Policy brief on the impacts of climate change on root and tuber crops in African, Caribbean and Pacific countries

Executive summary

Climate change will have a significant impact on the development of tropical root crops (TRC) in the African, Caribbean and Pacific countries. Factors such as unseasonal rainfall, increase intensity of dry and wet periods, increasing temperatures, sea level rise causing soil salinity and intrusion into fresh water systems, will impact negatively and sometimes positively on root and tuber crop production. Development of predictive models is imperative for counteracting these phenomenons; however development of these models is restricted by lack of and incomplete climatic data sets which demonstrate inconsistencies in data collection. The main policy recommendations include investing in both human and physical resources by all stakeholders to allow for the collection, processing and use of predictive models in a timely manner; sharing of these data sets amongst all stake holders through coordination will allow for more effective predictive modeling.

Context

The Intergovernmental Panel on Climate Change (IPCC) 2007 report estimated that warming global temperatures are likely to reduce drastically African, Caribbean and Pacific (ACP) agricultural production by 2020[1]. The impact of climate change on rainfall is far less certain, particularly because global climate models often have difficulty reproducing ACP's complex monsoonal rainfall, which is dominated by waves of moisture moving east across the continent[2]. Large changes in the global water cycle are anticipated with dynamic changes in the atmosphere due to increasing temperatures, but exactly how these changes will affect ACP is unclear and whether the impact will be negative or positive. Changes in temperature and rainfall pattern will have significant effect on agricultural production in ACP because the region is dominated by rain-fed agriculture[3]. Climate variability and climate change will continue to impact negatively on the ability of farmers to grow enough food to feed their families and earn revenues for themselves.

Increased investment in the agriculture sector will help ACP to cope with these threats, as most of the poor and food-insecure reside in the ACP. Local, small-scale agriculture projects and appropriate technology that are sustainable without significant outside investments will be critical to improve productivity in the ACP and reduce vulnerability of some of the world's poor[3]. Agriculture dominates the economies of most ACP countries, being the key employer and major source of income and exports.

Roots and tubers are highly important food resources in ACP countries and elsewhere in the developing world. The pressure on demand for food by rapid growth of human population stressed the importance of tropical root and tuber as a staple food commodity in the diet, especially of lower income groups in ACP. They are also used for animal feed and various industrial applications. Their broad agro-ecological adaptability and adaptation to marginal environments, great flexibility in mixed farming systems, ability to produce reasonable yields where most crops cannot, and their capacity to provide high quantity of quality carbohydrates make them the basis for food security at household level for resource poor farmers in ACP[3]. Increasing frequency and intensity of hurricanes due to climate change and variability in the Caribbean and Pacific are major source of destruction for above ground crops. Growing below ground crops such as root and tuber crops (RTCs) therefore becomes an important food security strategy against these challenges.

Although several predictive models to measure the impacts of climate change in developed countries have been developed, those that have would apply to the ACP

regions for hurricanes, sea levels and rainfall variability are less advanced. This policy brief presents the effect of climate change on root and tuber crops. An attempt is made to suggest policy direction to mitigate the adverse effect of climate change on root and tuber production in ACP.

Climate requirements for major root and tuber crops in ACP

Cassava *(Manihot esculenta):* It is a tropical root crop which grows well in warm and humid climates. It thrives well between 25 and 35°C but does not grow well below 15°C. Cassava is drought resistant once established and able to withstand dry spells for more than 3 months.

Yam *(Dioscorea species):* It is a tropical tuber crop hence requires warm sunny weather. It is widely reported that the optimal temperature is 25-35°C under high humid conditions. However, below 20°C the crop is affected. Adequate moisture is required for good growth, development and yield of tubers. Water logging will damage the tubers and severely reduce the yield.

Sweet potato *(Ipomoea batatas)*: mainly grown from sea level up to 4000m in tropics and have wide climatic adaptability.

Potato *(Solanum tuberosum)*: It is mainly grown in the mid altitude and tropical highlands above 1000m above sea level. It requires well distributed rainfall of about 1200mm per annum.

Taro *(Colocasia esculenta)*: It is grown in warmer part of tropical and subtropical region in upland and lowland ecosystem. It grows well in 25-32°C. It requires evenly distributed rainfall of above1500 mm. Taro can withstand water logging.

Tannia *(Xanthosoma sagittifolium)*: Tannia is grown in warm humid climates and is prevalent in tropical regions of the world. For well sustained growth and production, it requires an evenly distributed rainfall of above 1500 mm.

Climate change – Root and tuber crops to the rescue in ACP countries

Worldwide, extensive research is being carried out on crop and livestock systems to cope with climate change through development of heat and drought tolerant varieties, shifting of crop calendars, and resources management practices (such as zero tillage, improved methods of water harvesting, enhancing irrigation efficiencies, etc). Root and tuber crops are tolerant to mid-season drought. Being long duration crops, their spread is limited by length of rainy season under rainfed conditions. Despite their economic and nutritional importance in ACP farming and food systems, little research has been done on the potential effects of climate change on root and tubers[4, 5].

There is strong evidence that atmospheric CO_2 is increasing as well as depleting the ozone layer[5]. This is likely to have detrimental effects on growth and productivity of several crop species. However, scientists have repeatedly recognized that species with large below-ground sinks of carbon and with apoplastic mechanism of phloem loading such as roots and tubers are likely the best candidate for a large response to rising atmospheric CO_2[4, 5]. An experiment conducted in Netherlands on the effect of elevated CO_2 on yield of potato showed that doubling CO_2 resulted in 24-40% increases in tuber yield[5]. It has also been shown that temperature increases, especially in warmer climates such as obtainable in ACP, may be assumed to have less influence on potato phenology than on the development of other winter crops such as cereals. A study conducted in USA on the effect of climate change on potato showed that CO_2 enrichment increased tuber yield and biomass dry weight by 30% and 34%, respectively. Daily temperatures beyond the optimal temperature range (16 and 22°C) may result in reduced growth and in turn lower harvest index and tuber yield[5]. However, with climate change, the prevailing temperature during tuber growth and development may likely be different, but the

effect of this changes on yield whether positive or negative is uncertain. Also, positive yield response to increased temperature and longer growing seasons by heat-loving crops such as sweet potato has been reported by Bueno et al. [6].

Currently, it may not be scientifically possible to extrapolate all the considerations and conclusions made for potato to the other root and tuber crops. The objective of this brief, *inter alia*, is to provide information that will guide ACP roots and tubers scientists or farmers to a critical analysis of issues that will help to identify the effect of climate changes on root and tuber crops and where more research is needed.

To assist in long-term poverty alleviation in ACP, the supply of RTCs will need to be drastically increased and their volatility in production during season decreased. Most of the RTCs cultivated in ACP are resilient to extreme climate conditions especially drought. Hence, regions where they are grown are better able to withstand potential food insecurity as a result of adverse climate changes than regions where cereals are less easily cultivated. However, new and emerging technologies appropriate for these marginal environments in which RTCs tend to grow are still largely missing, justifying the need for more opportunities in research on the effect of climate change on yield and postharvest handling/utilization of RTCs in ACP. Areas where RTCs are not currently suited but likely to be suitable in the future should also be identified.

Increased poverty, hunger and malnutrition are expected in many countries and low-lying areas as a result of rising sea level[7]. Sea level is predicted to rise by 1-1.5m by 2100 through global warming. In the South Pacific a significant production of TRC is grown below 5m above sea level (ASL) and the sea level rise will affect around 400,000 people who live below 2m ASL. Sea level rise will have a catastrophic effect on production and consumption of TRCs on low-lying coral atolls and low-lying areas. Main countries affected will be Islands of the South Pacific (Kiribati, Tuvalu, Fiji, Tonga, Cook Islands, Vanuatu, Federated States of Micronesia, American Samoa, Tokelau, Wallis and Futuna Islands).

Policy Recommendations

1. There is the need for regionally coordinated research to urgently examine the effect of climate change on productivity and postharvest characteristics of root and tuber crops (cassava, yam, sweet potato and taro) commonly grown in ACP Countries.

2. There is the need for an integrated type of GIS modeling system, to allow agricultural producers as well as policy makers to know the impact of spatial-temporal variation in climate on crop yield for better management, productivity and profitability.

3. There should be investment in future water supply expansion and efficiency enhancement through modern day irrigation systems by all stakeholders (government, NGO, private sector and investors) in the agricultural sector to support RTC and other crops.

4. Breeding of TRCs that will survive high salinity, low and high moisture levels must be a priority for low lying regions where RTCs are important staples

5. Agricultural reform should be implemented to enhance infrastructure investment in ACP to improve production, storage, processing and marketing.

6. Farming techniques needs to be improved to enhance adaptation to climate change by farmers in ACP.

Bibliography

1. IPCC (2007). Intergovernmental Panel on Climate Change (IPCC). Fourth Assessment Report; Intergovernmental Panel on Climate Change: Geneva, 2007.

2. K. Cook and E.K. Vizy, (2006). Coupled model simulations of the West African monsoon system: 20th and 21st century simulations. Journal of Climate, 19: 3681–3703.

3. P.S. Sivakumar, M. Brown, B. Intermann, N. Higgins (2009). Markets, Climate Change, and Food Security in West Africa. Environmental Science Technology, 43: 8016–8020

4. S.K. Jata, and M. Nedunchezhiyan (2010). Adoptability and Adoption of tropical tuber crops to climate change. Orissa Review, May-June – 2010

5. F. Migilietta, M. Bindi, F. P. Vaccari, A.H.C.M. Schapendonk,J. Wolf and R.E. Butterfield (2000). Crop ecosystem responses to climate change: Root and Tuberous crops. In: eds. K.R. Reddy and H.F. Hodges, Climate and global crop productivity, CAB International. Pp. 189-212.

6. Bueno, R., Herrzfeld, C., Stanton, E. A., Ackerman, F. (2008). The Caribbean and Climate Change: The costs of inaction. Stockholm Environment Institute and the US Centre Global Development and Environment Institute, Tufts University. May. 35p.

7. Chandra, S. (2010). Presented at the second Project Management Committee meeting of the Science and Technology for Enhancing the Contribution of Tropical Root Crops to Development in ACP Countries Project at the 11th Symposium of the ISTRC-AB, Kinshasa, Democratic Republic of Congo, 30 September – 8 October 2010.