Determination of Soil Moisture Retention Curve for Available Water Capacity and Crop Water Requirement under different Climatic Scenario in Papua New Guinea

Introduction

Soil, plant and atmosphere are interdependently linked in a sequential system know as soil-plant-atmosphere continuum (SPAC). The atmosphere part of the system currently seems unfavorable for agricultural activities. This is caused by the global climate change (green house effect) that affect our local climate and the regional climate change (Southern Oscillation). Thus inflow precipitation is restricted and continuous high evapotranspiration demand during El Nino or vise versa, that on the other hand resulted in La Nino and sometime erratic rainfall. This leads to moisture deficit and excess scenario that severely affect crop growth and performance.

Climate change is uncontrollable and therefore researchers around the globe focuses on crop breeding, together with soil and water management to cater crop production under this changing environment. Developed countries use high cost technologies like hydroponics (controlled environment) and commercial irrigation etc to produce enough food for the growing population. Where as farming communities in PNG have some adaptation technologies (raise mounds, drainage, mulching etc.), but cannot survive with these technologies in long extreme scenario. The possible way to mitigate these problem is to study the past extreme climatic scenario, current and future scenario, the soil characteristics to possess moisture and crop water requirement of a particular area at different scenario. Hence, a suitable crop, soil and water management can be identified for adaptation.

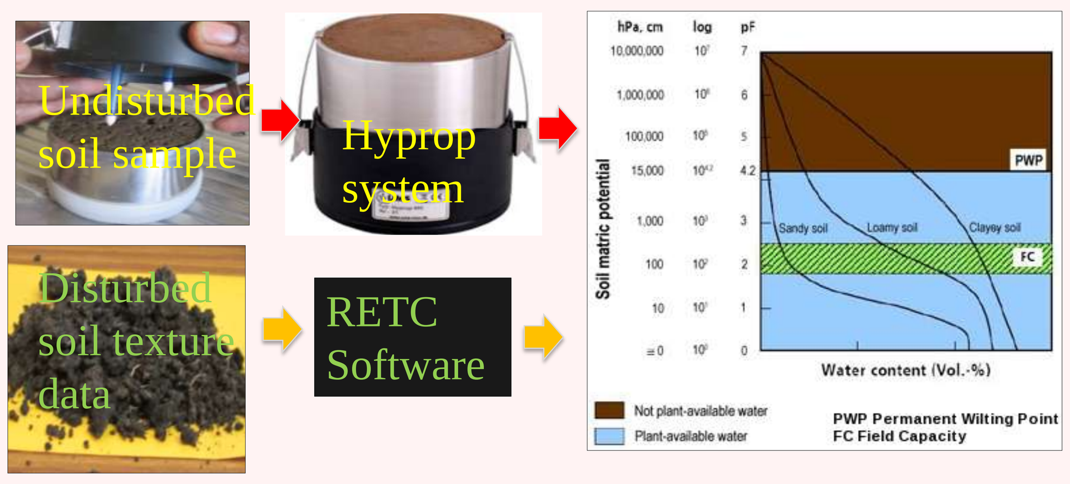
Therefore, this project came about to generate the past and current wet and dry extreme scenario together with future scenario, determined soil moisture retention characteristic curve and calculated crop water requirement for the major food crops in different agroecological zones in PNG.

Materials and methods

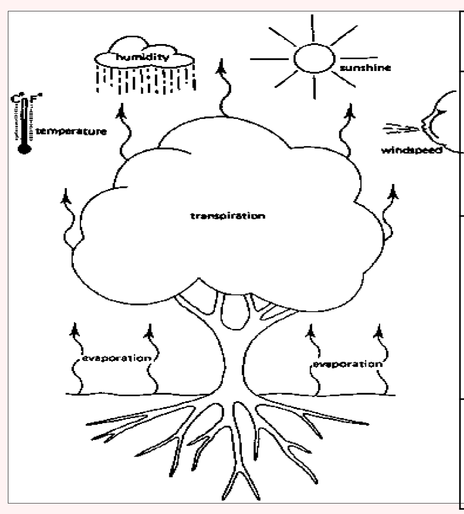
There were three different approaches respectively taken to generate soil moisture retention curve, weather scenario generation and calculate crop water requirement.

1.Moisture retention curve

- Generated through Hyprop system and RETC software



2. Weather Scenario Generation



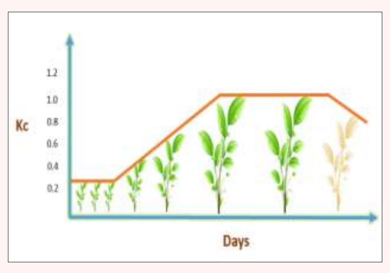
Scenarios	Sources	Comments
Past wet and dry	PNG National Weather Service	1997(Dry) and 2000 (wet)
Long term average (current)	PNG NWS (1996-2014) & NewLocClim Software	NewLocClim generated for unavailable real time data
Future	MarkSim tool	used CSIRO-Mk 3.6.0 model

3. Calculation of crop water requirement

- Crop water requirement(ETc) = *reference evapotranspiration (ETo) x Crop Coefficent (Kc)*
- Meteorological data generated at different scenario used in FAO-Penman-Monteith Equation to calculate reference evapotranspiration(ETo) which then multiplied by crop coefficient(derived from literatures) to determine crop water requirement.

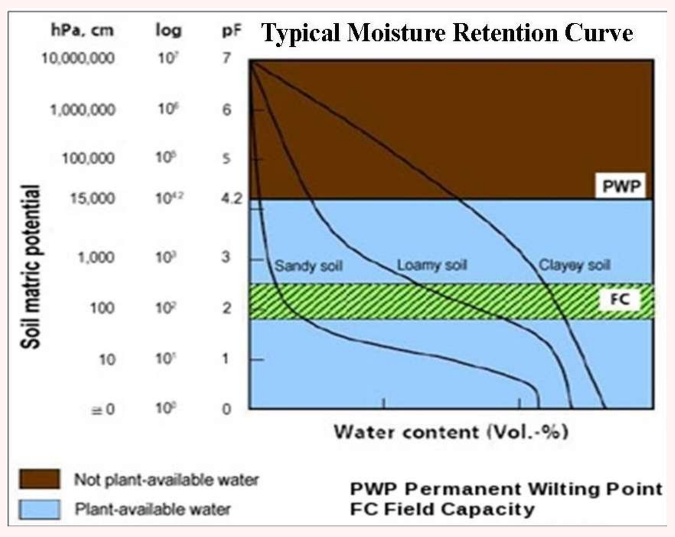
FAO-Penman-Monteith Equation . *Example of crop coefficient*

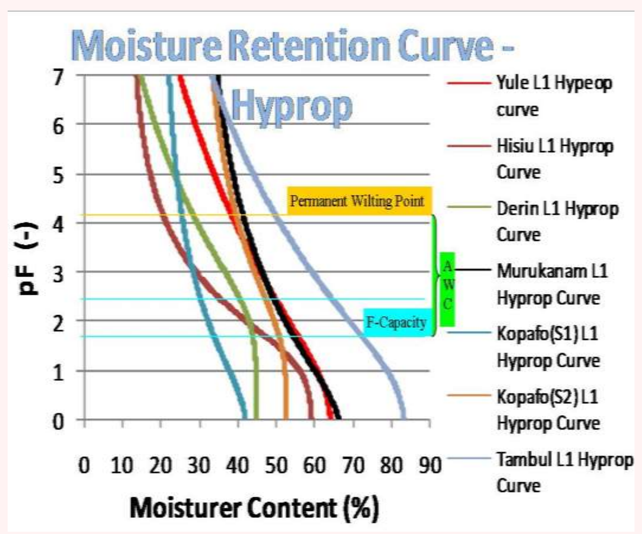
$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma\frac{900}{T+273}u_2(e_s - e_a)}{\Delta + \gamma(1+0.34u_2)}$$

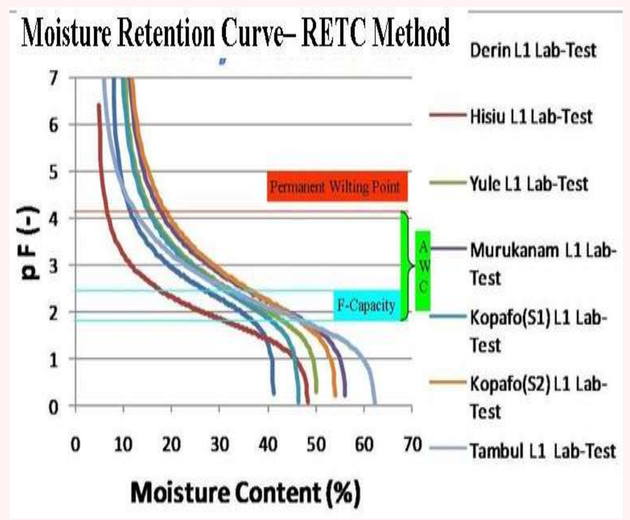


Results

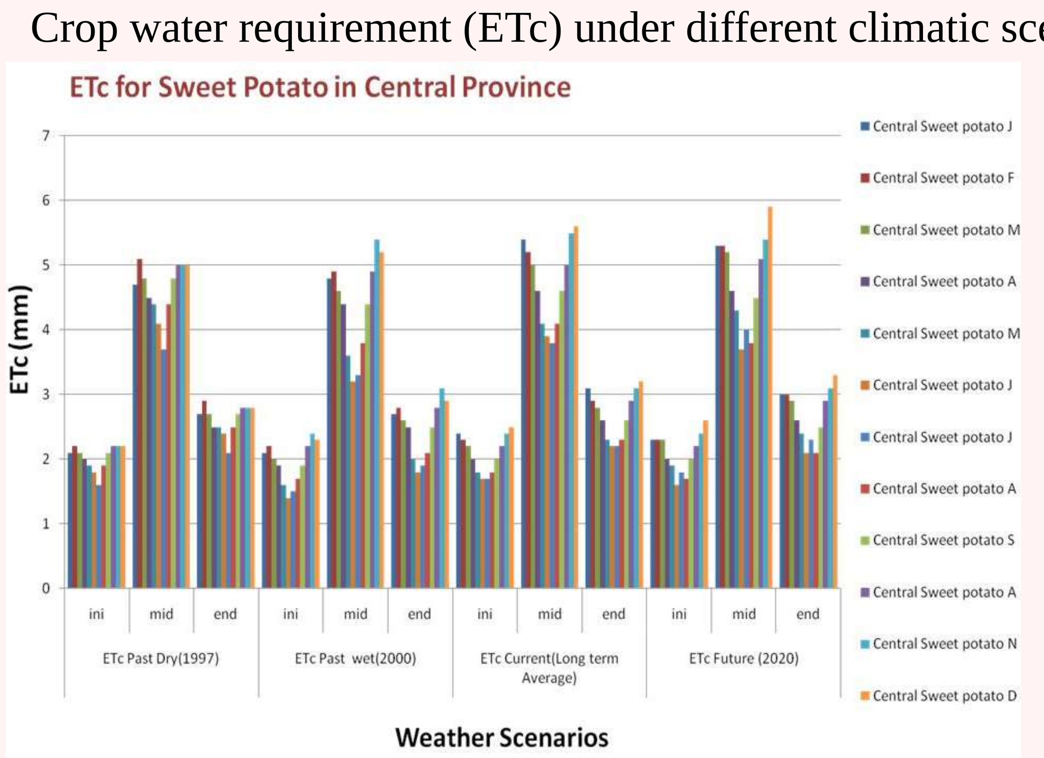
Moisture retention curves generated from the two different methods together with the a stand curve

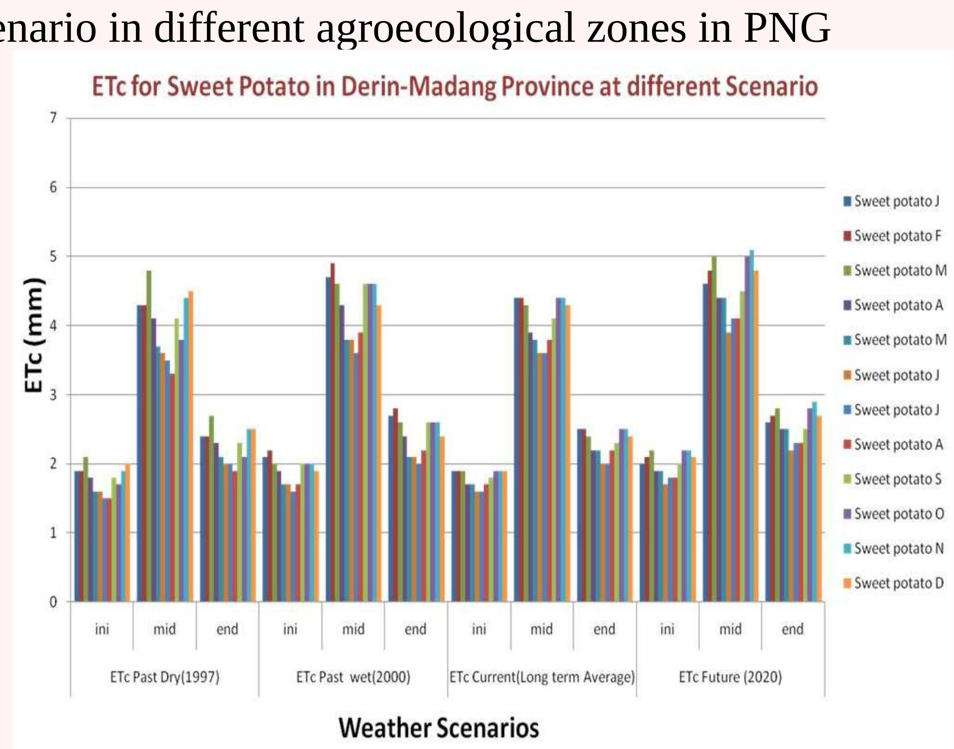






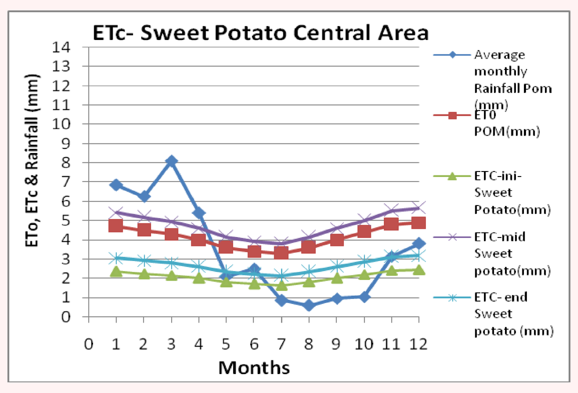
Crop water requirement (ETc) under different climatic scenario in different agroecological zones in PNG

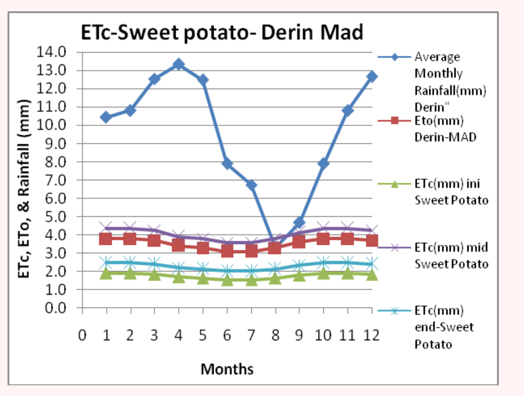


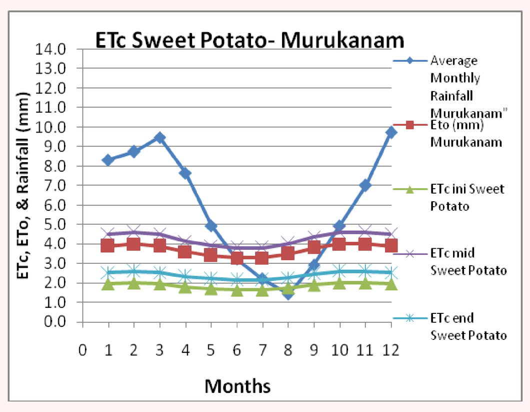


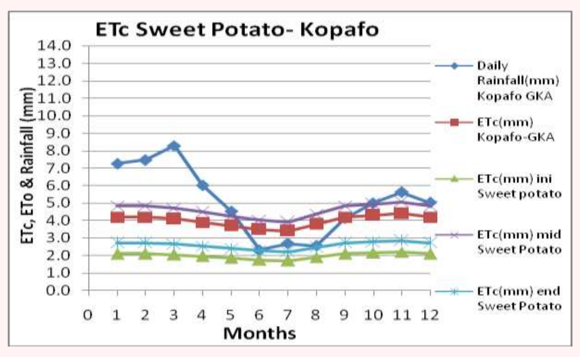
Inflow precipitations under different scenario correlated with crop water requirement

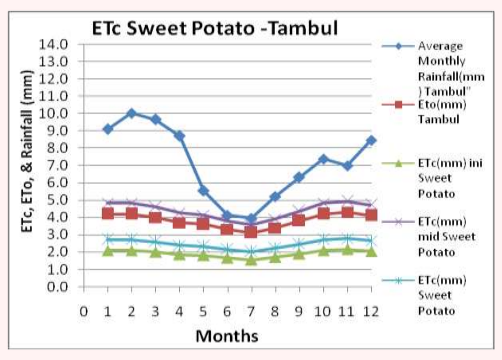
- Only the results for the current scenario of different sites resembles results as shown below











Discussions

Summary of study sites

- In central province at any scenario crop water requirement (major tuber crops) exceeds precipitation for more than five months annually. The Haplustolls soils of Yule Island have shallow top soil that shrink during the long dry season making moisture unavailable even though the soil has moderate moisture storage capacity. Thus the study site soil is favorable for agroforestry to minimize evapotranspiration, trees access soil water from the subsoil and build up organic matter for moisture storage.
- Hisiu soil at the project site have good water storage capacity, that can sustain high evapotranspiration for some time and also have shallow ground water table that have potential for irrigation during the dry season, on the other hand the cutting down of coconut palms and trees can change crop land to swamp due to rising of ground water table.
- In Derin precipitation during normal and wet scenario always exceed ETc. Whereas dry scenario fluctuate together with future scenario having ETc overestimated the rainfall for two months but the soil have good moisture storage capacity that can be compensated by residual soil moisture.
- Murukanam study site soil have heavy clay that possess a high water content but not much is available to plant (tightly bound to the soil particle). Rainfall decrease from June to August and rise afterwards. Cropping strategies are needed during these months to avoid crop moisture stress. Improve fallow, mulching etc to be practiced to improve OM for better water storage.
- Kopafo on the slopping area have high bulk density that resulted in poor water storage. On the valley farming is supported by conserved soil moisture during dry season. Prolonged wet and dry season affect crop production. For dry and normal scenario rainfall underestimated by ETc for almost 3 months (June –Aug). Slope agricultural land technologies is highly needed on the sloped area and irrigation as alternative option for farming in the valley during extreme dry period. Cropping strategies also needed in the low rainfall months to maintain crop production. In the future rainfall will fluctuate in a wide range which need soil moisture conservation practices a lot.
- Tambul area normally receive high rainfall, however the soil is highly sandy with high OM content (volcanic ash soil) that favor nutrient leaching . Crop ETc for the present is underestimated by inflow rainfall and in the future under the CSIRO-Mk 3.6.0 model suggest to receive less rainfall which may favour crop production. Local high nutrient (cations) accumulating plant species can be used as compost to balance out nutrient leaching .

Conclusion/Recommendation

- Hyprop generated moisture retention curve is more likely similar to the standard curve whereas RETC software generated curve in only suitable for light textured soil (loam to sandy)
- The CSIRO-Mk 3.6.0 model used in this study for future climate projections is not in line with the calculations made by the Pacific Climate Change Science model, which shows that not all the tools and models gives good current and projected data, it all depends on the type and quality of real time data for validation and interpolation between weather stations
- National Weather Service meteorological data should be easily accessible
- Temperature rise may have effect on ETc but may be compensated by high rainfall and cloud cover.
- The information on SPAC, should be made known to farmers to support drought resilience, adapt new cropping strategies and post drought recovery.

Acknowledgments

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