soil sample) and RETC software (parametric model using soil texture and bulk density data) to generate soil metric potential and water content data for curves. These high cost Hyprop and with Low cost RETC methods were evaluated for their suitability in PNG context. Finally crop water requirement was calculated (FAO. 1998a) using the meteorological data generated at different climatic scenario for shallow root crops at different project sites.

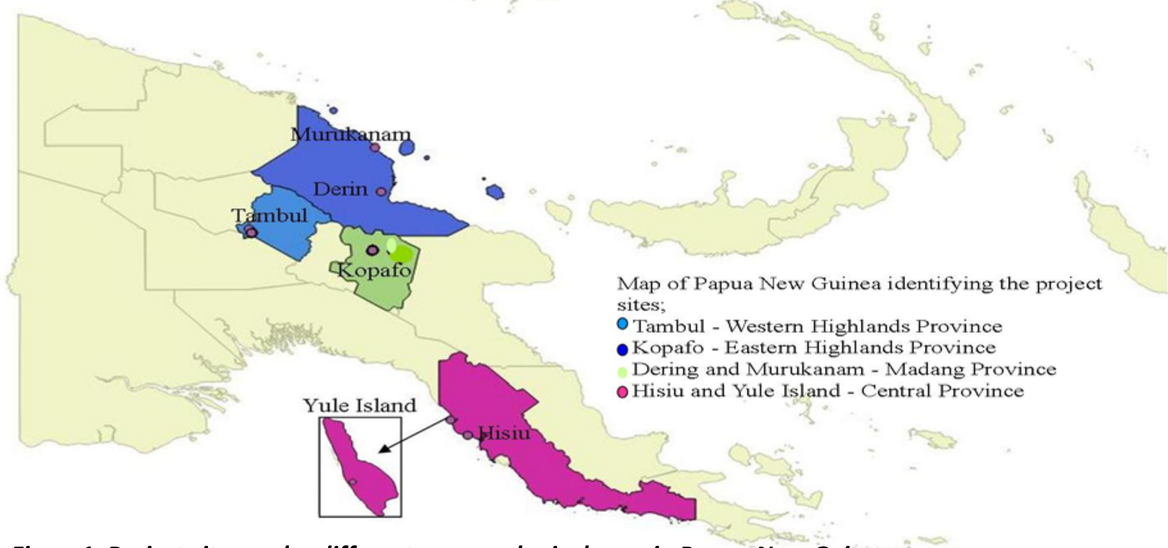

Figure1. Project sites under different agro ecological zone in Papua New Guinea

Results and Discussion

Moisture Retention Characteristics Curves

The hyprop generated SMC reflected well the soil texture, bulk density and organic matter content of the soil for specific sites. The curve shows that soils with thin organic matter content, high bulk density and heavy clay had poor water storage capacity whilst light to medium textured soils with high organic matter (OM) content with low bulk density have good storage capacity.

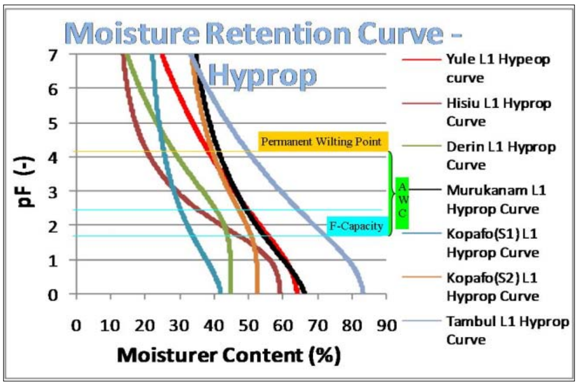

Figure 1. Hyprop generated Curves

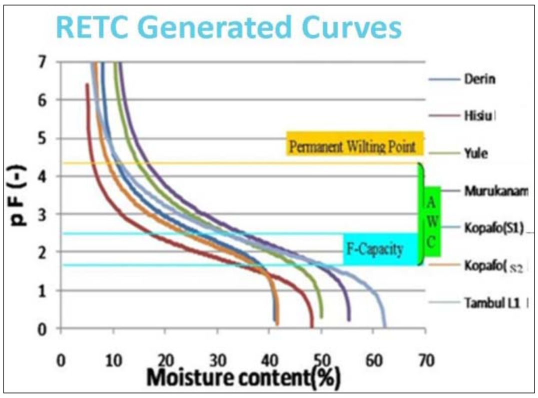

Figure 2. RETC generated Curves

However, the RETC generated curve was dominant to light textured soil characteristic. Thus the available soil water capacity considered for this study taken from the hyprop generated curves.

Crop Water Requirement (ETc) at Specific Climatic Scenario

Findings showed that in the past dry scenario tuber crops ETc exceeds rainfall for more than 5 months in Hisiu and Yule Island, besides that 3-4months (June to September) water deficit in other sites. Moreover under wet and normal scenario, the dry areas experiences fluctuation on rainfall against ETc in Kopafo,

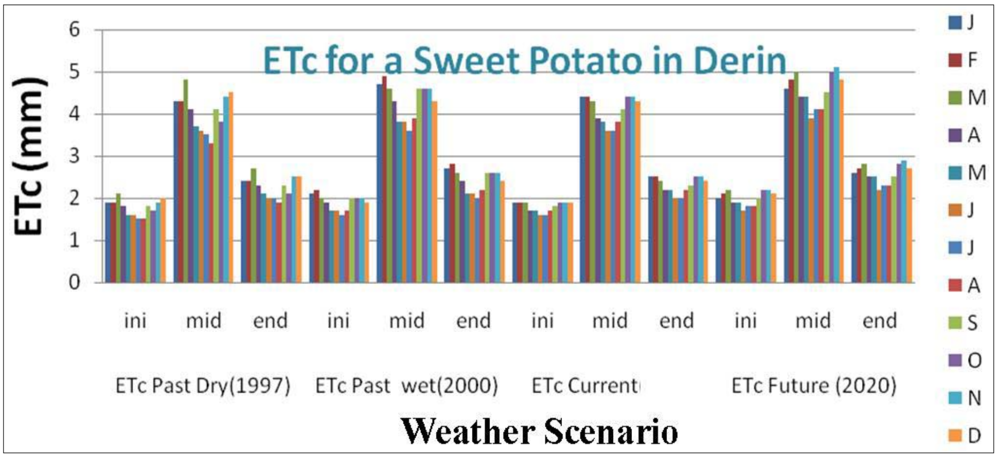

Figure 3 ETc of a sweet potato for Derin resembling results under different climatic scenario.

Tambul, Derin and Murukanam in the month of June to August and in Hisiu and Yule Island rainfall concentrated in one half of the year and deficit on the other half of the year. Rainfall exceeded ETc in wet areas (Derin and Tambul) under normal and wet scenario. Crop ETc is projected to increase in the future as the temperature increases

Crop Growing Environment and Farming Strategies

Yule Island soils have poor available water capacity (AWC) due to very thin top soil with vast subsoil of rock pebble type. Similar (poor storage) for soil of Kopafo on the sloped areas in terms of low OM with high bulk density that dominated by soils under influence of iron oxide (Bleeker. P. 1983). These sites are drier areas, which have huge water demand for crops. Hence, it is better to practice slope agricultural land technologies and/or agro forestry. These will increase OM, minimize evapotranspiration, help surface inflow water, conserve top soil and access ground water table. The soil of Murukanam and Kopafo on the valley (also dry areas) do not have all the soil water content available to crop due to their heavy clay content (Aghdasi .F. 2010). Thus, improves fallow practices, deep ploughing, organic farming will change the soil texture, structure and improve OM for better water storage. In addition to that, irrigation is vital to meet crop water demand and/or the soil has potential for aquaculture rather that abandoning it during wet scenario. Hisiu soil had better AWC and has a shallow ground water table better for irrigation in dry scenario. However the area is also vulnerable to water logging due to rising of sea level and continuous cutting down of tall trees. Therefore, reforestation and maintaining of palms and local trees will balance ground water table. Finally Tambul soil has thick dark black volcanic ash soils that make it to possess very good AWC. On other hand it is prone to leaching under high rainfall and therefore farming system involved in the application of OM with high cation will balance leaching. In general, wet areas are encouraged to plant moisture tolerant crops and in moisture deficit areas drought resilient crop are encouraged to adopt into the farming system to maintain food security.

Evaluation of Tools and methods Used

Hyprop generated better SMC curves but needs constant electricity supply to complete a measuring campaign. RETC curves may be applicable for light textured or be further evaluated. The settling method used to generate soil texture data as RETC input data gives reasonable result compared to laboratory results. For meteorological data generation the NewLocClim software generated almost better data for sites that do not have real time available data. The CSIRO-Mk3.6.0 GCM under MarkSim tool for rainfall projection was not in line with the Pacific Climate Change Science (PCCS, 2001) high resolution GCM. This might be due to lack of real time available meteorological data, variation between interpolated areas, the type of model used or there might be a weather shift in the future.

Conclusions and Outlook

Slope agricultural land technologies with other traditional and modern moisture conservation techniques will cope with changing weather condition to maintain crop production. For example rainfall distribution and/or intensities vary occasionally which resulted in crop performance shocks, thus irrigation can compensate crop water needs. Furthermore, the soil has to be improved to accommodate optimum water for crop productive use rather that going out as unproductive water. Not all the tools and model used always will give accurate results, it all depends on; the real time available meteorological data, variation between interpolated areas, the type of model used or there might be a weather shift in the future.

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