Review: Adoption of Agroforestry by Smallholder Farmers As A Way of Improving Food Security and Rehabilitation of Land

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Abstract: Low crop productivity and inherent soil fertility can be improved by adoption of agroforestry by smallholder farmers. Smallholder farmers are resources poor farmers who are not able to buy large quantities of inorganic fertilisers. Adoption of agroforestry has the potential to transform small arable areas used by smallholder farmers into productive lands. High grain yield can be easily achieved after two –three year of adoption of agroforestry. The only limiting factor for adoption of agroforestry is land hence farmers can use degraded land for agroforestry and transform these lands into productive. In Nigeria the use of agroforestry showed significant increase of maize grain yields from 1.74tha-1 to 2.42tha-1. In Zimbabwe maize grain yields were also improved in Domboshava by use of improved fallow where Acacia angustissima was used on conventional tillage compared to no tillage systems. Farmers are recommended to adopt agroforestry and start the projects on small scale as agroforestry projects takes two to three years to see the benefits.

Keywords: Adoption, agroforestry, food security, rehabilitation, smallholder & farmers.

1. Introduction

Low crop production has been a major threat in smallholder farmers in arid and semi-arid areas of Zimbabwe, with a major concern in region 4 and 5 which widely affect Masvingo. Smallholder farmers in these areas are often faced with low crop productivity, scarcity of fuel wood and fodder. They are only expected to readily adopt agroforestry practices that enable them to increase yields with minimal external inputs (Kabwe, 2010). Agroforestry is the only solution which can reduce the effect of land degradation due to the continual use of inorganic fertilisers by farmers. Adesina et al. (2000) and Mercer (2004) have indicated that adoption and diffusion of agroforestry technologies have lagged
behind scientific and technological advances attained, thereby reducing their potential impacts. Adoption of agroforestry also apply to sub-Saharan Africa including countries such as Malawi, Zambia, Tanzania, Mozambique and Zimbabwe is also a part (Ajayi et al., 2006c, Nyamadzawo et al., 2008). Agroforestry has the potential to help many poor resource farmers from poverty. Agroforestry promotion organisations such as International Center for Agroforestry (ICRAF) have introduced several programmes to increase adoption of agroforestry. In Zimbabwe, Domboshava alone had over ten organisations promoting agroforestry technologies (Nyamadzawo et al., 2008). Low adoption levels are not only experienced with agroforestry technologies but also with many other successful agricultural initiatives (Chitakira and Torquebiau, 2007).

Over the past two decades, food production levels in sub-Saharan Africa mostly Zimbabwe have been declining (NEPAD, 2003; Djurfeldt et al., 2005). This has especially affected smallholder farmers, that is, farmers who produce on a small-scale mainly for subsistence and irregularly sell surplus produce. The lagging agricultural productivity growth in sub-Saharan Africa is partly explained by low levels of inputs such as chemical fertilizers, improved seeds and pesticides (Larsson, 2005; Morris et al., 2007). These inputs are too expensive to smallholder farmers due to their low income levels (Mazoyer and Roudart, 2006). In Zambia, nearly 21 percent of the smallholder farmers have been said to have adopted improved fallows (Ajayi et al., 2006). Improved fallows are an agroforestry technology involving the establishment of nitrogen fixing leguminous species during a fallow period of one to three years (Mafongoya et al., 2006). In Zimbabwe agroforestry has been done years ago as a traditional method of improving yield where most people left their parts of fields for 2-3 years not knowing its improved fallowing. Technically, agroforestry was introduced in Zimbabwe formerly some few years ago through ICRAF in Domboshava (Mafongoya et al., 2006a). This is because of the promising research findings for agroforestry to address smallholder farmer problems (Kuntashula et al., 2004; Kwesiga et al., 2003; Mafongoya et al., 2006a; Mafongoya et al., 2006b; Mafongoya et al., 2004; Sanchez, 2002) and the holistic effort by government, international organisations, NGOs and CBOs to extend these technologies to the smallholder farmers (Chitakira and Haruzivishe, 2007; Franzel et al., 2001a; Franzel et al., 2004; Kabwe, 2001; Kabwe et al., 2004, 2010).

2. Review of Literature

Several studies have been done to understand the adoption potential of improved fallows, and to determine factors that affect adoption (Ajayi, 2001; Ajayi and Kwesiga, 2003; Ajayi et al., 2003; Ajayi et al., 2006b; Ajayi et al., 2007b; Ajayi et al., 2007c, 2007d; Franzel, 1999; Franzel et al., 2002a; Franzel et al., 2002b; Franzel et al., 2001b; Kabwe, 2010; Chitakira and Torquebiau, 2010). Some studies have been done in Zambia and Zimbabwe with the same scientists who tried to identify factors affecting adoption of agroforestry technologies in sub-Saharan Africa. The studies showed that most smallholder farmers failed to adopt agroforestry due to lack of interest, land ownership problems and others including time of enjoying results (Chitakira and Torquebiau, 2010). Chikowo (2004) revealed that improved fallows had a great potential of being adopted in the areas where natural fallow periods were decreasing and farmers perceived a decline in soil fertility. Most smallholder farmers cultivate crops, mostly maize, every year regardless of whether they address the soil fertility problem or not (Ajayi et al., 2007b) since this is their only means of sustaining their livelihoods. Soil fertility is one of the primary constraints to smallholder agricultural production in sub-Saharan Africa (Kabwe, 2010; Chitakira and Haruzivishe, 2007; Chikowo, 2004; Parwada et al., 2010). Soil fertility management problems result from continued land degradation that is associated with high population increase and continual use of inorganic fertilisers (Parwada et al., 2010).

Although the use of inorganic fertilizers would be the easiest way to overcome nutrient depletion (Sanchez, 2002), this product is not readily available for use by smallholder farmers because it is expensive. Those farmers who have used inorganic fertilizers to improve soil fertility usually apply it at levels far less than recommended rates (Kwesiga et al., 2003; Mafongoya et al., 2006a; Mafongoya et al., 2006b). However, farmers currently require adding higher quantities of inorganic fertilisers than they did before in order to meet crop needs (Damisa and Igonoh, 2007) but this causes soils to be more acidic creating unfavourable conditions for crop growth. There is need to use organic fertilisers which have a variety of nutrients for crop growth. The unavailability of organic fertilisers in most smallholder
farmers due to deforestation causes increased decline in yield and soil fertility. Introduction of agroforestry with the growing of leguminous trees such as *Gliricidia sepium*, *Cajanus cajan* and *Sesbania sesban* which fixes nitrogen improves its availability to soil (Ghee, 2009). Incorporation of biomass from these leguminous trees improves soil conductivity, structure and texture leading to increased infiltration rates and moisture conservation (Nyamadzawo *et al*., 2003, 2008).

3. Importance of Agroforestry

Today, agroforestry offers a unique set of opportunities for arresting land degradation, and providing ecosystem services in both low-income and industrialised nations (Nair, 2007). The emphasis of agroforestry in developing countries is on alleviating poverty, securing nutritional security and arresting land degradation, particularly under resource-limited conditions and lower-input situations, which cover an estimated 1.9 billion hectares of land and 800 million people (Motis, 2007; Nair, 2007). In the industrialised nations, the primary role of agroforestry is in providing ecosystem services, including water quality control, carbon sequestration, biodiversity conservation, and good land ethics and aesthetics (Garrity, 2006; Mafongoya *et al*., 2006a).

Agroforestry technologies have high considerable importance in the sub-Saharan African countries because it provides a variety of tree products for domestic use and / or for sale (Kabwe, 2010; Chitakira and Torquebiau, 2010; Motis, 2007). In Zimbabwe most agroforestry trees are grown in farmland, homegardens and even around the yard (Maroyi, 2009). Most of these are fruit trees such as *Mangifera indica*, *Psidium guajava*, *Upaca karkeana* and *Citrus limona* which smallholder farmers harvest and use as food as well as for selling to get income (Maroyi, 2009). Smallholder farmers also get fire wood, biomass and Non Timber Forest Products (NTFPs) from these trees such as honey. Some smallholder farmers practice apiculture in these agroforestry trees.

Agroforestry plays a significant role in increasing agricultural productivity by nutrient cycling (nutrient mining), reducing soil erosion, and improving soil fertility, conserving water (moisture) and enhancing farm income compared to conventional crop production (Kang and Akinnifesi, 2000; Neupane and Thapa, 2001; Neupane *et al*., 2002; Chikowo, 2004; Nair, 2007; Nair, 2009; Kabwe, 2010).

Agroforestry can also potentially reduce deforestation while increasing food, fodder, fuel wood production and controlling climatic conditions such as wind (Neupane and Thapa, 2001; Neupane *et al*., 2002). Benefits that accrue from usage of agroforestry include food and nutrition security, increased income and assets, improved land management, improve water conservation and soil structure (Nyamadzawo *et al*., 2003; Garrity, 2006), it also creates environmental and management synergies (Race, 2009, Nair, 2009).

Traditional agroforestry has been practiced for decades by agrarian-based societies throughout the world (Garrity, 2006; Kabwe, 2010). Farmers never noticed it would come in another dimension. The World Bank estimates that 1.2 billion people in the world practice some form of agroforestry on their farms and in their communities some decades ago (World Bank, 2004). Although agroforestry has been practiced by these farming communities for a long time, there is inadequate awareness about its potential to the millions that live in poverty (Garrity, 2006; Mafongoya *et al*., 2006b). In the past 3 decades, agroforestry has progressed as a science-based pathway for achieving important objectives in natural resource management and poverty alleviation (Garrity, 2006). If it continue to progress well it means most farmers will adopt the technology. To enjoy benefits of agroforestry, there is need for better management because in Europe where traditional agroforestry was stopped some years ago were because of compact management and its composition (Kabwe, 2010). Importance of agroforestry is grouped as environmental and socio-economic benefits (Nair, 2009; Kabwe, 2010).

3.1 Environmental benefits of agroforestry

Environmental benefits of agroforestry include soil erosion control (Nair, 2006; Motis, 2007) improvement of soil quality through increased nitrogen input, improved soil hydraulic conductivity, structure, porosity and improvement of water dynamics (Nyamadzawo *et al*., 2008; Phiri *et al*., 2003), and increased activity of soil biota (Sileshi and Mafongoya, 2006a, 2006b). Agroforestry systems such as woodlots do supply fuelwood, poles and can therefore alleviate the demand from natural forests and
therefore reduce deforestation leading to increased growth of annuals reducing soil erosion (Sileshi et al., 2007). Increased foliage promotes decomposition by micro-organisms and macro-organisms which increase soil aeration and porosity. This leads to improved soil hydraulic conductivity which improves water availability due to increased infiltration rates (Nyamadzawo et al., 2008).

3.2 Socio-economic benefits of agroforestry

Economic analysis done by Reyes (2008) showed that improved agroforestry methods are able to raise incomes from their crop production significantly compared to traditional agroforestry systems. Agroforestry systems have high income returns in the long run compared to use of fertilisers under monoculture (Kwesiga et al., 2005). Improved fallow showed low income compared to use of fertilisers over a short period of time (Kabwe, 2010). Unlike fertilised fields, improved falls do not involve any cash expenditure and the benefits are spread over a two to three year period. Economic analysis from on-station trials indicates that a two-year fallow is more profitable than a one or three-year fallow (Kabwe, 2010). Agroforestry systems such as biomass transfer are more profitable compared to use of fertilisers because biomass contains several nutrients and it is readily available at cheap cost (Ajayi et al., 2006a). Use of biomass transfer is more profitable because it extends from one to three years compared to fertilisers which need to be applied every season (Mafongoya et al., 2004, 2006a; Ajayi et al., 2006a).

Home gardens were found to produce supplementary staple crops and also served as sources of income for several families (Maroyi, 2009). In addition to that, other agroforestry systems have the diversity of crop species and production cycles in homegardens enables year-round production of different products, reducing the risk of production failure (Abebe et al., 2006).

Shackleton et al. (2008) found that goods harvested from agroforestry trees are consumed within the home, buffer households during times of stress, and are bartered with neighbours or sold in local and regional markets. These include fruits, timber, fuelwood and even NTFPs which are used as medicine. Fruits from Sclerocarya birrea are used to brew traditional beer which is used for celebrations during traditional ceremonies (Ngorma, 2006).

4. Contribution of Agroforestry to food security

The objectives of farming among the smallholders are in two-fold, to meet the food requirements for the year as well as raise income to meet other essential needs such as buying products for domestic use. It is therefore necessary to determine the contribution that agroforestry makes towards achieving these goals. To determine the level of contribution economic analysis needs to be done (Shackleton et al., 2008). Essentially, economic analysis of agroforestry practices are more complicated than that of annual crops because they involve both trees and crops (and in some cases animals). They also require a period of several years between the time of establishing trees and when impact can be achieved (Franzel, 2004). Due to long waiting periods, economic analysis becomes expensive and problematic to manage as experimenting farmers get influenced to change some of the parameters, making comparisons across farmers impossible (Franzel et al., 2001b; Franzel, 2004). This creates difficulties in coming up with true values compared to monoculture where economic analysis is done every season.

The benefits of improved falls when compared with continuously cropped maize were the labour saved in the first year when maize was not planted, firewood produced in year two, increased maize yields in years three through to five, and the reduced land preparation and weeding costs in the first maize crop year post fallow (Franzel, 2004). Fodder banks have a great advantage because it reduces costs of feed supplement during dry periods. Through use of fodder banks there is increased milk production, improved carcass quality and high growth rates reducing time for pen fattening, hence animals reach market mass earlier (Ajayi et al., 2006). Generally, agroforestry benefits are usually of great importance because there is maximum utilisation of land, improved soil fertility, reduce soil erosion, and reclaim degraded land through growing of trees (Motis, 2007). Most trees which are used in agroforestry are multipurpose trees which have several functions. These benefits includes, food, fodder for animals, fruits, NTFPs, poles, create microclimate (Nair, 2007) and most are involved in nutrient mining (Chikowo, 2004). Agroforestry trees practice climate change amelioration where they
sequester greenhouse gases (GHGs) (Ghee, 2009), provide shade to animals and annual crops thereby creating favourable temperatures (IPCC, 2007b, 2007c).

Agroforestry increased crop performance and yields due to improved soil bio-physio-chemical properties and conservation of moisture. Experiments done in Nigeria, Kenya and Zambia showed that maize grain yields increased from an average of 1.74tha⁻¹ to 2.42tha⁻¹ where alley cropping of *Leucaena leucocephala* has been used in Nigeria (Atta-Krah and Sumberg, 1988). In Kenya maize grain yields increased from 1.94tha⁻¹ to 3.54tha⁻¹ in plots mulched with *Leucaena leucocephala* (Kang et al., 1981). In Zimbabwe experiments done in Domboshava produced higher results were obtained from plots where *Acacia angustissima* was used as part of improved fallow on conventional tillage compared to no tillage plots (Nyamadzawo et al., 2002). This is because the use of leguminous trees and their prunings improves soil chemical and physical properties (Kwesiga et al., 2005). Improvement of soil characteristics enhances crop performance leading to improved grain yields. In Mashava (Zimbabwe), the use of biomass transfer showed a significant increase in pearl millet grain yields and panicle length (Kugedera and Kokerai, 2019).

5. Contribution of Agroforestry to land rehabilitation

Agroforestry has a great potential in rehabilitating the land allowing it to be used for arable purposes. The use of agroforestry techniques such as improved fallow restores soil fertility by increasing soil Nitrogen in the soil by Biological Nitrogen Fixation (BNF). The use of legume trees in improved falls which are deep rooted practice deep capture, thus bringing nutrients back to the plant root zone. Nutrients will be locked in the plant root zone because trees do nutrient mining (Kwesiga et al., 2005). The major environmental benefits of improved fallow are improved soil physical properties, such as better infiltration and aggregate soil stability, which reduce soil erosion and enhance the ability of the soil to store water (Kwesiga et al., 2005). It also improves soil physical properties such as increasing soil texture, soil aggregations and soil hydraulic conductivity (Nyamadzawo et al., 2008a). Growing of leguminous trees in arable lands for agroforestry reduces surface runoff, soil erosion and improves infiltration. Soil structure can be restored by increasing Cation Exchange Capacity (CEC) which later improves crop performance and productivity. Total N percentage will also be increased by BNF, decomposition of foliage and incorporation of prunings hence improving soils such as increasing clay content and reducing sand content (Kugedera and Kokerai, 2019). Tree roots bind the soil together to reduce soil erosion and improve infiltration due to increased vegetation cover as results of high decomposition rate.

6. Conclusion and Recommendations

Adoption of agroforestry by farmers has a great potential to improve soil fertility, crop performance and grain yield of cereals. Agroforestry is the only technique which can be used by farmers to restore soil fertility and rehabilitate degraded lands to their near original state. Agroforestry has the capacity to increase food security since it provides fruits, vegetables, edible worms and other non-timber forest products which can be sold by farmers to generate income. The use of agroforestry can improve smallholders’ standards of living as they provide a variety of nutrition. Farmers are recommended to adopt agroforestry as these are long term technique which improves food security. Farmers are also recommended to start agroforestry on small scale and on abandoned lands so as to reduce competion of land for crop production and livestock.

7. References


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