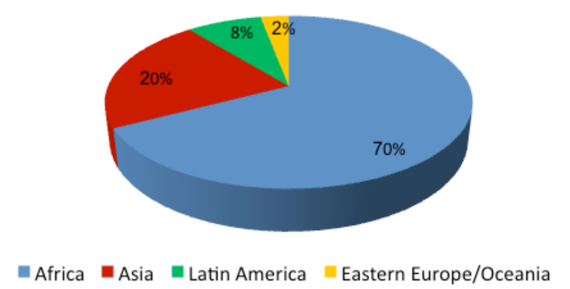
Comparative Environmental Sustainability of Small-Scale and Large-Scale Agriculture in Mozambique

A worldwide demand for agricultural land has increased dramatically in Africa over the past decade. Of the 45 million ha of land allocated to foreign investors worldwide, 70% are located in Africa. In southern Africa, Mozambique alone represents 25% of the total grabbed lands. Agrofuels production and the introduction of carbon credits are the main drivers of this surge in large-scale land investments. However, while a growing body of literature has begun to address the socio-economic dimensions of small-scale versus large-scale agriculture, related environmental impacts have received little attention.

Thematic Focus: Ecosystem Management, Resource Efficiency and Environmental Governance

1. Why is this issue important?

Figure 1: Percentage of globally grabbed lands- 2009



Data source: World Bank

Population growth and higher per capita consumption will have major implications for food demand in the next 40 years (IFAD, 2013). Global population is projected to surpass 9 billion by 2050, with most of the additional 2 billion people living in developing countries (UN, 2012). However, the key question is how to feed that larger population, while adopting sustainable practices in a context of increasing land, energy and water scarcity, environmental degradation and climate change. This uncertainty in the future of food supply has propelled a growing number of investors to acquire large land of areas in many developing countries, particularly in Africa, for commercial production or long-term investments (World Bank, 2010). Of the 45 million ha of land purchased worldwide as estimated by the World Bank (2010), 70% are located in Africa (Figure 1). However, it is the same land that peasants across rural Africa require to support their livelihoods and smallholder production that is targeted by such large-scale investments (Odhiambo, 2011). This overlapping of interests has triggered a debate on small-scale versus large-scale agriculture, and on the future of small farmers in developing countries.

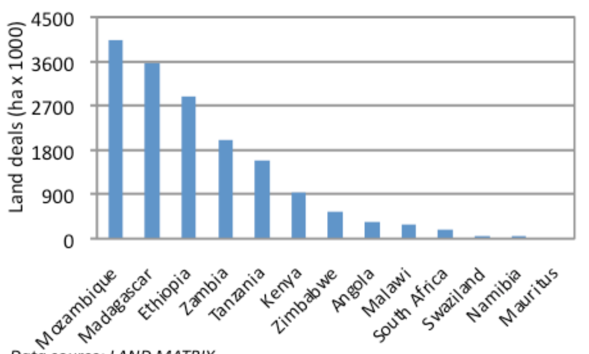
Mozambique is a less developed country in southern Africa with more than 68% of its population living in rural areas (FAOSTAT, 2014). With substantial assistance from international donors, the country is rebuilding its economy damaged by 16 years civil war, which ends in 1992. Agriculture is the most significant livelihood activity to which rural households depend on for income and food security (Coughlin, 2006). It is more intensively practiced in the central and northern parts of the country where agroecological conditions are favourable. Average crop yields are about half of the regional average, and the country lives with cyclic hunger and malnutrition, especially in the southern region (World Bank, 2010). Many studies suggest that measures to improve smallholders' capacity to increase food production, as well as to link them to markets, will not only enhance their purchasing power but will also increase wider food availability and contribute to global food security (Wegner & Zwart, 2011). The G20 Seoul Summit in 2010 supported this vision, and the development consensus and action plan reports: ''We are committed to promoting increased procurement from smallholder producers and to strengthen their access to markets, in line with domestic and regional strategies''. However, this vision is not shared by the international agribusiness community which favours production-oriented agriculture (Collier, 2008). Proponents of large-scale agrofuel investments argue that not only will investors and consumers benefit from these investments, but the recipient economies will also experience rural development and economic growth (Wegner & Zwart, 2011). Aside from this potential benefit, negative impacts of large-scale farms on food security and local communities are regularly raised. Moreover, many smallholders have seen their traditional lands taken away by investors, including their own governments and national elites (FIAN, 2010). Large-scale farming also produces strong pressures on resource use, which can disrupt the functioning of ecosystems, and leave an environmental legacy for local communities to cope with in many developing countries (Lazarus, 2014).

2. What are the findings?

2.1. How much land is being grabbed in Mozambique?

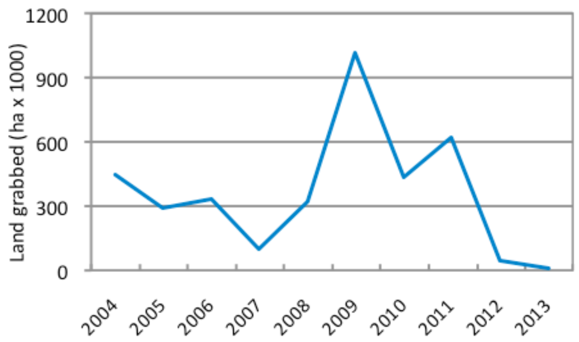
Land grabbing has been defined as taking possession of, and/or controlling a large amount of land for commercial and industrial production, that is disproportionate in size in comparison to average land holdings in the region (FIAN, 2010). FAO argues that one may talk about land grabbing if the investment exceeds 1000 ha (Cotula, 2009). The exact number of land grabs worldwide and in particular in Africa remains contested and controversial (Scoones *et al.*, 2013), because these deals defy transparency, and area, boundary, ownership, jurisdiction, access and terms are difficult to verify (Borras *et al.*, 2012; Cotula 2012; Edelman, 2013). Various organisations such Land Matrix (ILC, 2014) and GRAIN (2014) have put in place online databases to catalogue land grabbed worldwide.

Figure 2: Land deals in southern Africa (2000-2013)



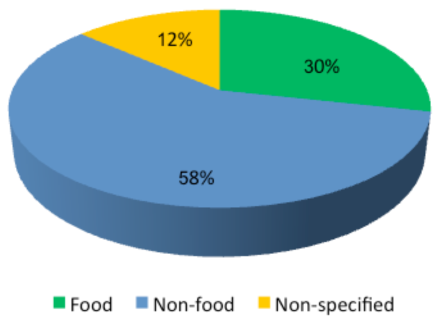
Data source: LAND MATRIX

Figure 3: Reported land acquisitions in Mozambique



Data source: LAND MATRIX

Figure 4: Percentage of food and non-food crops



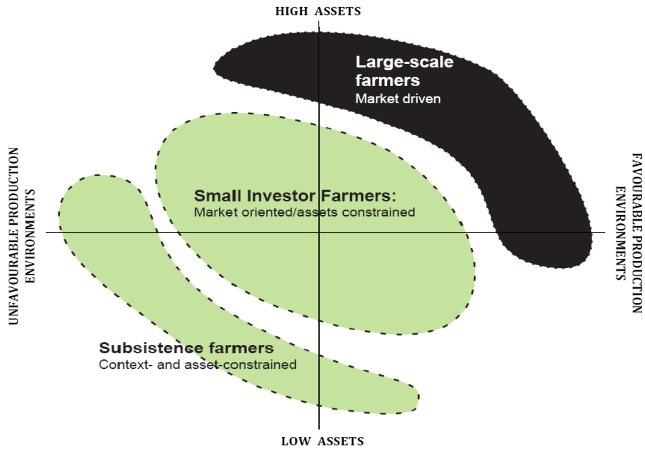
Data source: LAND MATRIX

Land Matrix shows that five countries concentrate 91% of the reported grabbed lands in southern Africa (Figure 2). Mozambique alone represents 25% of the total land grabbed with about 4 million ha (nearly one-seventh of the country's available arable land). Figure 3 shows that land grabbing in Mozambique accelerated greatly after 2007, peaking in 2009 before slowing down again in 2010 and following years. The sharp increase in land acquisitions during the 2007-2009 periods is related to the food crisis that triggered new investors' interest in lands; the slow down observed in land deals from 2009 is associated with the financial crisis of 2008 (Anseeuw *et al.*, 2013).

Lands grabbed by investors are not always entirely used for food crops, and investors are usually unclear about the type of crops they plan to grow (Casson *et a*l., 2007). As shown on Figure 4, 12% of production is non-specified crop, while food crops account for 30% of reported grabbed lands, against 58% for non-food crops production. The importance of non-food crops shows the extent to which investors are attracted by biofuels and other, more traditional, ''high value crops'' such as cotton and tobacco. For example, over 183,000 ha of arable land have been allocated to jatropha crops alone for the production of biodiesel (FEE, 2012). Although the moratorium of the Government of Mozambique has slowed down land deals from 2011 (Actionaid, 2012) (Figure 3), the global trend suggests that land grabbing will intensify. Moreover, to satisfy projected future food demand, it is estimated that cropland will have to increase by 2.7 million ha per year (Lambin & Meyfroidt, 2011), while at the same time, increasing demand for sources of energy requires additional 1.5 million ha per year (Pelletier & Tyedmers, 2010). Therefore, more integrated actions must be taken, firstly to promote sustainable agriculture and efficient use of resources, and secondly to increase agricultural production without degrading the environment.

2.2. Small-scale and large-scale agriculture

Figure 5: Models of farming systems



Source: Berdegué & Escovar (2002)

Notes to figure 5: **Assets** = access to land, capital, training, education, health programmes. **Production environments** = roads, irrigation systems, markets, transportation, influence.

Mozambique's agriculture is strongly bimodal, split between approximately 3 million of small-scale farmers producing 95% of agricultural GDP (Gross Domestic Product), and less than 500 large-scale farmers. **Small-scale farmers** are those with less than 10 hectares of cultivated area (Coughlin, 2006). In Mozambique, they mainly consist of subsistence farmers with multiple small plots of less than 2 ha on average (Jayne *et al*., 2010). Their total cultivated area is estimated at 3.7 million ha. Small-scale farmers are not a homogenous group, but rather a diverse set of households with varying farms and characteristics (Fan *et al*., 2013). The dominant farming practice is shifting cultivation, in which plots of land are cultivated temporarily, then abandoned and allowed to revert to their natural vegetation while farmers move on to other plots (Sitoe *et al*., 2012). In fact, shifting cultivation tries to compensate for depletion of soil nutrients. Smallholders' main staple crops are maize and cassava, while cash crops are cotton, sugarcane and tobacco. Small-scale farming is highly rain-fed and characterised by use of rudimentary cultivation techniques and low agrochemical inputs (Coughlin, 2009). As shown in Figure 5, small farmers lack most types of assets aside from unskilled labour, and operate in unfavourable production environments. Therefore, the productivity per hectare is low for the vast majority of smallholders. In fact, increases in crop production usually arise from farming more land rather than from use of improved inputs and technology (Sitoe *et al*., 2012).

Large-scale or commercial farmers have farm sizes of at least 50 ha, and their production is generally directed to supplying national markets, agro-industries and for export (Berdegué & Escobar, 2002). The total area cultivated by large-scale farmers is about 121,000 ha, and the main agrofuel crops are sugarcane (for bioethanol), jatropha (for biodiesel) and sunflower (for biodiesel). Commercial farming is spurred by a favourable context and high asset positions, and driven by market forces (Figure 5). Their management may be local or foreign, and farmers of this category have direct access to credit, modern decision-support tools to manage risks, information and all required infrastructure necessary to remain competitive in their business operation. Large-scale farmers have the skills, education, networks, organisations, political power and capital required to mobilize and influence both the public and private sector (Berdegué & Escobar, 2002). Yield per hectare from large-scale agriculture is higher, because the farming system has some technological know-how; uses agrochemical inputs, and has access to credit and irrigation systems.

Large-scale agriculture relies on contract farming to deliver supplies of agrofuels feedstock. Investors' companies deliver inputs (seed, fertilizers and pesticides) and provide technical assistance through extension services to farmers, who are committed to sell their entire production to the company that provided the assistance (Sitoe *et al*., 2012). The cost of services and products provided to farmers are deducted from their sales incomes. Although contract farming sounds like it leaves the farmers in command of their fields and production but in fact, it does the opposite. For instance if weather or pests reduce the yields, the farmers take all the risk, often still required to deliver equal value of cash that the crop would have provided, plunging them into debt (Mushita & Thompson, 2007). In regions where farmers have replaced food crops with agrofuels crops (non-food), this can leave them with no source of food and no means of buying food elsewhere (Ambiental & UNAC, 2009). In other words, contract farming can transform farmers into powerless labourers on their own land, retaining little or no role in decisions about production but simply executing what the global corporation requires. Moreover, large-scale farming has very high requirements for transportation, supplies, professional services, marketing and processing, which unfortunately comes at the expenses of the environment.

2.3. Environmental sustainability of agricultural practices

Large-scale farming is generally associated with a number of negative environmental impacts. These include deforestation, a heavy demand on scarce water, water quality deterioration caused by the excessive or inappropriate use of agrochemicals, and loss of soil fertility among the most pressing issues concerning agriculture sustainability (Gomiero *et al.* 2011a). Pest infestation due to monoculture, biodiversity loss due to land use change, emissions of greenhouse gases (GHGs) from agricultural activities and increased consumption of fossil fuel are also causes for concern.

a. Deforestation

In Mozambique, the rate of deforestation has increased very rapidly between 1990 and 2004, leading to a loss of 3.8 million ha of forest cover (Sitoe *et al*., 2012). The deforestation is mainly concentrated in the central and northern provinces where population density is the highest (Marzoli, 2007). A major part of the deforested areas is primarily the direct impact of conversion of forests to areas of permanent agriculture (Geist & Lambin, 2002), both for large-scale production of global commodities (DeFries *et al*., 2010), and small-scale production of food and crops (Burgess *et al*., 2002; Fisher, 2010).

▪ ***Large-scale agriculture***

Figure 6 illustrates land use change in the Mafambisse Sugar Estate located in the district of Dondo (Sofala province, central Mozambique). This region is characterized mainly by large sugarcane cultivations (ADB, 2005). The multi-temporal satellite imagery shows that the expansion of the agrofuels sector has led to a rapid conversion of large areas of forest into sugarcane plantations. Since large-scale agriculture uses modern technologies to clear cut forest cover, a great extent of deforestation can take place in relatively short periods as shown on the three satellite images (Figure 6). In Mozambique, large-scale production of sugarcane and jatropha crops among others is causing the destruction of large areas of native forests (UNAC, 2009) (Figure 7). In 2008, a study of the West African Economic and Monetary Union (UEMOA) argued that in sub-Saharan Africa, dry secondary forests have often been affected by the expansion of jatropha plantations, and that industrial business model are directly associated with deforestation (UEMOA, 2008).

Using high-resolution satellite imagery, DeFries *et al*. (2010) found that forest loss in sub-Saharan Africa is positively and significantly correlated with the international demands for agricultural products and urban population growth during the period of 2000-2005. A similar pattern is observed in Amazonia where the increasing role of large-scale agriculture and the vast remaining potential for expansion of farming is causing much concern about deforestation and the loss of ecosystem goods and services (USDA 2003; Foley *et al* 2007, Morton *et al* 2006). Looking at the environmental impacts of agro-industrial expansion, Nepstad *et al*. (2006) also came to the conclusion that the traditional way of clearing forests for small-scale agriculture to meet the subsistence needs is no longer the main driver of deforestation, but the responsible is rather the large-scale agro-industry.

▪ ***Small-scale agriculture***

In some places, long-term small-scale practices may be sustainable while in others, poverty and the need to satisfy immediate needs may lead to

Figure 6: Expansion of sugarcane plantations in Mafambisse (Sofala) (Landsat TM)

Source: Landsat.org

Figure 7: Large-scale jatropha crops in Maputo (Mozambique)

Source: Friends of the Earth International unsustainable practices and over use of natural resources (IFAD, 2013). Figure 8 shows that shifting cultivation practices inherent to small-scale farming can cause deforestation and forest degradation (Burgess *et al*., 2002; Fisher, 2010). Many studies found that the slow expansion of smallholder agriculture is the dominant driver of deforestation in Africa (Palm *et al*., 2005, Fisher, 2010; FAO, 2002 & 2009). They argued that the production of staple crops of small farmers is strongly correlated with deforestation rate in Africa. However, the increased production is not correlated with yield increases over the same time period, meaning that production increase results mainly from agricultural areas expansion (Fisher, 2010).

Figure 8: Shifting cultivation and slash-and-burn (Niassa, Mozambique)

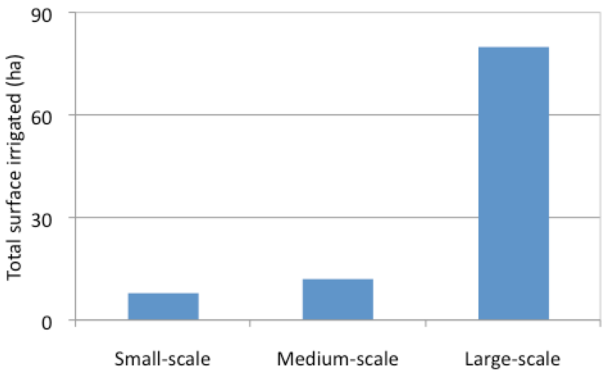
Source: Silva et al. (2009)

FAO studies show that in sub-Saharan Africa, the direct conversion of forest areas into small-scale permanent agriculture accounts for about 60% of the total deforestation, against 10% for the conversion of forest into large-scale permanent agriculture (FAO, 2002 & 2009). But, when these numbers are brought down to the Mozambican context where smallholders cultivate a total of about 3.7 million ha against 0.12 billion ha for large-scale farmers, it shows that impacts of large-scale agriculture on deforestation is five times higher than large-scale agriculture. This is a n indication that impacts of small-scale farming on forests are highly context-dependent as shown by Silva *et al*. (2009) in their study based on multi-temporal satellite imagery (1989-2005) and interviews with farmers. They examine the relationship between shifting cultivation and forest cover change in the districts of Marrupa and Mandimba (Province of Niassa), and found a significant shift in locations of small-scale farms in the Marrupa district meaning a high level of shifting cultivations. Contrary to the Marrupa district, small-scale farms were more stationary in the district of Mandimba characterized by intensification of agriculture towards permanent cultivation. In other words, small-scale farming may occur in many directions and at different rates simultaneously, and therefore impact differently on deforestation from regions to regions. Other driving forces such as fire used to open small-scale farms (slash-and-burn) impose additional pressure on forests cover (Figure 7). The decline in agricultural productivity and subsequent decline in income has increased the dependence of smallholders to off-farm employment such as collection of fuel wood and production of charcoal, which contribute also to deforestation and forest degradation (FAO, 2010).

b. Water use

Water use estimates for Mozambique in 2011 indicate a total water freshwa ter withdrawal of 774 million m3 (FAOSTAT, 2014). Agriculture is the main consumer, and it accounts for 573 million m3 (74%) of freshwater withdrawals, followed by the domestic sector using 177 million m^3 (23%) and industry consuming 25 million m^3 (3%). In terms of farming practices, rain-fed small farms have a lower water consumption rate than irrigation-oriented

Figure 9: Cultivated areas actually irrigated



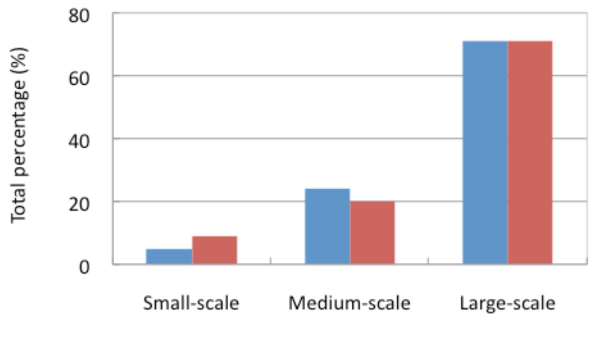
Data source: FAOSTAT

large-scale farms (Figure 9). The small number of smallholders who irrigate their farms use hand pump-mounted boreholes and shallow wells throughout the country. Contrary to small farmers, large-scale biofuel productions require a high amount of water. For example, it takes up to 9,100 litres of water to grow the soya for one litre of biodiesel, and up to 4,000 litres for the maize to be transformed into bioethanol (Steenblik 2007; The Independent, 2009). With the global warming, agrofuels will compete with food crops for diminishing quantities of available water, especially in southern regions of Mozambique where water is scarce due high variability of rainfall from year to year.

c. Agrochemicals and water quality

Use of fertilizers and pesticides is of key importance in large-scale agriculture. Figure 9 indicates that 71% of all agricultural fertilizers and pesticides are used in large-scale farming. This high amount of agrochemicals turns out to be a major concern for water quality. Fertilizers and pesticides use in Mozambique have increased considerably over the past 20 years, mainly due to large-scale farming practices (Figure 10).

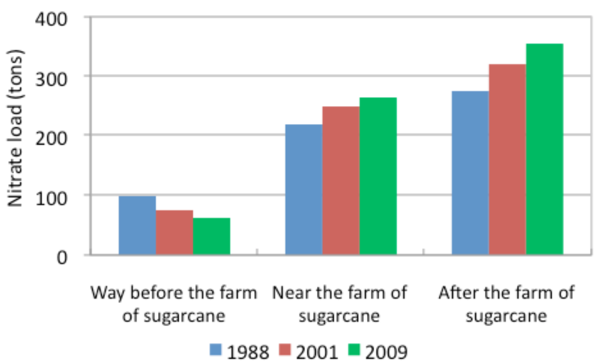
Figure 10: Percentage of agrocemicals use



Data source: FAOSTAT

Several studies show that intensive use of fertilizers and pesticides has led to the degradation of water quality in many regions where high nitrogen and phosphorus concentrations were observed in waterways and coastal zones (Carpenter *et al*., 1998; Bennet *et al*., 2001). As illustrated in Figure 11, agrochemicals exported from sugarcane plantations have major negative impacts on water quality of the Umbeluzi River (Maputo, Mozambique). A multi-temporal land use analysis of these impacts using the Soil Water Assessment Tool (SWAT) model revealed that nitrogen concentrations in the river increase as sugarcane areas increase over time (GMES-GMOSAIC, 2014). The nitrogen load increases as well as the river passes through the sugarcane farms and is measured at different stations. Folmer *et al.* (1998) has demonstrated that large-scale farming cause the depletion of more soil nutrients than small-scale farming. Indeed, intensive agriculture increase soil erosion, sediment load, reduction of soil organic matter content (Gomiero *et al.,* 2011a), and leaches nutrients and agrochemicals into groundwater, streams and rivers. In fact, agriculture has become the largest source of excess nitrogen and phosphorous entering waterways and coastal zones, and can causes eutrophication of rivers (Bennet *et al*., 2001). Also, some pesticides are persistent, bio-accumulative toxins. They degrade very slowly and accumulate in fauna and flora tissues, and can later contaminate human being or kill for instance pollinating insects necessary for crop production (USAID, 2010).

Figure 11: Nitrate load in the Umbeluzi river



Source: GMES-GMOSAIC (2014)

d. Soil erosion

Soil erosion is a natural process caused by water and wind, but human activities can greatly influence its rate, especially through agriculture and deforestation. Erosion commonly occurs following conversion of natural vegetation to agricultural land - carrying away fertile soil as well as fertilizers, pesticides and other agrochemicals (Lal, 2012). Famba (2010) showed that land degradation in Mozambique is mainly in the form of erosion due to intensive cultivation, deforestation and soil salinisation. They highlighted that the problem of salinity of soil in Mozambique is aggravated by inadequate water management and poor drainage systems, and salt-water intrusion during the dry season. Overall, in agricultural systems where erosion rates are high, nutrient depletion is much higher, and erosion accounts for at least 55% of that depletion (Folmer *et al*., 1998). In terms of agricultural practices, large-scale farming which uses heavy equipments, that tend to leave soil uncovered for long period of the year causing topsoil erosion, sediments load and reduction of the content of organic matter (Gomiero *et al*., 2011b). The uncover soil removed by either wind or water erosion is 1.3 – 5.0 times richer in organic matter than the soil left behind. As a result of soil erosion, during the last 40 years about 30% of the world's arable land has become unproductive and, much of that has been abandoned for agricultural use (Pimentel, 2006).

e. Monoculture plantations

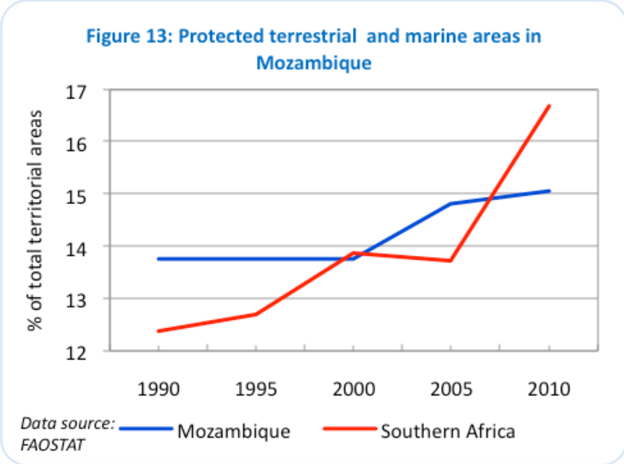
Large-scale plantations are grown usually under monoculture cropping systems to optimise infrastructures, while small-scale farming is based on multiple cropping, intercropping and crop rotation. Over time, growing the same crop in a field may lead to pest and pathogen build-up, declining soil fertility, loss of biodiversity and land degradation (FAO, 2001). In general, monoculture puts more pressure on soil as each crop has its specific nutritional needs. Extended cultivation on the same plot of land leads to depletion of nutrients from the soil, causing a reduction in yields in the medium term, which then needs to be improved by the use of large fertilizers and pesticides (FAO, 2008a).

Figure 12: Jatropha crop with pests in Maputo (Mozambique)

Source: Friends of the Earth International

Another impact of monoculture is the specialization of pests which became more resistance to pesticides. In southern Mozambique, the large-scale production of jatropha crops has been found to be vulnerable to diseases, viruses and insect pests (Ambiental & UNAC, 2009) (Figure 12). The extensive use of pesticides has still not solved the problems. The greater concern now is the growing evidence from the subsistence farmers and experts, of jatropha pests spreading to surrounding food crops (Ambiental & UNAC, 2009). If sustainable development policies are not clearly defined and implemented in Mozambique, large-scale monocropping systems could endanger the environment and food security.

f. Biodiversity loss



Agricultural expansion has direct impacts on local biodiversity through landscape modification, which in turn results in loss of ecosystem services (Yaap *et al.,* 2010). The FAO has concluded that industrial agriculture and livestock breeding are the chief cause of the loss of biodiversity in plants and animals (FAO, 2007). Forest cutting can threaten the environment, biodiversity, carbon stocks, and land and water resources. Converting forest or rangelands to large-scale monocropping reduces diversity in flora, fauna and agro-biodiversity, as well as above-ground and sub-surface carbon stocks (Braun & Meinzen-Dick, 2009). For instance the population of pollinators are declining due to monoculture, destruction of habitats and use of pesticides (UNEP, 2010). In addition, agricultural intensification, which replaces traditional varieties of seeds with modern high-yielding but genetically uniform crops, are threatening biodiversity across the globe (Jackson *et al.*, 2005; Sachs *et al.*, 2009). The policy response of the Government of Mozambique to the loss of biodiversity is measured by the coverage of protected areas (Figure 13). From 1990 to 2000, the number and extent of protected terrestrial and marine areas covered only 14% of the country's territory (FAOSTAT, 2014). The increased interest of the government and civil society to protect terrestrial and marine areas to ensure the long-term conservation of biodiversity with ecosystem services and cultural values began to increase slightly from 2000 to reach 15% of the national territory. However, compared to regional efforts to protect terrestrial and marine areas, the Mozambique has much more to do to catch up with the other countries of southern Africa.

3. What are the implications for policy?

To protect vulnerable communities against land abuse and achieve environment-friendly agriculture, the Government of Mozambique should establish an appropriate regulatory framework, which must be communicated to foreign investors. In addition, environmental policies and regulations have to be clearly articulated, implemented and enforced, and environmental impacts assessments integrated in land deals transactions (GEAS, 2011). It is urgent to enhance the institutional capacity of the Mozambique to manage issues related to land tenure, deforestation, pest and pesticides management, and the lack of tools to assess the environmental footprint of agricultural practices.

a. Land tenure

To satisfy projected future food and energy demand, more land will be grabbed worldwide. The FAO advocates an urgent review of agrofuels policies and subsidies in order to preserve the goal of world food security, protect poor farmers, promote broad-based rural development and ensure environmental sustainability (FAO, 2008b). Measures are taken at the international level to minimize the negative socio-economic and environmental impacts of land grabbing, but it is only voluntary guidelines. This is the case of the ''Responsible Governance of Tenure'' of the FAO (FAO, 2012) and ''The Framework and Guidelines of Land Policy in Africa'' (AUC, 2010). The Mozambican's Government should be inspired by these guidelines to reform its land policy and better regulate the increasing large-scale land acquisitions. This reform is needed to strengthen the land rights of local communities, and to prevent environmental degradation. Although media, NGOs and research institutions are working hard to for public awareness, it is not enough to slow the appetite of large-scale land investors in Mozambique.

b. REDD+ initiative

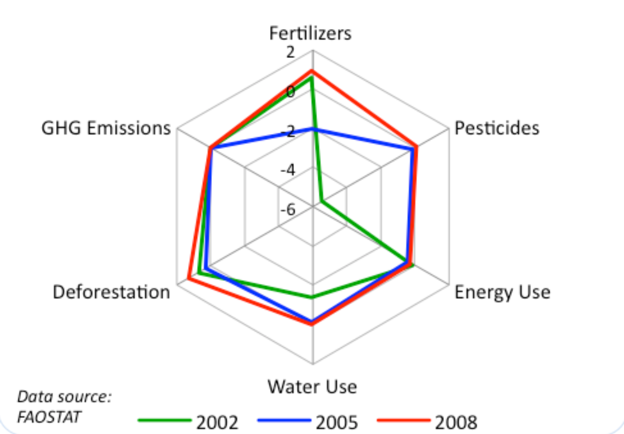
The causes of deforestation are various and complex and they differ from one country to another and from one region to another. To reduce emissions from deforestation, the Bali Action Plan to mitigate climate change included REDD+ (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) as a possible action that developing countries need to implement (UNFCCC, 2007). Payments for reducing emissions are incentives for people to curb deforestation and help them develop at the same time. Beginning April 2010, various meetings were held across the country in the scope of the south-South cooperation such as the Brazil-Mozambique initiative to develop the REDD+ National Strategy. But to make REDD+ more effective and operational, reliable baseline data is required to reasonably evaluate the effect of policies and interventions compared to historical trends (Sitoe *et al.*, 2012). Therefore, it is important to prioritise data collection surveys using satellite imageries, particularly in the main deforestation areas of the central and northern regions. This will create the conditions for Mozambique to embark correctly on a national REDD+ initiative.

c. Integrated pest management

Mozambique has adopted a good pesticide legislation according which only pesticides registered with the National Directorate of Agrarian Services can be used in the country (MDPD, 2013). However, the capacity of the country to enforce this legislation is weak. In addition, no specific policies exist in Mozambique for pest management and crop protection in a context of Integrated Pest Management (IPM) approach (MDPD, 2013). IPM is a mix of farmer-driven, ecologically-based pest control practices that recognize the need of productivity while seeking to reduce reliance on chemicals pesticides and protecting human/animal health and the environment (Grzywacz *et al.*, 2010; CGIAR, 2014). Continuous efforts should made by the Government of Mozambique, NGOs and private companies to successfully implement a Pest Management Plan to regulate pesticides usage under certain conditions. This plan should include outreach activities, and provide training on type, amount, time of application, and poisonous effects of pesticides. In fact, decision-makers can also learn from the Mozambican's cotton industry which has a long experience of IPM (Chamuene *et al.*, 2010). Indeed, the cotton industry's ongoing IPM approach can be scaled up to agricultural projects in the country to minimize reliance on pesticides, and to emphasize contribution of other controls methods.

d. Environmental footprint of agricultural practices

Figure 13: Environmental footprint of Mozambique



Agriculture operates on the interface of two dynamic complex systems, socio-economic and ecosystems which evolve in time and space (Giampietro & Pastore, 2000). Therefore, to evaluate the performance of environmental sustainability of farming practices, tools that integrate multiple dimensions are required to enable more informed decision-making.

The Amoeba[1] model (Rigby *et al.*, 2001) combined with the impact decoupling index (DI) (UNEP, 2011) can respond to that need. DI refers to the ratio of change in the rate of a given impact, to change in the rate of

[1] AMOEBA in Dutch language stands for General Method of Ecosystem Description and Assessment.

economic growth within a certain time period. The Amoeba/DI approach can allow quantitative and simultaneous comparison of several indicators to assess the environmental footprint of agricultural practices. For instance Figure 13 present trend that emerges by applying this approach to some agri-environmental indicators of the section 2.3. The main observation is that from 2002 to 2008 there was a greater dependence of economic growth on forests and fertilizers. In other words, the resource use efficiency was low, and the deforestation rate and environmental impacts high. But for the other indicators, the resource efficiency was high and environmental impacts low. The AMOEBA/DI tool makes the environmental sustainability more understandable to political decision-makers, and it can help making sound agricultural policies (Wefering *et al*., 2000).

4. Conclusion

To attract foreign investments and stimulate the economic development of its country, the Government of Mozambique has hosted the development of agrofuels industries. Those industries have been portrayed as a ''green'' solution to the fossil fuel energy and a sustainable source of employment opportunities and higher income for local populations (Bassey, 2009). But in many developing countries such as Mozambique, the dream was not realized. Large-scale agrofuels production rather strengthen the agricultural model that pushes small-scale farmers aside as ''inefficient'' and ''unproductive''. In addition, agrofuels crops compete directly with food crops for fertile land and water, which threaten the environment and the food security of local communities. The Government of Mozambique should clearly define and implement its national strategy for biofuels, so that the country's economy and local communities can benefit from this growing industry. However, if no serious reforms are put in place to regulate the development of agrofuels, the country could end up with rivers polluted by agrochemicals, destroyed forests, depleted water resources, and local communities without lands to cultivate.

The Mozambique Government should invest more to develop the capacity of small-scale farmers who produce 95% of the agricultural GDP. In fact, when we look at the impacts of large-scale agriculture, small-scale farming can be far superior to its rival (Broad & Cavanagh, 2012). It has the advantage of reducing dependence on inputs, and it is more resistant to external shocks. In addition, small-scale farmers have inherited complex farming practices from past generations, which help them to adapt to local conditions and to sustainably manage harsh environments while meeting their subsistence needs (Altieri *et al*., 2012). In Mozambique, the small-scale agriculture model must be better conceptualized and evaluated in a comprehensive framework. This is necessary to provide adequate policy recommendations to help solve the problems of productivity and efficiency commonly raised by the proponents of industrial agriculture. The successful implementation of these recommendations will not only enhance small farmers' purchasing power but will also increase wider food availability and contribute to the country's food security.

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