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IMPROVING CREDIT ALLOCATION TO SUSTAINABLE AGRICULTURE IN SUB-SAHARAN AFRICA: A REVIEW OF CARBON SEQUESTRATION BENEFITS

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ABSTRACT:

Financing of agriculture in rural Sub-Saharan African in recent years has been relatively constant despite remarkable increase in the number of regional financial institutions. This development may be attributed to how these institutions view the business of agriculture and the risks involved. However the slow pace of financing sustainable agriculture which may impacts energy security and opens up new opportunities through mandatory or voluntary emission trading schemes has received less attention. Diverse literatures are used in exploring the potential of bio-based agriculture with emphasis not restricted to carbon sequestration alone but agriculture value added and its effect on smallholder's livelihood. The evidence suggests that if financial and non-financial institutions re-evaluate and reassess their stands on sustainable farming, development of agriculture in rural areas is inevitable. Constraint to agriculture financing due to lack of access to credit can however be reduced if innovative and sustainable smallholders are identified.

keywords: credit, climate-change, agriculture, carbon certification, bio-energy.

INTRODUCTION

Agriculture remains a vital economic driver for developing countries and would play a critical role in eradicating poverty especially in low-income countries. This sector generates a substantial level of revenue while increasing real income (Christiaensen & Demery, 2007). The agricultural sector not only employs an estimated 75 per cent of the work-force in low income countries in sub-Saharan Africa, which is the highest level recorded for any sector, but it is also a major contributor to Gross Domestic Product (GDP) estimated at approximately 30 per cent (The World Bank, 2007). The development and growth of agriculture apart from ensuring food security and sustainability, is also a milestone in establishing a stable bio-based economy which provides an alternative to conventional energy. Energy security is vital for the development of low-income developing countries. In the sub-Saharan Africa region, households, medium and small scale industries, excluding those in southern Africa, make use of biomass, most notably "firewood" or fuel-wood, charcoal and animal waste (dung) on a large scale (81.18 per cent), implying that long term energy supply cannot be sustained and air pollution will be on the increase (United Nations, 2004a). The regions per capita energy consumption which is estimated at 387.89 Mtoe, is also ranked amongst the lowest (United Nations, 2004a). This low consumption may serve as an indicator for low economic activity and therefore moderate development.

The continent´s smallholders appears not to be self-sufficient, which may to a large extent be attributed to issues such as low productivity, land inequality, health, unfavourable international agricultural agreements and lack of urban demand (Jayne, Mather & Mghenyi, 2010). Global challenges such as food security, dependency on fossil energy and rural development are therefore of particular concern. These concerns are justified considering the exponential growth rate of global population which is forecasted to reach between 7.4 and 10.6 billion by 2050, with Africa expecting a 7 per cent population growth (United Nations, 2004b). This trend could further exert pressure on food as well as energy leading to spike in prices. Taking the continent's endowment of natural resources into consideration, while acknowledging regional differences, the question then arises if the agricultural potentials that abound are able to support a move towards Sustainability and bio-based economy.

A vast array of literature identifies credit constraints as one of the major problems confronting development of agriculture, especially in the adoption of innovation, not only in sub-Saharan Africa, but also globally (Ahmed, 2005).The fact that a number of smallholders use different farming methods, some sustainable and environmentally friendly while others do more harm to the environment, means it may not be ideal to generalize farmers. This paper looks at the potential of segmenting rural agriculture into sustainable practice with bio-energy production, while approximating the resulting benefits of environmental services to asset (income), and then analysing its effects on credit constraints.

The paper proceeds by elaborating the importance of asset to credit allocation as well as features of rural smallholders. We then explore the current bio-based economy stock of the continent with the view of revealing what the future may hold for alternative energy production in sub-Saharan Africa. The next section examines the possibility of using an international mechanism such as the Kyoto protocol´s clean development mechanism (CDM) or a voluntary carbon market to overcome the effect of credit constraints to rural smallholders. The section thereafter provides a rough estimate of sequestration cost and revenues, and how sustainable agriculture can be integrated into institutional operations. The paper then concludes with recommendation for future sustainability and credit allocation.

FINANCIAL CONSTRAINTS TO AGRICULTURE IN AFRICA

Credit constraint is a major problem hindering the global development of agriculture, this then implies that the adoption of innovation as well as a possible move towards a bio-based economy especially in developing countries remains an uphill task (Feder & Umali, 1993; Fernandez-Cornejo & McBride, 2002). Studies have shown that by providing credit to smallholders, adoption of new technology (e.g. hybrid maize) is being encouraged and the ability of smallholders to bear risk has increased (Diagne, Simtowe & Zelle, 2009). All studies found that a credit constraint had a negative impact on the adoption of agricultural innovation, which ultimately might lead to limited agricultural growth, development and increased poverty. The rural smallholders are therefore limited to sourcing funds from their savings (when, and if available) or from family and friends or other sources such as wealthy people or money lenders in the community who usually charge above market interest rates (Salami, Kamara & Brixiova, 2010).

There is little doubt that such a development will not help promote sustainable agriculture. Smallholders in Kenya have expressed their dismay at the credit situation that they are facing, insisting that it was the main cause of low agriculture productivity. Low government spending on agriculture of less than 6 per cent of GDP in the last three decades in most of sub-Saharan Africa has had little positive impact on agricultural development (Salami et al, 2010). It is estimated that less than

10 per cent of total lending by commercial financial institution in sub-Saharan Africa goes to agriculture with large scale farmers as core benefactors (Mhlanga, 2010). *Table 1* below provides an overview of the lending pattern of commercial banks to agriculture in a number of selected sub-Saharan African countries. The resulting graph *(figure 1)* shows that lending in most of the countries have been constant, however in some cases on a slight decline. Sub-Saharan African agricultural production is characterized by a disproportionately large fraction of agricultural output which is in the hands of smallholder farmers whose average land holding is about one to three hectares. While some sort of agricultural asset (in the form of farmland) is available in rural areas, a number of smallholders lease or rent farmlands for cultivation (Ogunlela and Mukhtar, 2009).

Although non-commercial financial institutions such as micro-finance institutions (MFIs) have helped facilitate credit to the rural smallholder by adopting a different approach, which is based on a business's cash flow evaluation or income as a substitute for collateral, its impact has however not been widespread (Salami et al., 2010). Co-operatives in rural areas have also helped to spread agricultural credit, as information complied on respective members by the organization is useful not only in the loan assessment process, but also repayment due to peer pressure. Furthermore, financial institutions do not have to engage in high infrastructure costs which come with the institutional set-up (Admasu & Paul, 2010). Financial institutions can thus reduce transaction costs by aligning operations to those of the co-operatives.

As financial and non-financial institutions in sub-Saharan regions are increasing their regional operations, it is important that these institutions also adhere to international and regional financial regulations (Lafourcade, Isern, Mwangi & Brown, 2005). In 2003, available data for micro-finance entities operated by commercial and non-commercial institutions in sub-Saharan Africa shows that of the total 163 institutions only 36 were unregulated, these unregulated institutions were however considerably restricted in their operations (Lafourcade et al., 2005). In order to protect stakeholders and/or depositors of financial and non-financial institutions, monitoring and measuring of risk is a vital component of financial operations. Portfolio quality is an indication of the risk associated with loan delinquency and also determines future revenues, as well as the institution´s capability to serve existing clients (Lafourcade et al., 2005). A reason that financial institutions may have overlooked smallholders is due to their lack of collateral, which in the case of agriculture is perceived to be restricted to farmland (Katchova and Barry, 2005). However, as earlier stated, stable income (off- and on-farm) may also be a proxy to collateral.

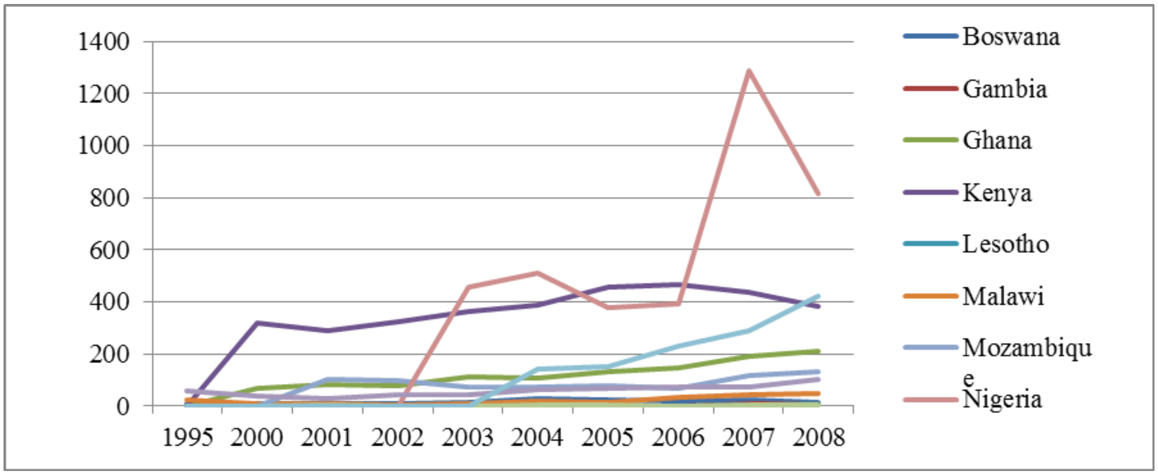
Collateral plays a major role in evaluating credit risk and capital requirement of an agriculture portfolio (Katchova and Barry, 2005). Credit risk calculation such as the probability of default (PD) which estimates the probability that an individual farmer will not be able to meet his/her obligation, is influenced by asset or collateral evaluation, Value-at-risk (VaR) which estimates probability distribution of credit losses conditional on portfolio composition also encompasses asset or collateral value (Thonabauer & Nosslinger , 2004). If the asset valuation of the rural smallholder at the initial period is perceived to be zero, default therefore already occurs when the smallholder applies for the loan. This modeling of agriculture credit risk according to international standards marginalizes small scale and/or smallholders due to the high risk and even higher capital requirements that financial institutions would face. Agricultural risk modeling which impacts credit lending, may be discriminatory toward small sustainable agriculture practitioners who have asset, which under given condition is, eligible as collateral apart from the conventional farmland.

Table 1: *Share of commercial bank lending to the agricultural sector of selected countries in Africa, 1995 - 2008 (percentage of total portfolio)*

Country	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Botswana	1.04	0.61	0.93	0.67	0.76	1.42	1.42	1.13	1.06	0.68
Gambia	-	-	-	-	-	-	-	-	7.20	5.53
Ghana	-	9.65	9.56	9.38	9.45	7.65	6.71	5.37	4.41	4.28
Kenya	-	6.57	6.01	6.07	6.20	6.00	6.25	5.38	4.08	3.60
Lesotho	-	-	-	-	-	-	-	0.31	1.90	8.17
Malawi	28.62	7.55	8.63	3.23	10.40	12.11	9.90	15.25	16.27	14.60
Mozambique	-	-	17.87	15.97	12.37	10.69	8.66	6.39	9.42	8.05
Nigeria	-	-	-	-	5.16	4.46	2.44	1.96	3.11	1.37
Sierra lone	-	4.84	8.29	1.12	1.75	1.93	1.97	0.88	2,49	2.95
Uganda	22.54	10.71	8.57	11.14	9.69	11.07	10.05	9.13	6.67	5.88
Tanzania	8.10	6.30	9.60	17.1	12.0	13.90	12.40	13.94	11.01	12.35

Source: Mhlanga , 2010

Figure 1: *Value of commercial Bank lending to the agricultural sector of selected countries in Africa 1995 -2008 (USD million)*



Source: Authors calculation using the data of Mhlanga , 2010

POTENTIAL OF A RURAL SUSTIANBLE BIO-BASED ECONOMY

Certain African countries such as Algeria, Egypt, Libya Nigeria, Angola and South Africa are endorsed with relatively huge reserves of natural resources such as coal, fossil fuel and natural gas while a substantial number of countries are not only energy importers but also less developed (IEA, 2007). Rural inhabitants and business rely mostly on combustible renewable (firewood) for their energy demand even in so-called oil rich countries (IEA, 2007). In sub-Saharan Africa, it is estimated that 1.6 billion people are without electricity, while 2.5 billion people are dependent on firewood. The balance between energy production and consumption in Africa remains to be seen, as 79 per cent of total electricity production is traceable to certain countries that constitute a mere 22 per cent of the continent´s total population (IEA, 2007). The negative environmental effect of using firewood such as erosion, desert encroachment, soil fertility- and biodiversity losses, and increased health hazards are therefore eminent. It is estimated that combustible renewable (firewood) supplies 284 Mtoes, which is equivalent to 47 per cent of sub-Saharan Africa´s Total Primary Energy Supply (TPES) (IEA, 2007).

Low income countries endowed with relatively limited natural resources pay heavily for the high price volatility of conventional energy (Mol, 2007). It is argued that a spike in the price of crude oil of US$10 would lower the GDP of oil importing sub-Saharan Africa countries by 1.5 per cent, as a large proportion of sub-Saharan Africa countries spend 14 per cent of their revenue on oil importation (Sielhorst, Molenaar & Offermans, 2008). This assumption corresponds to the events in 2005 when the surge in oil price reduced the GDP of oil importing developing countries by almost half from 6.4 to 3.7 per cent, which further plunged more people into poverty (Rossi and Lambrou, 2009).

Despite bioenergy investments and projects being undertaken to supplement conventional energy in sub-Saharan Africa, reliable scientific data on sub-Saharan African bioenergy stock are not comprehensive (FAO, 2008). The reluctance of investment in sustainable bioenergy may be due to the fact that information on the relationship between yields and other variables such as soil, climate, crop management and crop genetic material, on which base investment decisions are made, are poorly documented (FAO, 2008). The unsustainable alternative energy consumption of most of rural sub-Saharan in form of firewood and agricultural residue, is becoming scarce and unaffordable for rural inhabitants.

It is important for developing countries to seriously consider an alternative to conventional energy and move towards a sustainable bio-based economy if it is deemed viable. The bio-based economy potential of sub-Saharan Africa looks at the possibility of using products which are biologically educed as an energy source in a sustainable manner. The feasibility of a bio-based economy was elaborated on in a study which found that cultivating 10 per cent of the land in sub-Saharan Africa which is not forest, wilderness or cropland with biomass energy crops, would produce 18 EJ which is equivalent to 429.92 Mtoes of energy (Amigun, Sigamoney & von Blottnitz, 2008). This is almost twice the amount of TPES currently generated by the solid "combustible renewable" energy source. However, utilizing rainforest and other areas such the savannah or grassland solely for biofuel production will be more polluting, releasing 17 to 420 more tons of CO_2, compared to the reduction which occurs by replacing fossil fuel with biofuel (Brittaine and Lutaladio 2010). The global consumption of biofuel, which stood at 0.50 EJ (11 Mtoes) in 2002, is expected to rise drastically to 50 EJ (1,194.22 Mtoes) by 2050 (Sims, Hastings, Schlamadinger, Taylor, & Smith, 2006). There is however, no doubt that a bio-based economy and sustainable agriculture brings benefits and challenges. Examples of some of these benefits include knowledge transfer on bioenergy production, employment, carbon dioxide (CO_2) emission reduction and revenue generation. Perennial bioenergy crops improve soil conditions, increase soil carbon storage and reduce soil erosion. Potential benefits therefore provide important (additional) reasons to invest in a bio-based economy across the region.

International organizations however caution that without proper institutional monitoring mechanisms, there might be a complete shift to a bio-based economy, thus giving rise to food insecurity, high food prices and agro-biodiversity losses as well as increasing pressure on natural resources (Rossi and Lambrou, 2009)

The Food and Agricultural Organization (FAO) argues that bio-based economy on a small scale can be viable and in the interest of the public if it is derived from local sources thereby boosting employment and wealth. Constraints to bioenergy and sustainable agriculture production in developing countries are mainly due to lack of access to capital, technology and markets by smallholders, as well as pre-existing socio-economic and gender inequality particularly in terms of access to - and control over - productive assets (Rossi and Lambrou, 2009). A United Nations report on the potential benefits of biofuel depicts how ongoing bioenergy cropping projects, especially via planting and processing in sub-Saharan Africa, have improved the rural energy matrix and livelihood (United Nations, 2007). The report also stresses the need for finance and investment in bioenergy, and the co-existence of sustainable large scale and rural small scale biofuel production, concluding that it is particularly important to enlist local financial and micro-finance institutions that understand local markets, conditions and clients.

Despite high production costs, sustainable bioenergy production in semi-arid and arid regions of sub-Saharan Africa may still be desirable because it is a potential driver for rural economic and social development (Wicke et Al., 2011).

ENVIRONMENTAL SERVICES AND CARBON

Climate change due to the emission of greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) as a result of human induced consumption, amongst others, is a global threat. Agricultural practices contribute to atmospheric GHGs, for instance fertilizer usage releases N_2O. The felling and burning of trees, land conversion all release CO_2 while animal dung contains both of these gases (Seeberg-Elverfeldt, 2010). Activities such as afforestation and reforestation, the management of forests, soil, livestock, manure and land, sustainable biofuel production, improved energy efficiencies and biodiversity conservation are methods that help reduce or mitigate GHGs emissions (Seeberg-Elverfeldt, 2010). Therefore sustainable agriculture has a favorable impact on climate change, since it has the ability to store and capture CO_2.

Today carbon uptake and storage is economically viable due to the ability to trade these activites on the secondary market similar to those being carried out on stock exchanges. Rural smallholders may therefore be able to sustainably mitigate climate change by engaging in afforestation (reforestation) which has bioenergy potential. One plant that may be used for this purpose by rural smallholders is the *Jatropha curcas(Jatropha)***,** which, due to its robustness, minimal maintenance requirements and ability to prevail in semi-arid and arid areas, makes it unique for this purpose (Brittaine and Lutaladio, 2010). This tropical, low-growing, oilseed tree can be mono or inter-cropped which makes it one of the formidable candidates when considering climate change mitigation. An estimated 120,000 hectares of Jatropha is currently being cultivated in Africa, while Asia and Latin America have 760,000 and 20,000 hectares respectively, bringing global Jatropha cultivated area to 900,000 hectares,which by 2015 is projected to increase to 12.8 million hectares (Brittaine and Lutaladio, 2010).

The Jatropha seed has been in use in sub-Saharan Africa for half a century, predominantly in the making of soap and its extracted oil for lamps. The tree is inedible to animals and humans alike due to its high level of toxicity, it also possesses an invasive nature which is the reason it is used for fencing purposes. One aspect that has received less attention is the carbon sequestration potential that Jatropha presents, considering that a tree has a life span of between 30 and 40 years, which equals carbon capture and storage. To illustrate what an environmental service may look like, a rural smallholder with three hectares of land may grow staple crops while simultaneously cultivating a total of one hectare with Jatropha, which depending on plant density varies between 1,100 and 2,500 trees. Cultivation on marginal land or wasteland results in the reclaiming of the land which is then economically viable, however under such harsh conditions optimal growth of the tree should not be expect. Planting and intercropping 1,600 Jatropha trees on one hectare of land will result in approximately 200 kg of biomass per tree in seven years, which is a total of 320,000 kg, of which dry matter content or wood makes up 25 per cent of the total weight given 80,000 kg or 80 tons (Benge, 2006). Half of the dry matter content or wood, in this case 40 tons is CO_2. The 40 tons of carbon sequestrated by the farmer in the seven year period, in essence is a climate change mitigation measure which should and is under certain climate-change agreements eligible for compensation in the form of carbon credits. The fact that little is being done to explore the carbon sequestration potential in rural sub-Saharan Africa, which may be due to a range of reasons ranging from information asymmetry, lack of commitment to high initial investment cost, means that the use of the Jatropha tree for this purpose is limited.

The yield of the Jatropha tree oil varies between 400 and 2,200 litres per hectare (Sielhorst et al, 2008). The immediate benefit of jatropha cultivation to the farmer is the extra revenue generated from medicated soap made from its seed oil using simple local production techniques. The amount of soap derived from 12 kg of Jatropha seed (equivalent to 3 litres of Jatropha oil) taking an estimated five hours of work time, is 28 pieces of soap each weighing 170 g (Benge, 2006). The total value of the input for soap production is valued at US$3.04, while the revenue from soap and seed cake residue sales is US$4.20, the farmer thus earns a net profit of US$1.36 or US$0.28 per hour (Benge, 2006). Seed cake residue, which is a by-product of soap production, serves as an organic fertilizer. The use of this type of fertilizer on farmland may also be eligible for carbon credits because it does not contribute to the release of N_2O.

Jatropha biodiesel production costs range from 26 US$ GJ^{-1} in semi-arid Zambia, Tanzania, Kenya and Burkina Faso to 889 US$ GJ^{-1} in arid South Africa (Wicke et al., 2011). The production of biodiesel in sub-Saharan Africa is assumed to have its complications as it requires the use of methanol which is not locally produced. To this end, the few firms, mostly in the southern part of the continent, producing the biodiesel have stopped production due to high seed and production prices. Sustainable agriculture as described above may therefore lead to a steady income if used in the conventional sense (soap production) but also present a new type of financial asset (income) when taking climate change mitigation mechanism into consideration.

EVALUATING THE FINANCIAL BENEFITS OF CARBON

Opportunities and benefits of climate change mitigation such as the CDM or voluntary carbon trading abound for rural development if properly implemented (Jurgens, Schlamadinger & Gomez, 2006). There have also been several discussions and studies on how to create a broker between the demand and the supply of carbon certification within the CDMs and the voluntary carbon market. It is argued that promoting a carbon sink (even on degraded African drylands) either through the Kyoto protocol or other international agreements provides a promising avenue to address the north-south equity disparity issues combined with necessary support for the rural poor (Tschakert, 2004). Conservation or sustainable practices are beneficial to smallholders while the degree of benefit varies depending on the practice and household endowment (Tschakert, 2004). Carbon trading presents a win-win situation for both carbon buyers and sellers, especially for sustainable smallholders in developing countries (The World Bank, 2011). The trading partners however, have to be linked by an investment vehicle with adequate financial capital, which is able to dedicate substantial capital to the project (Perez, Roncoli, Neely, & Steiner, 2007). The investment vehicle aims to establish a contract with a pool of sustainable smallholders which gives them the right to their ecosystem services which is then sold to potential buyers. Payments to farmers may be on a per hectare basis or per ton of carbon sequestrated which may also increase the value of poorly fertile or common agricultural land.

The complexity of the carbon market in practice is its integration on a multiple level, ranging from farmers technical ability to store carbon in the production system, monitoring of carbon stock, to technical financial and allocation capabilities of the investment vehicle (Perez et al., 2007). There is therefore a strong need for a suitable institutional arrangement which will facilitate processes of aggregation, monitoring and verification. A negative observable trend of the climate change mitigation tools is that international organizations are encouraging a shift towards a demand-driven system based on private service providers which may benefit the powerful stakeholders and discriminate against the landless poor, women and minorities (Perez et al., 2007). There is therefore need for a detailed financial assessment (cost and return) of carbon sequestration on

African dry-land as earlier studies have underestimated costs (Tschakert, 2004). Thus, applied research and practical experience are needed to better understand the uncertainties entailed in carbon sequestration and trading, and to devise an approach that minimize risk and cost, creates efficiencies, and promotes participation (Perez et al., 2007).

The magnitude of the productivity effect of conservation or sustainable investment plays a critical role in determining its profitability, and interacts strongly with factors such as financial position, commitment etc. (Antle and Diagana, 2003). Sustainable smallholders entering into a carbon contract with either financial institutions acting as local partners or brokers, may be viewed as providing environmental service resulting in carbon credits thus should be seen as agricultural collateral. Payment to farmers per unit of environmental benefit or carbon produced was identified to be more efficient than a per hectare mode of payment. Accumulating and storing carbon may also yield higher returns whereby these returns may come with a lag or delay. If this is the case, farmers may require a positive financial incentive, such as a loan, to be encouraged to bear the fixed and variable costs of adopting and maintaining conservation practices (Antle and Diagana, 2003). In a country with well-defined financial institutions, farmers could plausibly participate in a domestic or international market for tradable emission credits thus carbon market could function as a form of financing of this sustainable investment, by paying in advance all or part of the capitalized value of the carbon expected to be sequestrated (Antle and Diagana, 2003).

Detailed case studies are needed to assess the economic feasibility of soil carbon sequestration under conditions representing different regions of the world. Assessing the feasibility and cost of an institutional mechanism is essential in coordinating the creation of carbon sequestration contracts. Financial institutions may come up with innovative carbon credit program or loan or which could help rural farmers overcome barriers caused by imperfect capital market. Going back to the previous example of the smallholder with the Jatropha plantation, it was established that 40 tons of CO_2 can be sequestrated in seven years by the 1,600 Jatropha trees intercropped on three hectares of land. Taking into consideration that carbon prices differ depending on market participation, 2007 carbon data show that on average, the CDM offered US$11 per ton of carbon dioxide equivalent (CO_2e), for the European Union´s Emission Trading System (ETS) it was US$20.5 per Ton CO_2e, while on the voluntary carbon market it was US$12.5 per Ton CO_2e (Green Markets International, 2007). Carbon capture and storage in the seven years of this example may lead to a payment of US$440 (CDM), US$820 (ETS) or US$500 (voluntary carbon market). The average life span of the Jatropha tree on average is 40 years. Therefore the total carbon payment payable to the farmer would amount to approximately US$2,514 (CDM), US$4,685 (ETS) or US$2,857 (voluntary carbon market). The fact that no observable negative Land Use, Land Use Change and Forestry (LULUCF) and that organic fertilizer (Jatropha seed cake) is applied by the farmer means that payments may be higher due to the non-emissive and mitigating nature of this practice.

Sub-Saharan financial institutions wanting to innovate and internationalize their portfolios should carefully examine likely cost to be incurred and revenue earned when going into new ventures such as certified emission reduction (CER) projects, alternatively they may include the value of carbon certificates in their credit modeling. In the case of the former, an estimated cost of carbon market participation of a micro-scale project (less than 5000 ton CO_2/yr) is at least US$65,000 for the CDM and US$25,000 for the voluntary carbon market. The variation in cost is largely due to the cost of periodic project monitoring and periodic verification as other components such as project design, document preparation, registration fees, validation, transaction negotiation and contracting, and initial verification are fixed (Green markets international, 2007). The revenue that the investors may generate varies depending on the number of participating sustainable smallholders. If 500 sustainable smallholders sign up for the project under the CDM then potential revenue will amount to ca. US$1.25 million over the life-span of the jatropha plantation. The annual carbon sequestration payment for each smallholder taking a potential investor´s profit margin of 10 per cent and the initial cost for market participation for each smallholder is about US$ 53.31(market prices and other factor may vary). The return on investment (ROI) for the venture is positive, estimated at 5.28. An annual payment of US$ 53.31 would have an impact on smallholder income revenue and may go a long way to improve agricultural productivity via innovation adoption such as the purchase of improved seeds. *Table 2* shows that the average per capita income of smallholders with access to minimal land, in five sub-Saharan African countries, is less than US$100 in four of the five countries (Jayne, Yamano, Weber Tschirley, Benfica, Chapoto & Zulu, 2003). Kenyan smallholders command a higher income because their economy is comparatively better developed and diversified, which enables these smallholders to engage in off-farm activities via the labor market, thus earning a better livelihood (Jayne et al, 2003).

Table 2: *Household attributes by per capita land access quartile in five Sub-Saharan countries*

Country	Dimension		Quartiles of per capita land access			
		Aver.	1	2	3	4
Kenya	Land access (ha)	2.65	0.58	1.26	2.11	6.69
	Per capita income (1996 US$)	336.7	209.9	275.3	312.4	550.3
Ethiopia	Land access (ha)	1.17	0.20	0.67	1.15	2.58
	Per capita income (1996 US$)	71.6	53.1	52.1	88.3	91.0
Rwanda *	Land access (ha)	0.94	0.32	0.63	1.00	1.82
	Per capita income (1991 US$)	78.7	54.5	59.4	79.3	121.7
Mozambique **	Land access (ha)	1.80	0.55	1.17	1.92	3.46
	Per capita income (1996 US$)	43.1	26.2	34.1	42.7	69.2
Zambia	Land access (ha)	2.81	0.79	1.61	2.68	6.16
	Per capita income (2000 US$)	62.9	48.2	53.3	65.9	84.2

Source: Jayne et al., 2003

Note: All numbers are weighted except for Kenya where weights are not available. Exchange rates:

Kenya 58Ksh-1997 US$; Ethiopia 6.2birr-1996US$; Rwanda 125.1FRW-1991 US$; Mozambique 11,294

Meticais-1996 US$; and Zambia 2811Kw-2000 US$.

* Income figures include gross income derived from crop production on rented land.

** North-Central Mozambique only where income data is available.

An annual carbon payment of US$ 53.31 to smallholders in Ethiopia results in an increase in income of 74.1 per cent. For Rwanda, Mozambique and Zambia the percentage increase in smallholder income due to carbon payment will be 67.5, 123, and 84 per cent respectively. The payments for environmental services should take the form of a carbon loan where the initial investment as well as the periodic cost of monitoring bone by the financial institution would be incorporated into an affordable interest payment scheme. In the case of lending constraints and credit modeling, where initially they were without sustainable practices, the farm asset had no valued due to lack of collateral or stable cash flow. However with the inclusion of environmental services or carbon certification there may be a new base for the PD and VaR calculations.

The volatility of the carbon price depends on demand and supply. Price volatility may increase in times of economic downturn. However volatility could be reduced by entering into a long term contract with fixed payment within the CDM or voluntary market. There are other risk factors which needs to be considered such as bush fires, flooding and plant diseases which might require alternative solutions like agricultural insurance schemes, this may further reduce payment fee to sustainable farmers.

CONCULSION

The problems confronting sub-Saharan sustainable agriculture and ultimately a move towards a bio-based economy are complex and far reaching. The continent has not had its fair share of the green revolution which swept across Asia and Latin America in last three decades impacting agriculture productivity. Anticipated increase in population by 2050 compounded by the effects of climate change may put sub-Saharan African at a disadvantage. As the demand for fossil fuel as well as food surge in the presence of limited supply, raising concern of high prices and sustainability means sub-Saharan Africa would most probably be highly vulnerable to these dynamics. In order to ensure sustainable food and energy security, agricultural development is of key importance. A consequence of this is the emergence of the food versus fuel debate.

A possible solution to correct such an imbalance may arise from the cultivation of perennial, non-edible agricultural plants which can be propagated on arable, arid or semi-arid land, which possess a bio-energy potential and can be intercropped with staple food crops. An example of such plant is Jatropha, a tree planted on farmlands in and around a number of rural communities in sub-Saharan Africa. The eligibility for carbon credits due to sustainable agriculture through a mechanism such as Kyoto protocol or voluntary carbon market means that these farmers are potential recipients of long-term income from the provision of environmental services. This type of sustainable farming practice carried out in rural communities should be identified by both financial and non-financial institutions and given preferential treatment.

The active participation of financial and non-financial institutions on the carbon market may provide a base for the internationalization of rural smallholders. Other opportunities that climate mitigation instruments presents may be used to reverse not only the trend of credit constraints but boost productivity.

The regulations and law guiding international climate agreements such as the Kyoto protocol´s CDM and voluntary carbon markets should be well formulated and made less complex in order to be beneficial to rural sustainable smallholders in developing countries, therefore significantly contributing to agricultural productivity, rural development ultimately food and energy security. There is also a need for policies to be enacted by local and national government agencies thereby promoting internally orchestrated country specific sustainable agricultural practices. A number of issues however need further investigation, such as the interrelationship between smallholders, financial and non-financial institutions, investments and carbon market and other possible risks involved in a model like this.

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