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## **AGROFORESTRY PRACTICES AS AN OPTION FOR CLIMATE CHANGE ADAPTATION: A REVIEW**

**Uisso, A.J**

Tanzania Forestry Research Institute (TAFORI), P.O. Box 1854, Morogoro, Tanzania

Corresponding author's Email: [uissoaj@yahoo.com](mailto:uissoaj@yahoo.com)

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**Abstract:** Climate change is one of the greatest global challenges in the 21<sup>st</sup> century that have captured the attention of many countries. It has become a centre of concentration by many governments worldwide due to its induced changes that affect the viability of livelihoods of the people especially the poor. Researches have been and are underway to establish basis for decision making to act upon the challenges of climate change. In this regard, the existing knowledge on climate change adaptation and agroforestry are synthesized as a basis for decision making for future adaptation strategies. With the aim of informing the policy makers the article focuses on overview of climate change, climate change and agriculture, climate change adaptation, opportunities and barriers to climate change and agroforestry practices as a means to climate change adaptation. It was noted that climate change is a reality in agriculture sector and agroforestry can be used as an effective adaptation strategy to the impacts of climate change. The review recommends that agroforestry practices that are potential to climate change adaptation and mitigation need to be given priority. Awareness creation and education on the linkage between climate change agroforestry is needed to create knowledge and encourage more farmers to practice agroforestry. Agroforestry practitioners need to be linked to carbon credits that they can get funds to be used to increase their adaptive capacity to climate change. Further studies are needed to identify farmers for financial assistance and areas for capacity building in adapting to climate change.

**Keywords:** Adaptation, Agroforestry, Climate change.

**Postal Address:** Tanzania Forestry Research Institute (TAFORI), P.O. Box 1854, Morogoro, Tanzania Mobile: +255754989507

### **INTRODUCTION**

The world is concerned with the climate change issues. It is one of the greatest global challenges in the 21<sup>st</sup> century that have drawn the attention on many countries (IPCC, 2007; UNEP, 2007; UNFPA, 2009). The climate change has become a centre of concentration by many governments worldwide due to its induced changes that affect the viability of livelihoods of the poor (Carney, 1998). This has led to new innovations to respond to the changes and is incorporated in livelihood strategies. More importantly, land use cover changes combined with impact of climate changes have affected the livelihood. Again, land use changes have been identified as the

major driving force contributing to environmental change and climate change in particular (IIASA, 1998). Climate change results in changes in ecosystem functions and the ecosystems' capacity to provide society with goods and services, affecting society's options for socio-economic development (IUFRO, 2009). Climate is a critical factor affecting forest ecosystems and it has the capacity to cause the ecosystems to change to new status, for example, it can change from forest to savannah (Mendes, 2007; Nepstad, 2007; IUFRO, 2009). Therefore, mitigation and adaptation of the adverse impacts of climate change is a high priority on the international agenda (IFPRI, 2008). However, the main challenges remain in

developing best practises for adaptive measures to maintain ecosystem resilience and to reduce vulnerability in the presence of various climate change scenarios (IUFRO et al., 2008).

Despite the fact that climate change impacts are on global scale, African countries are the most vulnerable to the impacts of climate change and variability due to high level of poverty, low resilience and weak institutional capacity (IPCC, 2001). As a result, these impacts of climate change and variability have undermined the efforts made in improving the socio-economic development of African countries (*ibid*). This indicates that efforts are needed to prepare the developing countries to respond to the climate related impacts (FAO, 2007). Hepworth (2010), pointed out that to address the issue of climate change adaptation, African countries need to be supported interms of substantial financial resources and they also require information systems, technical capacity, and the right policies and institutions.

Climate is the major factor that influence agriculture practices and according to Ekpo and Asuquo (2012), climate change has already affected the agriculture sector. It is a human activity that is most vulnerable to the impact of climate change (Roy et al., 2011). As agriculture depends on optimal temperature and water availability, climate change has been and will continue to be a critical factor affecting different activities within the sector (Ajayi et al., 2009; Lasco et al., 2011). On the other hand, sustainable agricultural development is widely acknowledged as an important component in a strategy to respond to the challenges of environmental degradation and adaptation to climate change (Antle and Diagana, 2003).

Globally, different strategies have been developed to tackle the challenge of climate change in the sector. Agroforestry is among of the strategy that provides a particular example of an innovative practice (Ekpo and Asuquo, 2012). It is designed to enhance productivity in a way that contributes to climate change mitigation through enhanced carbon sequestration, and that can also strengthen the

ability to adapt to adverse impacts of changing climate conditions (IPCC, 2001; Ekpo and Asuquo, 2012). The United Nations Framework Convention on Climate Change (UNFCCC) lists specific areas of particular needs of adaptation that includes coastal zones, water resources, agriculture and areas affected by drought, desertification and floods. Therefore, in this review the existing knowledge on climate change adaptation through agroforestry are synthesized and discussed as a basis for decision making for future adaptation strategies.

### **Overview of Climate Change Adaptation**

UNEP (2001), defined adaptation as all responses to climate change that can be used to reduce vulnerability. The fourth IPCC assessment report, noted that adaptation to climate changes are through adjustments taken to reduce vulnerability or to enhance resilience. However, for the purpose of this article adaptation include all necessary actions being it long term or short term that are taken to respond or cope with the impacts of climate change and variability. Adaptation strategies are intended to reduce vulnerability and build resilience to the impacts of climate change that can no longer be reversed (ECA, 2009). Adaptation practices to climate change are already taking place. It can be taken in different scenarios and can be differentiated along several dimensions like by spatial scale (local, regional, national) and by sector (water resources, agriculture, tourism, public health, and so on) (Agner et al., 2007). There is a long experience of societies in developing a range of adaptation strategies to the impacts of weather and climate. These include proactive measures like crop and livelihood diversification, irrigation, water management, seasonal climate forecasting, community based disaster risk management and famine early warning systems. They also include reactive or ex-poste adaptations, for example, climate change adaptation through agroforestry (*ibid*). However, adaptation alone is not enough to offset the impacts of climate change, and will thus need to be supplemented by mitigation actions (ECA, 2009).

## **Opportunities and Barriers for Adapting to Climate Change**

There are several opportunities that can be used for enhancing adaptation to climate change. Increased global recognition and support on climate change issue is among those opportunities. There has been a global concern for the developed countries helping developing countries towards climate change adaptation and mitigation strategies. The developed countries have been supporting the developing countries with technology and financial aid being it grant or loan to support development activities towards climate change adaptation and mitigation. For example in Tanzania DANIDA gave funds to the government to develop methodology and capacity building in Green House Gases (GHG) mitigation assessment (Shemsanga, 2010). This has encouraged many countries to act upon climate change issues including adaptation and it is likely that the burden of climate change impacts could be reduced.

Another opportunity is that climate change issues are being considered and highly supported by international policies as a way to adapt to climate change. Article 4.1b of the UNFCCC provides that all parties must formulate and implement national or regional programmes containing measures to facilitate adequate adaptation to climate change. Furthermore, Article 4.5 refers to promoting, facilitating and financing transfer of environmental friendly technologies and technical know-how to enable developing countries to implement provisions of the Convention. These technologies include among other things adaptation technologies as well as the technologies for reducing GHG emissions. Recognising the threats caused by climate change many countries in Africa have ratified the UNFCCC including Uganda in 1993 (Hepworth, 2010), Malawi in 1994 (MMNRE, 2006) and Tanzania in 1996 (URT, 2006a) to mention a few. This will also encourage other countries to sign the convention and deal with the impact of climate change.

Also, there has been increased developing countries recognition of being affected by

climate change. In view of this, climate change issues have been given priority in some national development strategies, policies and plans. For example, Malawi, Tanzania and Uganda by recognizing that the countries are affected by climate change there have been effort to develop National Adaptation Programme of Action (NAPA) and implement it (MMNRE, 2006, URT, 2006a, MWE, 2007). The objectives of NAPA are to provide a process for the Least Developed Countries (LDCs) to identify priority activities to respond to the urgent and immediate needs to adapt to climate change impacts (Hepworth, 2010). More specifically, the Tanzania's NAPA vision is to identify immediate and urgent climate change adaptation actions that are robust enough to lead to sustainable development in a changing climate (URT, 2006a).

Despite the fact that some adaptation issues like tree planting can also act as mitigation measure, the major concern of the document is on adaptation issues. The preparation of adaption strategy and its concentration is an indication that the focus is on adaptation rather than mitigation. Therefore, this brings important concern on why they concentrate on adaptation alone? Further in Tanzania climate change issues are also reflected in its State of the Environment Report, National Strategy for Growth and Reduction of Poverty (NSGRP) (commonly known by its Swahili acronym, MKUKUTA) and the Tanzania Five Year Development Plan 2011/2012-2015/2016 (URT, 2012; URT, 2010, URT, 2006b).

On the other hand, there are some barriers of climate change adaptations especially in agriculture and natural resource sectors. The IPCC noted that over dependence on the ecosystem, rain-fed agriculture and low adaptive capacity are the major barriers to climate change adaptations. Furthermore, taking into account gender dimension, there are individuals and groups within all societies that have insufficient capacity to adapt to the impacts of climate change. For example, in the Southern Africa, subsistence farmers especially women, are disproportionately burdened with

the costs of recovery and coping with drought (Agner et al., 2007).

### **Agroforestry and Climate Change Adaptation**

Agroforestry refers to the integration of tree species with agricultural crops and/or pastures on the same land unit resulting in the integration of economical and ecological interactions between the components (Young, 2002). Agroforestry as a practice of integrating trees on farm has a major role to play in climate change impacts (Verchot et al., 2007) and there are many types of agroforestry systems that are employed in a number of regions of the world at different levels (Montagnini and Nair 2004). In Costa Rica farmers have adopted different agroforestry land management practices as a climate change adaptation strategy in order to cope with a longer and more intense dry seasons. These include silvipasture with *Brachiaria brizantha*, maintenance of trees on farmland, fodder banks, live fences, shade for pasture grass and livestock, enhanced nutrient cycling, soil and water conservation, fuelwood and fruit production (Oelbermann and Smith, 2011). In Tanzania, various programmes, projects and agroforestry interventions have been initiated and implemented by the government and private sectors institutions (NASCO, 2006). These interventions have developed and implemented various agroforestry technologies which include rotational woodlots, boundary planting, fodder banks, planting fertilizer trees (nitrogen fixing trees), improved fallows, *ngitiri* (traditional fodder conservation system developed by Sukuma agro pastoralists) and homegardens (Pye-Smith, 2010; NASCO, 2004). These technologies were generally developed to solve the problem of soil fertility depletion, food security, shortage of fuelwood, fodder and land degradation (NASCO, 2004). However, they could also play important role in climate change adaptation. Therefore, under climate change scenario these technologies could be further encouraged to more farmers. They should be convinced that it will be to their advantage to take on the agroforestry technology to both improve agriculture

production and tackle the problem of climate change. The country average agroforestry adoption rate by 2006 was about 20-25% (NASCO, 2006). At present this could have been increased. This is an indication that increased adoption of agroforestry will continue to play a major role in climate change adaptation. Agroforestry practices provide an opportunity of responding to the adverse impacts of climate change through the joint action of adaptation and mitigation (Verchot et al., 2007; Roy et al., 2011). In mitigating climate changes crops and trees on farm can be a major source of carbon sinks. As an adaptation option sustainable agroforestry practices can be potential for protecting ecosystems and livelihood, and creating foundation for economic and social development (Mangala and Makoto, 2014). Furthermore, agroforestry practices provide ecosystem services, and are a means of diversifying agricultural production and increase food security for farmers, especially under current climate change scenarios (Verchot et al., 2007; Ekpo and Asuquo, 2012). For example in India agroforestry is a common practice that is useful in maintaining production during drier years (Roy et al., 2011). Similarly, in Nigeria agroforestry systems provide an opportunity for maintaining production during wetter and drier years. It is an appropriate means of diversifying agriculture production and increasing the sustainability of smallholder farming systems (Ekpo and Asuquo, 2012).

Trees in agroforestry systems can tolerate to drought than crops, therefore it helps to avoid total failure in the farm. Ekpo and Asuquo, 2012 pointed out that tree in agroforestry systems are highly valued by farmers because their products compensate for the loss of crop yield. For example farmers in Kenya and India, have developed agroforestry system using the fast growing indigenous species such as *Melia volkensii* and *Populus deltoide*, which is recognised to be highly compatible with crops and can provide high value timber in short period of time between 5 to 10 years (Stewart and Blomley 1994; Chauhan et al., 2010). Trees on farms plays

important role to enhance the coping capacity of smallholder farmers to climate change risks through crop and income diversification, soil and water conservation and efficient nutrient cycling (Lasco and Pulhin, 2009). In Tanzania, a study by Charles *et al.*, (2013) concluded that products from agroforestry practices improved resilience of smallholder farmers against the impact of climate changes. In particular they improve farm production (food, fodder, timber, fuel wood, and manure), ecosystem services (soil improvement, climate amelioration, wind break, erosion control, and disease and pest control) and household income. Therefore, agroforestry techniques can be used as an effective development strategy to help subsistence farmers reduce their vulnerability to climate change related hazards (Thorlakson and Neufeldt, 2012).

## CONCLUSION

The review noted that climate change is a reality in agriculture sector and agroforestry have been and can be used as an adaptation strategy to the impact of climate change. Agroforestry can help after practices to increase farmers' resilience to climate change thus ensure availability of food. It is also predicted that climate change will continue to be among the most pressing issue that affect the world in all sectors including agriculture. This indicates that adaptation together with mitigation strategies is urgently and continuously needed. The review recommends that agroforestry practices that are potential to both climate change adaptation and mitigation such as rotational woodlot and boundary planting, *ngitiri* and homegarden need to be given priority. Awareness creation and education on the linkage between climate change agroforestry is needed to create and enhance knowledge and encourage more farmers to practice agroforestry. Agroforestry practitioners need to be linked to carbon credits that they can get funds that can be used to increase their adaptive capacity to climate change. To enhance agroforestry practices for climate change adaptation farmers need to realize the economic benefits that they could

continue practicing the same. New innovations and market accessibility for agroforestry products need to be accessible. Further studies are needed to identify farmers for financial assistance and areas for capacity building in adapting to climate change.

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