New Climate, New Agriculture: How Agroforestry Contributes to Meeting the Challenges of Agricultural Development in Tanzania

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Abstract

Never before have so many governments; multilateral and international organizations put so much interest in the agricultural sector. Recent scientific assessments and analyses of the global trends in development, climate change impacts as well as rising fuel prices predict a crisis in the sector. Developing countries will suffer most, especially countries like Tanzania with over 80% of its population depending on agriculture for livelihood. While global assessments predict crop yield reductions from climate change of up to 10% by year 2050, the Tanzania 2007 National Adaptation Program of Action Report predicts reductions of up to 84% in maize yield in the dry parts of the country. Furthermore fertilizer prices in Tanzania rose by 250% in the last two years. These trends are putting agriculture at a crossroads, while agriculture growth in developing regions remains fundamental for poverty reduction and food security. Despite these challenges, there are opportunities from agricultural innovations such as agroforestry that can contribute to meeting these challenges. The adoption of these agricultural innovations which are generally low-cost, improve livelihoods and also minimize negative environmental impacts should be promoted. The MKUKUTA Status Report 2006 underscores the importance of accelerating growth through a more strategic and prioritized approach to generate balanced agricultural growth. Agroforestry options include low-cost technologies that improve livelihoods but also lessen the environmental impacts of agriculture. In this paper we review the potential contribution of agroforestry in agricultural development in Tanzania and suggest action points for consideration within the agricultural sector development framework.

Key words: agroforestry, climate change, poverty alleviation, soil fertility

Introduction

Never before have so many governments, multilateral and international organizations put so much interest in the agricultural sector. In a recent high profile event, where World Bank launched a global food crisis response facility, the problems in the agricultural sector were likened to a silent tsunami (Zoellick, 2008). Ranking low in economic and human development indicators, Tanzania is at high risk of failing to feed itself, with over 70% of its people depending on rain-fed agriculture for their livelihood (Table 1).

Table 1: Tanzania's economic and human development indicators

Indicator	Value
Land area (km^2)	945,000[1]
Total population (million)	40.4[1]
Gross domestic Product Per capita USD at constant 2000 prices (2007)	403[1]
Agriculture GDP (%)	45[2]
Population dependent on agriculture (%)	80[2]
Population below basic needs poverty line (%)	36[2]
Population below the food poverty line (%)	19[2]

[1] AFDB/OECD 2008
[2] URT 2005

Tanzania is listed among thirteen African countries

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worst affected by climate change impacts and vulnerability and having the least adaptive capacities (Thornton *et. al.,* 2006). A review of the status of Tanzania's agricultural sector (for the Agricultural Sector Development Program) notes that the country is lagging in achieving its targets on reducing poverty and food insecurity and in achieving the Millennium Development Goals targets (URT, 2006). Tanzania has a challenge of revitalizing her agricultural sector by improving the natural resource base i.e. soil, water and biodiversity. Agroforestry the integration of trees in agricultural landscapes can offer robust options to improve productivity and achieve environmental sustainability.

Tanzania National Agroforestry Strategy

The National Agroforestry Strategy prepared in 2004 envisions at least four million rural households adopting and benefiting from agroforestry practices in a sustainable manner by 2025. Its goal is that by 2020, agroforestry technologies are adopted and contribute to improved livelihood of 60% of resource poor households in the country. This goal complements the national development strategy framework "MKUKUTA", which emphasizes poverty reduction and increasing household income while conserving the environment (URT, 2005).

Leakey (1996) defines agroforestry as "a dynamic, ecologically based, natural resources management system that, through the integration of trees in farmland and rangeland, diversifies and sustains production for increased social, economic and environmental benefits." Trees and/or shrubs (woody perennials, including bamboo) along with agricultural crops, including food and 'cash' crops and livestock create a web of resilient land use practices that mitigate and adapt to climate change, halt land degradation and conserve on-farm biodiversity.

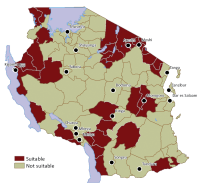
Agroforestry is therefore a powerful tool for tackling the emerging global and local challenges. Tanzania is home to several traditional agroforestry systems. Some have been documented such as the Chagga home-gardens, the related Mara region home-gardens known as "Obohochere" and the traditional Wasukuma silvopastoral system called "Ngitili". One outstanding aspect of these traditional methods is the use of multi-layered systems with a mixture of annual and perennial plants, which imitate natural ecosystems.

Agroforestry research and development activities in the country have been going on for more than 30 years. National institutions including research centres and universities have conducted trials to screen exotic and indigenous tree and shrub species for suitability for different agroforestry technologies. Over the past 20 years, the World Agroforestry Centre (ICRAF) in collaboration with several national research institutions, the government extension service, NGOs and CBOs, has developed several technologies which are now benefiting thousands of farmers in Shinyanga and Tabora Regions and elsewhere in the country. Proven technologies include: fertilizer trees and biomass transfer for soil fertility improvement, rotational woodlots, indigenous and exotic trees for food and health security, trees for livestock feed and trees for reclamation and enrichment of traditional land use systems. These technologies are transforming lives in many parts of the country. Figure 1 describe some of the proven agroforestry options and give their spatial distribution in the country.

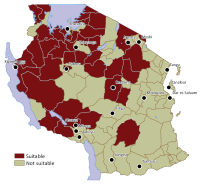
Agroforestry for Improving Soil Fertility

The use of fertilizer and improved seeds in Tanzania is very low compared to other countries. While Tanzanian farmers use an average of 9 kg/ha annually of nitrogen fertilizer the average for Malawi farmers is 27 kg N/ha, and Vietnam 365 kg N/ha (MAFSC 2007). Government efforts to overcome the declining soil fertility problems have been only partially successful. Despite the government's involvement in distributing fertilizer and seed to smallholders and encouraging private traders to distribute the same, less than 20% of smallholder farmers use fertilizer in Tanzania. For 2008/2009 the government is issuing agricultural input vouchers (fertilizer and improved seed) to 2,600,000 farm families out of over 4,000,000 in the country. The total cost of the programme for 2007-08 was $18 million (Tshs 21 billion). In 2008-09 the subsidy is set at $26 million (Tshs 31 billion). However, skyrocketing oil prices have strained every stage of food production, from fertilizer to tractors to transport. In the past three years fertilizer prices have

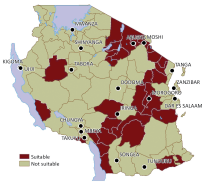
more than doubled (Figure 2).



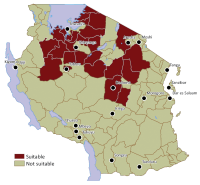
Multistrata/home-gardens agroforestry: Trees, shrubs and herbaceous plants grown together in a dense spatial mixture.
Major function: Land use intensification and soil and water conservation strategy in high gradient landscapes.
Limitation: Increasing land pressure and low soil moisture.
Agro-ecological zone: High altitude, high rainfall areas of the high plains and plateaus



Improved fallow: Rotation of planted trees, mainly N-fixing, with crops.
Major function: soil fertility and soil structure improvement.
Limitation: land size; labour required to incorporate litter into the soil.
Agroecological zone: central plateau and medium altitude plains of western Tanzania.



Biomass transfer: A tree litter mulching system, where biomass is transported from one area to another for nutrient replenishment.
Major function: Minimizing tree-crop competition, while maximizing use of organic matter to replenish soil nutrients.
Limitation: Labour, where simple tools, such as the hand hoe, are the main farm implements.
Agroecological zones: Medium altitude plains and the eastern plateaus and mountain blocks.



Silvi-pasture system:
A tree/pasture/livestock production system, mainly for agro-pastoral systems linked to traditional systems such as Ngitili (Sukuma land) and Olalili (Maasai).
Major function: Rangeland management in drylands to reduce land degradation.
Limitation: Land tenure security and large livestock herds.
Agroecological zones: Medium altitude volcanic plateaus and the medium altitude plains.

Figure 1. Best areas for agroforestry options

Policies to help produce food more cheaply and in environmentally sustainable ways will benefit the majority of farmers and the country as a whole. Current policies do not take advantage of these promising new technologies.

Nitrogen is the main nutrient that plants need, which is in short supply in the soil. But it is abundant in the atmosphere, and "fertilizer trees" can capture it from the atmosphere and make it available to crops. World Agroforestry Centre (ICRAF) and partners in Southern Africa region (including Tanzania) have developed four related fertiliser tree options for soil

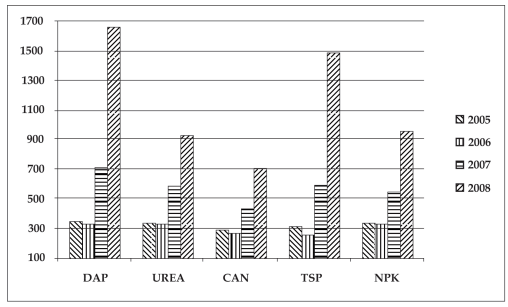


Figure 2. Fertiliser prices (USD pr ton) in Dar es Salaam 2005 – 2008 (source:URT 2008).

improvement (Akinnifesi *et al*., 2004). These are:

1. Sequential fallow rotation of nitrogen-fixing trees with cereal crops;
2. Fertilizer tree/cereal inter-cropping managed as coppiced fallow;
3. Annual relay fallow intercropping of shrubs with cereals;
4. Biomass transfer.

Continuous cultivation of maize with Gliricidia sepium in Malawi yielded more that 5 tones per hectare in good years and using *Sesbania sesban* and *Tephrosia vogelli* provided 100 – 250 kg of nitrogen per hectare (Pye-Smith, 2008). Similarly in Tanzania high in-organic N content of soils under fallow and increase in maize yields after fallowing has been reported by Banzi *et al.,* 2004 (Table 2).

The beauty of fertilizer trees goes beyond the increase in food production. They also conserve the natural resource base and protect the environment. Fertilizer trees can:

- Provide up to 10 tons of wood biomass per hectare, greatly reducing the burden of carrying firewood long distance and the time women spend searching for wood energy (Nyadzi, 2004).
- Provide alternative sources of stakes for curing tobacco and help reduce deforestation of the miombo woodlands. Today these woodlands are being deforested at over 400000 hectares annually in Tanzania (FAO, 2007).
- Suppress weeds and reduce soil compaction, thus reducing the burden of weeding. This aspect of fertilizer trees provides a big incentive for women who are traditionally responsible for weeding the

Table 2: Pre-season soil in-organic N in 0-30 cm soil depth and maize yields during three consecutive cropping seasons after tree fallow vs. natural fallow in Lubaga Shinyanga (Banzi *et al.*, 2004).

Fallow tree type	1998-99		1999-00		2000-01	
	Kg N ha^{-1}	Yield t ha^{-1}	Kg N ha^{-1}	Yield t ha^{-1}	Kg N ha^{-1}	Yield t ha^{-1}
A. polyacantha	82	3.2	48	1.9	35	1.8
L. leucocephala	87	2.8	57	2.2	32	1.6
A.nilotica	73	2.5	47	1.6	28	1.6
Natural fallow	51	2.0	35	1.2	26	1.1

family's fields.

- Contribute to mitigating the effects of climate change by sequestering up to 2.5 to 3.6 tons of carbon per hectare per year (Nyadzi, 2004).

Farmers grow vegetables widely during the dry season in wetlands in Tanzania but declining soil fertility and nutrient imbalance present a major challenge to many of them. Biomass transfer uses the nutrient-rich leaves of agroforestry species, usually planted in the uplands, (e.g. Tithonia diversifolia) as fertilizer for the production of high-value vegetable crops, and an extra maize crop in the lowlands during the dry season. This offers farmers the opportunity to supplement their incomes by growing cash crops that command high prices in urban markets. It also integrates agricultural production in upland and lowland areas. Biomass transfer increases food production and income for farmers in various ways:

- Helping smallholder farmers to produce diverse and high value crops (e.g. ginger, garlic, cabbage and onions).
- Improving farm income and household nutrition.
- Allowing production during off-season when farm produce attracts higher prices.
- Increasing production to 2-3 crops per season.
- Potentially being combined with fish farming.

Agroforestry for food and income

Indigenous fruit trees provide food from the wild during periods of hunger. Their fruits often mature at the time when maize shortage is most critical. Although not much research has been done in Tanzania in domestication of wild fruits, it is important to note that indigenous fruits such as kiwi fruit (Actinidia chinensis) and macadamia nut (Macadamia integrifolia) became popular on global markets through domestication efforts. Efforts by World Agroforestry and partners in western Tanzania have raised value of several species of miombo indigenous fruits. Indigenous fruits that achieved commercial production during a pilot project included *Parinari curatellifolia, Strychnos cocculoides, Vitex mombassae, Flacourtia indica, Sclerocarya birrea* and *Syzygium guineense*. An end-of-project impact assessment showed that more than 2500 women from more than 50 women groups are employed in fruit processing enterprises in western Tanzania. The products include well packed raw fruits, juices, jam, jelly and marmalade, and have been promoted in national and international trade fairs, and some local supermarkets.

Looking at the larger picture, one can see some significant milestones in the domestication initiative, for example:

- Indigenous fruits have changed from being a "snack" food to a main food source.
- Indigenous fruits provide income generation opportunities for rural women in processing and enterprise development.
- Conservation and selection of indigenous fruit trees avoids "eating up" the opportunities of future generations in regions where they are being lost to deforestation.

Agroforestry for climate change adaptation

A large and growing body of scientific evidence indicates that climate change impact is a major threat to sustainable development and achieving millennium development goals (UK Government, 2006; IPPC, 2007), Predictions for Tanzania show average temperatures increasing from 2.1 to 4oC, with central and western parts of the country showing higher changes. Areas with bimodal rainfall pattern are anticipated to experience increased rainfall of 5%

– 45% while those with unimodal rainfall pattern may experience a decrease of 5% – 15% (URT, 2003). This shifting weather regime will have many adverse effects on agriculture, including more frequent drought, increased fungal outbreaks and insect infestations, reduction in ecosystem integrity and resilience, and decline in biodiversity. The government and development partners are challenged on how best to work with local farmers to identify innovations that increase farming systems resilience and reduce farmers' vulnerability.

Both national and global assessments (URT, 2007; Thornton *et al.,* 2006) describe the Central Plateau ecological zone of Tanzania as one of the most vulnerable to climate change and variability. This vast area of drylands (covering most of Central regions i.e. Dodoma and Singida as well as western regions of Tabora, Shinyanga, Kigoma and Mwanza) falls in the priority areas for scaling-up of agroforestry technologies.

The agroforestry technologies described above have been proven to increase farming systems resilience by improving agricultural productivity and enhancing productive use of rainfall in drylands. The intensification and diversification functions of agroforestry practices strengthen the socio-economic resilience of rural populations to climate change.

Constraints to Agroforestry Scaling up

Despite their excellent performance, the widespread adoption of agroforestry technologies by smallholder farmers is constrained by local customs, institutions and policies at the national level. This is because technological innovation is important for widespread adoption, but not in isolation. Local and national policies need to be refined to incorporate agroforestry components. Soil fertility management options using fertilizer trees require skills in terms of management of the trees. The capacity for implementing agroforestry technologies will need to be built at the national level. One of the greatest constraints of some agroforestry technologies is the lack of access of farmer's quality seeds.

Unlike the seeds of annual crops, there is little or no institutional structure to make the seeds of agroforestry available "off the shelf". Such structures and institutions need to be developed and this process can be "kick-started" through a public sector investment (for a limited period) while allowing time for the private sector to take up the commercial opportunity of such a venture.

The human capacity, infrastructure and institutional support for agroforestry are not as well developed as for annual crop technologies. Such missing supports include well-developed input and output markets to enhance access of smallholder farmers to ensure that they get the price premium for their farm produce. Widespread adoption of agroforestry requires appropriate policies at the national and local level, but this has been hampered by a lack of local scale data on impacts of climate change on agriculture and environment.

Policy Recommendations

Technical aspects:

- Policies should promote trees and other integrated soil fertility management approaches in order to make the most efficient use of expensive mineral fertilizer
- Subsidize mineral fertilizer under the Agricultural Sector Development Project (ASDP) and District Agricultural Development Plans (DADP) and integrating fertilizer tree seeds, improved crop varieties as integral part of the inputs package under the Program to ensure sustainable soil fertility replenishment.
- Provide support for the implementation of the national agroforestry strategy and the targeting of priority scaling up areas in Tanzania.
- Provide more agroforestry technology training opportunities to government agricultural extension staff to help them provide information, and scale up the technologies to farm communities
- Reduce deforestation by encouraging on-farm tree cultivation for needed tree products, specially wood fuel
- Support agroforestry products markets and marketing infrastructure.
- Assess in a participatory manner the vulnerability to climate change and support local adaptation measures.

Support capacity building at all levels on climate change impacts on agriculture sector and adaptation strategies

Institutional aspects:

- Institutionalize agroforestry as part of the official programme of activities in the Ministries of Agriculture Food and Cooperatives, Livestock and Fisheries, and Natural Resources and Tourism.
- Institutionalize and support regular "science-policy forums" where updates on agroforestry research results and opportunities are presented to policy makers and stakeholders in Tanzania. The forum must emphasize the need to examine food security through a sustainable development lens.
- Assess how existing national policy and institutional setups either facilitate or constrain the adoption of agroforestry and take remedial measures as appropriate.

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