Note

Adaptation Technology to Climate Change in the Agricultural Sector

By Faraja Ntepa & Leslie Debornes

Summary

As one of the most climate-sensitive sectors, agriculture is among the key priority areas for climate adaptation in many developing countries. There, capacity to adapt depends on factors such as financial resources, skills, education, infrastructure, technology etc. Focusing on the latter, this note reviews a number of possible adaptation technologies that East African countries may consider promotinh, in areas such as rainwater harvesting, micro irrigation, soil moisture sensors, geographic information systems etc.

Introduction

Human activities have resulted to the destruction and increase of the atmosphere concentrations of greenhouse gases (GHG) that result to the climate change impacts in the globe. Agricultural sector is one of the world climate sensitive sectors in the World, hence the need to implement various measures to increase access and development of adaptation technology to climate change.

According to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001) "adaptation to climate change" is defined as an adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities.[1] Adaptation may reduce impacts of climate change and may enhance beneficial impacts. The capacity of adaptation to climate change depends on factors such as wealth, technology, skills, education infrastructure, access to resources, wealth and management capabilities.[2]

Adaptation technology can be defined as the application of technology in order to reduce the vulnerability or to enhance the resilience of a natural or human system to the impacts of climate change. Adaptation technology is imperative because it will help farmers to cope with climate change issues and remaining able to produce. While reducing the risks and vulnerability, there are different ways to implement adaptation technology such as: anticipatory adaptation done before the impacts of climate change, reactive adaptation done after the impacts of climate change; private adaptation initiated and implemented by individuals and private companies; and public adaptation also initiated and implemented by government at all levels (directed at collective needs).[3]

Rain water harvesting technology

Rain water harvesting technology is a technique of collection and storage of rain water into natural reservoirs or tanks. It is an accumulation of reused water on site, rather than allowing it to run off. Examples of rain water harvesting are roof top and ground. The components of rain water harvesting involve a catchment area (i.e. a place to harvest water can be agricultural, rocky, marginal, rooftop or paved road), storage facility where harvested runoff water is held from the time collected until it is used (i.e. tanks, jars, ponds, reservoirs, underground), and lastly the target area where harvested water is used.[4]

It can support farmers in adapting to climate change as, due to unpredictable climate changes that results to water scarcity, this technology could assure the access to water for them. In fact, collection and storage of rainwater can provide a convenient and reliable water supply during seasonal dry periods and droughts. Additionally, widespread rainwater storage capacity can greatly reduce land erosion and flood inflow to major rivers. Rainwater collection can also contribute greatly to stabilization of declining groundwater tables.[5] Also rain water is free from minerals, hence is good for the agricultural sector.[6]

[1] Robledo C, Kanninen M, Pedroni L (2005)Tropical Forests and Adaptation to Climate Change;Indonesia.Pg.2
[2] Ibid Pg10.

[3] Robledo C, Kanninen M, Pedroni L (2005)Tropical Forests and Adaptation to Climate Change;Indonesia.Pg.6
[4] Oweis T, Prins D, Hachum A(2012) Wataer harvesting for agriculture in dry areas;CRC Press.pg6

[5] Elliott M, Armstrong A(2011)Technologies for Climate Change Adaptation; UNEP. pg 51-53
[6] Rain water harvesting for storage 2017 by UNEP-DHI Partnership. https://www.ctc-n.org/resources/rainwater-

The Northeast of Brazil is a semi arid region which most of the times faces severe lack of water and drought. But adoption of rain harvest technology has supported the small scale farmers in cultivation and animal breeding. [7] The Brazilian Agricultural Research Corporation advocated the adoption of this adaptation technology for water storage and soil nutrients through research on the technology.[8] Brazil has also been cooperating with the Brazilian Association for Rain water harvesting and management through IFAD sponsored projects. Moreover, civil society, small scale farmers unions and cooperatives have taken alternative measures to support the catchments systems, also providing capacity building and raising awareness of this technology. Valid data on the economic efficiency of rainwater harvesting systems is not available yet. The associated costs of a rainwater harvesting system are for installation, operation and maintenance (i.e. costs for installation, the reservoir as well as storage tank) In Brazil the costs of rainwater harvesting technology are minimal, the main costs are in building and preparing the storage facility, also it requires very little maintenance once the site is chosen and prepared.[9]

Drip/micro irrigation technology

Drip irrigation technology is based on the constant application of a specific and calculated quantity of water to soil crops. The system uses pipes, valves and small drippers or emitters transporting water from the sources (i.e. wells, tanks and or reservoirs) to the root area, and applying it under particular quantity and pressure specifications.[10]

Drip irrigation adaptation technology has significant potential to reduce small farmers' vulnerability in facing variability in rainfall and prolonged droughts. Drip irrigation is appropriate where there is (or is expected to be) limited or irregular water supply for agricultural use. Drip/ micro irrigation is encouraged as a climate-adaptive technology that will reduce demand for groundwater and notably enhance the resilience of agriculture in light of ongoing groundwater overdraft and climate change induced shocks.[11]

Operation and maintenance of the drip tape or tubing must be carefully done in order to avoid leaking or plugging and emitters must be regularly cleaned to avoid blockage from chemical deposits (i.e. required specific training)

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The cost of a drip irrigation system ranges from US$ 800 to US$ 2,500 per hectare depending on the specific type of technology, automatic devices, and materials used as well as the amount of labour required. Farmers usually have to cover installation, design and training costs that represent about 30 to 40 per cent of final costs depending on the size of the land, characteristics and shape, crops, and particular technology applied.[13]

In India, micro irrigation technology has been

harvesting-storage

[7] Rainwater harvesting in semi-arid region helps women by Daniela Noguiera. http://genderandwater.org/en/gwa-products/knowledge-on-gender-and-water/articles-in-source-bulletin/brazil-rainwater-harvesting-in-semi-arid-region-helps-women-1/brazil-rainwater-harvesting-in-semi-arid-region-helps-women

[8] Luiz da Silva C, Bassi N(2016) Technologies for rational water use in Brazilian Agriculture.

[9] https://www.oas.org/dsd/publications/unit/oea59e/ch11.htm

[10] Sara L, Kim R(2015) Evaluating and Prioritizing Technologies for adaptation to Climate Change

[11] Trevor B (2017) Assessing India's drip-irrigation boom; pg13

[12] Trevor B (2017) Assessing India's drip-irrigation boom; pg13

[13] Sara L, Kim R(2015) Evaluating and Prioritizing Technologies for adaptation to Climate Change

adopted to manage water stress due to climate change.[14] India has accessed the drip irrigation adaptation technology through technology transfer mainly through Israel. Under the India-Israel Agriculture Project, a Centre of Excellences was established in various states which are helping the farmers in India to adopt the latest technologies, such as micro irrigation systems. The cooperation with Israeli agricultural technologies has helped in bringing the most advanced innovations to the Indian farmers to use drip technology at affordable prices. Israeli scientists and agronomists were enlisted for extension support in India with their vast practical experience from Israel and worldwide, then educate the Indian farmers through seminars and field visits.[15]

Moreover, the Central & State government recognized the importance of drip technology way back in 2003, with the formation of 'Task Force on Micro Irrigation'. The government has also been extending subsidy through bodies like National Mission on Micro Irrigation (NMMI) to encourage farmers to take up drip irrigation in a big way. Also through partnership with other organizations, such as the World Bank with whom the government signed a project for small and marginal farmers in Maharashtra for climate resilient practices to promote adaptation technologies, like the micro irrigation. [16]

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It can be noted that other organizations from Israel, like Bridges Israel Foundation, have supported the drip irrigation technology.[18]They have advocated for family drip system which can support the increase in production to small scale farmers and reduction of water usage.

Soil moisture sensors technology

Soil moisture sensor is an instrument that measures the quantity of water contained in a material, such as soil, on volumetric or gravimetric basis. It can also indicate what the roots are experiencing under the soil. Soil moisture sensors mitigate over application of water which allows both environmental and financial gain. There are volumetric sensors, which measure the amount of water in the soil, tensiometers which measures the tension between soil particles and water molecules and solid state sensors (the cheapest) which measures soil moisture content. The types of soil moisture sensors are differing in how they take field measurements for soil moisture levels.[19]

Soil moisture sensor adaptation technology is essential to farmers because it can inform when it's time to irrigate or to withhold watering. [20] Climate change has resulted to flood, drought which results changes to the soil. Soil moisture sensors can be used as an adaptation technology to test the soil and help farmers to be aware of the moisture, hence

[14] Climate Change and Water availability in Indian Agriculture by H Pathak. pg9
[15]Sheetal S (2017) Israel technology to transform Indian Agriculture
[16] Press release 2018 https://www.worldbank.org/en/news/press-release/2018/04/06/government-india-world-bank-sign-new-project-benefit-over-25million-small-marginal-farmers-maharashtra

[17]Sheetal S (2017) Israel technology to transform Indian Agriculture
[18] https://www.timesofisrael.com/drip-irrigation-startup-ndrip-gets-investment-from-uk-israel-impact-fund/
[19] https://mytrellis.com/blog/smstypes
[20]https://www.agritechtomorrow.com/article/2017/07/emerging-agricultural-technologies/10116

improvement of irrigation scheduling. Soil moisture sensor adaptation technology has played an important role in the agriculture sector. It has been used to support irrigation management decisions of crops like cotton. It has supported farmers to increase production in agriculture, because it gives a better evaluation of the soil through estimating the soil water content. It has the potential to provide maximum water use efficiency by maintaining soil moisture at optimum levels.

The Food and Agriculture Organization (FAO) of the United Nations have been sponsoring for the soil moisture sensors research.[21] The costs of the sensors varies but the most expensive is the volumetric sensor which costs from 100US Dollars per sensor, Tensiometers are simple to use and cheaper as they are from 80 US Dollars. [22]

In South Africa, a soil moisture sensor has been adopted for irrigation management to cope with climate change.[23] This is the case of the company *Aquacheck*, which trades soil moisture sensors, to support farmers by conserving water, increase the crop yields and avoid soil erosion.[24] Participatory modelling approaches and adoption designs directly involving stakeholders have been used to implement locally relevant adaptation plans for agriculture and water management. Moreover, agricultural researchers have undertaken studies assessing adaptation options in order to avoid climate related damages.[25]

Geographic Information System

This is a computer based tool that collects, displays, visualizes, stores and analyzes geographic information.[26] The GIS adaptation technology is essential for defining the agricultural and geographical areas that are more sensitive to climate change and identifying appropriate adaptation responses. It includes the implementation of map projection, boundary allocation, interpolation and a graphical display of special data that can help to adapt to climate changes and allow for sustainable development of agriculture.[27]

Geographic Information Systems (GIS) are incredibly helpful for farmers to map and project current and future fluctuations in precipitation, temperature, crop output, rainfall amount, soil type, and drought as well as risk prevention from flood.[28] By mapping geographic and geologic features of current (and potential) farmland, scientists and farmers can work together to create more effective and efficient farming techniques; this could increase food production in parts of the world that are struggling to produce enough. Costs of GIS technology vary from one area to the other depending on the network, infrastructure and power supply in place. The system developers should provide improved software functionality, integration, user interface, documentation and training to the farmers, especially in the developing countries.[29]

Prominent challenges for farmers to access the technology are associated with the lack of

[21] https://www.ars.usda.gov/news-events/news/research-news/2007/new-soil-moisture-sensors-assessed/
[22] https://mytrellis.com/blog/smstypes
[23] https://aquacheck.co.za/soil-moisture-probes/
[24] https://aquacheck.co.za/
[25] https://onlinelibrary.wiley.com/doi/full/10.1002/wcc.295

[26] https://gisgeography.com/what-gis-geographic-information-systems/
[27] https://www.emeraldinsight.com/doi/abs/10.1108/17568691111128986
[28] http://smallfarms.cornell.edu/2017/04/03/use-of-gis/
[29] https://www.tandfonline.com/doi/abs/10.1080/02693799108927829

reliable power, internet connection, computer system and accessories and appropriate software. The nature of the school curriculum and insufficient knowledge and skills on GIS also affects the access to farmers.

In Nigeria, the technology is accessed through skills and knowledge transfer to the farmers. There are companies like GIS stematix that provide consultation and training on GIS for farmers and other individuals.[30]Application of GIS ensures quality control, soil suitability, agro-climatology, management of natural resources, and crop's cultivation in a cost-effective manner so as to maximize yield, disease and pest control. Also, the use of GIS helps farmers to avoid excessive use of fertilizers and other chemicals which can have negative environmental effects based on analysis of data. [31]

The United States of America support the farmers by GIS adaptation technology through the United States Department of Agriculture (USDA).[32]The technology is called Agricultural Geographic Information Systems (AGIS) can map not only topography and crop health, but also help to solve issues from rural farming practices. Moreover, it is implemented through training and consultation from various private sectors like the (Environmental Systems Research Institute (ESRI) an international supplier of GIS software, web GIS they give awareness and provide capacity to farmers. Farmers in the States are able to access the GIS data on their lands; a program called CropScape and another called VegScape allows farmers to access relevant data without having a GIS themselves ask questions and interact. [33]

Greenhouse farming technology

A greenhouse (also called a glasshouse) is a building where plants are grown under a controlled micro environnent. It varies in size from small sheds to very large buildings. A greenhouse can be structured with different types of covering materials, such as a glass or plastic roof and frequently glass or plastic walls; it heats up because incoming visible solar radiation (for which the glass is transparent) from the sun is absorbed by plants, soil, and other things inside the building. Air warmed by the heat from hot interior surfaces is retained in the building by the roof and wall.[34]

One of the biggest advantages of greenhouses is the ability to achieve optimum growth conditions in any climactic zone, as compared to growing crops in open fields where climactic control is not possible. For example, peppers cannot be grown outside in winter due to the cold, but they can be grown in warmer conditions in greenhouses; and when it is too hot, dry or humid for certain crops in the summer, they can be grown in greenhouses under cooler controlled conditions.[35]

Adoption of this technology can enable both small scale and large scale farmers to grow crops in areas with diverse climatic conditions.[36] In Tanzania the farmers that have implemented greenhouse farming have increased production ten times more than the open farming and also have maximized profit. A farmer in Tanzania has stated "The advantage of greenhouse farming is that production goes on throughout the year and

[30] http://gisystematix.com/
[31] GIS and its nexus to agriculture by Asiru Monday
[32] http://www.esri.com/news/arcuser/0402/focus1of2.html
[33] https://www.gislounge.com/use-gis-agriculture/
[34] http://www.nafis.go.ke/vegetables/tomatoes/principles-of-green-house-technology/
[35] http://www.israelagri.com/?CategoryID=402&ArticleID=1490
[36] https://www.aboutuganda.com/uganda/agriculture/green-house-farming

does not depend on rain. The risk of diseases is also lower compared to open farming,"[37] *Affordable greenhouse limited* has been implementing greenhouse projects through helping both Tanzanian large scale and small-scale farmers with training and technical support for starting and maintaining greenhouse.[38]

The cost of greenhouse farming depends on the sizes and proximity of materials. In Tanzania the costs are from 1000 US Dollar, depending on the size. The main challenges in accessing this technology include lack of funds as well as lack of appropriate expertise. Therefore, they need capacity building and training so as they can be able to benefit from the technology.[39]

Way forward

Farmers and agro producers need technology transfer especially in the developing countries to access relevant adaptation technology to climate change. This can be done through South-South cooperation, such has already been demonstrated by Israel In fact, the Israeli government has advocated for greenhouse technology transfer to African countries through various training and trading materials. The Prime Minister Binyamin Netanyahu supported the 12th Africa- Israel economic mission held in Tel-Aviv that gathered African farmers and entrepreneurs to train them on adaptation technology so as they can improve the resilience of their agricultural sector.[40]

Once the technology accessible/ transferred, the farmers need technical, infrastructural and financial resources in order to fully implement the adaptation technologies.

The government, policy makers and climate negotiators should support the technology transfer and technology access to farmers, and the establishment of proper institutional infrastructures for management and operation of adaptation technologies. There is also a need to create an enabling environment (supporting policies and strategies at national, regional and multilateral levels) to support adaptation technology.

Lastly farmers, government and other stakeholders should cooperate to ensure that adaptation technologies are implemented so as to improve the resilience and productivity of agriculture sector while preserving environmental sustainability.

[37] http://www.africanfarming.net/crops/agriculture/tanzanian-farmer-demonstrates-potential-of-greenhouse-farming
[38] http://www.nudgesustainabilityhub.com/initiatives/2016/2/9/greenhouse-farming-in-tanzania
[39] www.kilimobiashara.net
[40] https://www.expogr.com/kenyafood/detail_news.php?newsid=1715&pageid=2

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37-39, Rue de Vermont, 1202 Geneva, Switzerland
geneva@cuts.org ● www.cuts-geneva.org
Ph: +41 (0) 22 734 60 80 | Fax:+41 (0) 22 734 39 14 | Skype: cuts.grc

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