Evaluating the impacts of plantations and associated forestry operations in Africa - methods and indicators

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SUMMARY

This study explores how the impact of large scale plantations and associated supplier and industrial operations can be evaluated. Whilst there is renewed interest from investors, governments and enterprises in the potential of planted forestry operations in Africa, doubts have been expressed by communities, environmental and socially orientated NGOs about their impacts. This paper seeks to provide a framework which can be used to examine the impacts of modern plantations in Africa, given that the context can be very different from plantations in temperate regions. An impact logic (theory of change) is developed which sets out the range of activities, stakeholders and intended impacts, based on two cases of investments in sustainable forestry operations in Tanzania and Mozambique. This, a literature review and interviews with stakeholders guided the development of indicators to assess economic, social and environmental impacts. The extent that a quantitative and qualitative (mixed methods) impact evaluation is possible and the data required to enable such an evaluation are deliberated. An evaluation framework and supporting indicators are proposed and discussed.

Keywords: Plantations, East Africa, development, impact evaluation, sustainable forest management

INTRODUCTION

The area of planted forests has been steadily growing to 7% of total global forested area in 2010 (FAO 2010). Planted forests provide ways to meet local and international demand for timber (Russell and Franzel 2004), fuel (Hiemstra-van der Horst and Hovorka 2009), paper (Gerber 2011), and non-timber products (Chidumayo and Gumbo 2010, Nawir *et al.* 2007), to respond to deforestation, forest degradation and climate change (Minang *et al.* 2014), and alleviate poverty and development (Akinnifesi *et al.* 2008). Investments in responsible forestry, demonstrated by verifiable forest management, value chain certification and carbon standards, have also been increasing (Auld *et al.* 2008, Bass 2001). Agroforestry has been for many years (and still is) promoted, particularly for small farmers (Russell and Franzel 2004) and plantation forestry, once the domain of donor funded and government schemes (Paquette and Messier 2010), has regained popularity in Africa. Recent investments in plantations have been driven

largely by the private sector (Lyons and Westoby 2014, Schoneveld 2011). Whilst there is renewed interest from investors, governments and enterprises in the potential of planted forests in Africa, doubts have been expressed by communities, environmental and social NGOs and other commentators about recent impacts (Gerber 2011, German *et al.* 2014).

Planted forests provide products (timber, fibre, energy and food), and environmental services (carbon, land restoration and reclamation, hydrological regulation and biodiversity and genetic resource conservation). They can have multiple, positive and negative sustainability impacts (environmental, social and economic impacts), which are strongly dependent upon the context in which they are planted and how they are managed (Evans 2009). Many of the impacts predicted from plantations in tropical areas, such as ecological and rural livelihood benefits, have not materialised, and when they do, have been unevenly distributed locally, particularly to the disadvantage of poorer and customary land users (German *et al.* 2010). The motives of public and private sector investors in planted forests vary significantly, and include increasing private sector economic activity, stimulating economic growth, (sustainable) profit generation, climate change mitigation and environmental benefits (Bellassen and Luyssaert 2014, Evans 2009).

Sustainability measurement is both an acute and controversial topic. The World Bank's (Hamilton and Clemens 1999) measure of genuine savings and Arrow *et al.*'s (2004) approach to inclusive wealth and genuine investment serve as measures of sustainable economic development over time. To compute the genuine savings rate, resource depletion and environmental degradation are subtracted from traditional net savings, while investment in human capital is added (Hamilton, 2000). A society's inclusive wealth is determined by measuring the shadow value of the economy's stock of capital assets (including manufactured capital assets, natural capital assets, human capital etc.). Genuine investment is then a measure of changes in capital assets weighted at shadow prices. Accordingly, positive genuine investment can be used as an indicator of sustainable development, and of changes in well-being. Sustainability related investment projects, such as plantations, are characterized by (1) uncertain future rewards or losses; (2) partially or completely irreversible sunk costs, and (3) flexible timing, in that waiting for better future insight is generally possible (Dixit and Pindyck, 1994). These three features need to be considered in an impact evaluation to avoid biases (Pindyck, 2000). A starting point is to identify reversible and irreversible, internal and external benefits and costs, at different levels: household, community, regional, national and international.

The assumptions behind the outcomes and impacts which can be attributed to investments in activities (Ton *et al.* 2014) can be traced using an impact logic (Bamberger *et al.* 2011). Also known as a theory of change, an impact logic can help untangle the diverse and often complex webs of direct and indirect people-environment-economic impacts. Indicators can then be used to measure the impacts of plantation and associated industrial operations. Performance measurement can aid further investments in planted forests to be made more sustainable and reflects the increasing interest by companies and international lending institutions in sustainable tree and forest products such as timber, pulp and paper (Siry *et al.* 2005;Finance Alliance For Sustainable Trade 2014a). Only a few rigorous impact evaluations, comparing both certified operations with a 'control situation' and assessing differences over time, have been conducted in the tropics (c.f. Cerutti *et al.* 2014, Romero *et al.* 2013), These studies have not assessed the entire value chain from forest to consumer, nor tropical plantations. A common impact assessment measurement toolbox for large scale investments in sustainable forestry could improve the efficiency of investors' portfolio allocation, facilitate risk management, increase investments in sustainable forestry and mitigate undesired impacts (Finance Alliance for Sustainable Trade 2014a). However, methods, including theories of change and a suite of indicators adapted to tropical and

developing country plantations and operations are at an early stage of development (Finance Alliance for Sustainable Trade 2014a).

This study seeks to contribute to such knowledge and methods, by providing a framework which can be used to examine the impacts of major investments by the private sector, institutional investors and governments in modern, large scale plantations in Africa, based on cases in East Africa. Practices and context can be very different from plantations in temperate and developed regions (Evans 2009, FAO 2010). Inherent in this framework is a methodology for an impact evaluation of plantation forestry, outgrower agroforestry this has stimulated and associated industrial operations . The general framework developed will be tested and used in the coming years, first to create a baseline and then an impact evaluation.

METHODOLOGY

A search of scientific literature was made using electronic databases (Scopus and Google Scholar), and of including publicly available internet documentation concerning plantation companies in East Africa. Key words in the search included: plantation, planted trees, pine, eucalyptus, agroforestry, timber sector/industry/value chain, Africa, East Africa, Tanzania and Uganda. This resulted in 42 publications and websites detailing the impacts and outcomes of plantation forestry and associated activities, including those with a focus on East Africa, which were analysed. From these, potential and actual economic, social and environmental impacts were classified.

In October 2014, private and government owned, large and small-scale, certified and non-certified pine and eucalyptus plantations were visited in Tanzania. These were judged as typical of both mature and new plantations and operations in East Africa. Guided by semi-structured questionnaires focusing on social, economic and environmental impacts of plantations and associated supplier and industrial activities, (group) interviews were conducted with 12 plantation managers and permanent staff and 39 temporary workers; one state owned and 21 private sector pole suppliers to the industrial operations (small-holder agroforests and small scale plantations known as woodlots); and four private sector and government clients for wood products. Two focus group meetings were held in communities near plantations with 36 people (23 men and 13 women) consisting of villagers, village leaders, teachers, health workers, tree grower association members and religious leaders, and a meeting was held with district authorities. A meeting was held with four banks investing in plantations between April 2014 and January 2015 as part of workshop led by Finance Alliance for Sustainable Trade (FAST) to develop indicators to guide investments in sustainable forestry in May 2014. From the literature and the findings from these meetings, an impact logic was developed and subsequently verified with one investor and a private forest company.

This case study was conducted as the first phase of an impact evaluation of public and private sector investments in a company with plantations and industrial operations in Africa and as part of the ongoing work of the FAST working group.

FINDINGS FROM LITERATURE AND INTERVIEWS

The literature review revealed a range of positive and negative, direct and indirect environmental, social and economic impacts from plantation and associated industrial operations. Many impacts depend strongly on how plantations are created and managed – for example whether forest and carbon certification are used – and the level and type of chain integration, associated investments and activities.

The environmental impacts attributed to planted forests (plantations and agroforestry) include their playing a significant role in reducing global net carbon emissions through carbon

sequestration (Babcock and Pautsch 1999, Lal *et al*. 1998, Purdon and Lokina 2014, Sedjo 1989, van Kooten *et al*. 2009, van Wilgen and Richardson 2012). Sedjo (1989) argues that conversion of agricultural lands to tree planting can lead to reduction of 2900 million metric tons of carbon annually. Likewise, afforestation improves the hydraulic properties of soil and thus reduction in surface runoff (Farley *et al*. 2005, Paudel *et al*. 2011, Pott 1997, van Wilgen and Richardson 2012). Farley *et al.* (2005) found that annual runoff was reduced on average by 44% and 31% when grasslands and shrub lands were afforested, respectively, with eucalyptus reducing runoff by 75% compared with a 40% decrease by pines in afforested grasslands. Plantations and agroforestry can reduce the pressure on natural forests for firewood (Bugayong 2003, Mithöfer 2003, Njenga *et al.* 2001), enhance biodiversity in landscapes that might otherwise contain only monocultures of agricultural crops (Guo 2000, Njenga *et al.* 2001, Noble and Dirzo 1997), and by their very nature, combat deforestation (FinnFund 2013, Rahim *et al.* 2007). Pannell (2009) contends agroforestry lowers water tables and reduces off-site impacts of waterlogging, dryland salinity and mitigates flooding, while Cole (2010) asserts it utilizes marginal areas with low opportunity costs. Negative externalities include planted forests leading to ecosystem services and biodiversity loss (Pott 1997, van Wilgen and Richardson 2012), and plantation species may become invasive species (van Wilgen and Richardson 2012). The increased fuel loads and biomass associated with plantations can lead to higher intensity fires and other detrimental effects (van Wilgen and Richardson 2012), including encroaching on fragile ecosystems. Chemical use may cause run off into surface and ground water, creating adverse ecological impacts (Lyons *et al.* 2014). Responsible forest management, guided by internationally developed sustainable forest governance and management guidelines , reflect common principles of accountability, effectiveness, efficiency, fairness/equity, participation of all interested people in decisions, transparency and availability of information how the forest is governed, and sustainable forest management (Capistrano 2010, European Commission 2010, FAO 2011, Finance Alliance for Sustainable Trade 2014b, Lawson and MacFaul 2010). Compliance with national regulations and independently verified certification schemes – such as Forest Stewardship Council (FSC), Programme for Endorsement of Forest Certification Schemes (PEFC), Verified Carbon Standard (VCS), Climate, Community and Biodiversity (CCB) standards – and international quality and environmental management standards can be seen as a demonstrable measures of responsible forest management.

In terms of social impacts, plantation forests and agroforestry create and diversify employment, including in East Africa (FinnFund 2013, Green Resources 2014, Makindara 2013, New Forests 2015, van Wilgen and Richardson 2012, World Bank 1982).Plantions have been shown to provide skilled workers with stable jobs and improved salaries (Finance Alliance for Sustainable Trade 2014a, Green Resources 2014, Makindara 2013), and fewer disparities in worker's wages (Bondevik 2013, Finance Alliance for Sustainable Trade 2014b). Certification, responsible forestry and management can enable workers to improve health and safety of working conditions, and access to social security, insurance and health care (Finance Alliance for Sustainable Trade 2014a, Kiparu *et al.* 2010) and for communities to access infrastructure such as schools, community halls, water wells, roads, and bridges established by companies in their communities (Green Resources 2014, World Bank 1982). It has created new products and markets for poles, logs, mouldings, charcoal, carbon credits, and increased the availability of wood fuel (Vihervaara *et al.* 2012, Green Resources 2014). This has contributed considerably to countries' gross domestic product (van Wilgen and Richardson 2012). Negative externalities to society include that large landowners, urban elites and middle classes, and capital-intensive industries tend to benefit most from plantations at the expense of indigenous groups living in and near forests (Bennett 2010). Plantations often result in losses of customary tenure and access rights to resources, rural displacement, disrupt cultural burial grounds and

ancestral worship places (Charnley 2006, Kaboggoza 2011, Lyons *et al.* 2014, Lyons and Westoby 2014), which may create tension and conflicts. Thus, stakeholder dialogues and community engagement are paramount for conflict resolution (Finance Alliance for Sustainable Trade 2014b, IFC 2008).

Economic impacts of plantations and agroforestry use the concept of biological asset value (BAV), net present value of anticipated future net cash-flows from the sale of tree products. To determine BAV, information is required on the asset's growth rate (expressed as Mean Annual Increment), expected future log prices and costs, and on the discount rate. Net cash flows take account of expected costs such as replanting, silvicultural activities, maintenance and thinning. It is assumed that stands are harvested at the age that maximises returns to investors. The biological stock remains stable in the long run. Plantations and agroforestry can create securer supplies of timber from smaller land areas (resulting in lower environmental footprint) compared to natural forests (Kaboggoza 2011, Sedjo and Botkin 1997). The range of timber and non-timber products, including carbon, can diversify revenues (Purdon and Lokina 2014, Rancane *et al.* 2014, Rahim *et al.* 2007) and benefit both large and smallholders (Mithöfer and Waibel 2003, Njenga *et al.* 2001). Plantations have created more stable business environments and local infrastructure such as school, roads and bridges in the East African region (Green Resources 2014). As a result, it has led to higher living standards through less unemployment and/or higher wages in the respective communities. As a business, plantation and associated industrial activities have created high shareholders returns, stability of suppliers and buyers as well as a revenue base from taxes for governments (Finance Alliance for Sustainable Trade 2014a, Pannell 2009), contributing to poverty alleviation (Kaboggoza 2011). Fisher (2004) indicates that income from forests reduces income inequality by 12 % across households while Irawan *et al.* (2010), Sangapitux *et al*. (2010), and Beckmann and Wesseler (2007) point out the importance of labour organisation for the distribution of income and the impact on income inequality, a key factor in labour intensive plantations. The distribution of benefits and costs differ over time and can be strongly influenced by government policies (Tassone *et al.* 2004) affecting cost and benefit distribution between stakeholders, including timber, non-timber products and environmental services (Wunder, 2008).

Interviews confirmed all of the above potential impacts and helped to nuance the indicators proposed to measure economic and social impacts for workers, suppliers and customers. The potential for spill over and multiplier effects arising from plantations and industrial operations, and investments in adjacent communities and stakeholders along the value chain was indicated. A wide range of stakeholders were indicated as being engaged in the value chain from plantation to consumer: Seedling nurseries and civil society organisations supporting tree planting, community organisations – mainly where workers reside and in villages adjacent to plantations and industrial operations, and local governments. Also – particularly until plantations mature – stakeholders include smallholder owners of wood lots and agroforests, and larger, state owned forest which supply timber to industrial processing operations. These stakeholders may continue to be suppliers or become competitors when plantations become mature and are harvested. Clients include both direct household consumers (sawn timber, plywood, charcoal and furniture), small and large scale businesses (sawn timber, pallets and plywood) and governments (electricity poles). Cumulative impacts of several operations in one geographic landscape were seen as likely. The importance of measuring both perceptions of environmental and socio-economic impacts, as well as quantitative data, was reinforced by interviewees, as these are often incongruent. Impacts and stakeholders were anticipated at local (plantation and industrial operations), regional, national and international scales. Trade-offs between some impacts were seen as probable, such as employment and economic efficiency, BAV and environmental outcomes.

IMPACT LOGIC AND INDICATORS

The literature and interviews combined provided the foundation for the impact logic (also known as a theory of change) shown in Figure 1. The steps of the causal chain (interventions/activities, outputs, outcomes and ultimate impact and those impacted) are included. Explicit assumptions include a semi-integrated value chain that includes plantation and industrial operations, as well as external suppliers of inputs and raw materials, and sustainable forest operations. The figure highlights the high degree of interconnectedness and complexity related to outcomes, derived from the aims of investors and owners of large plantations in East Africa.

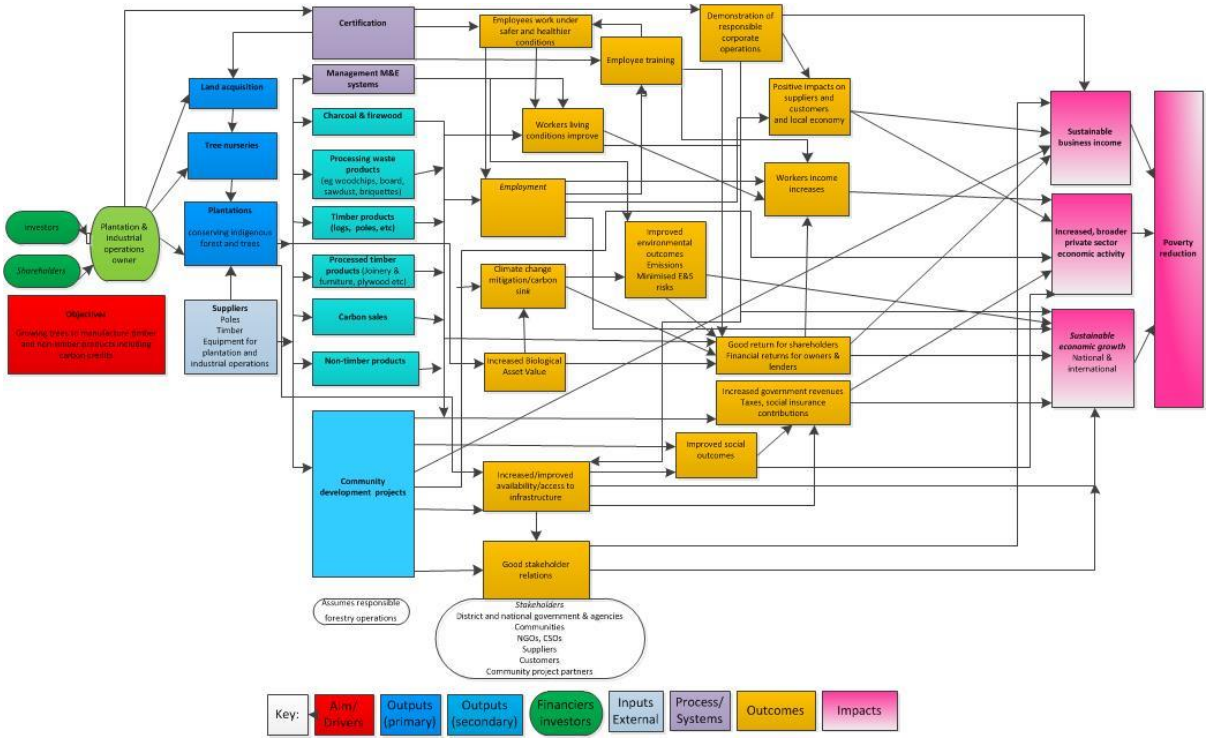

FIGURE 1 *Impact logic for sustainable plantation and associated industrial operations*

As attributing high level, ultimate impacts is notoriously difficult (Ton *et al.* 2014), pragmatic, measurable outcome level indicators were derived from the literature review and interviews, shown in Table 1. These indicators can be used to measure both direct and indirect and cumulative impacts.

TABLE 1 *Outcome indicators and data sources to assess sustainable plantation and associated industrial operations*

Outcomes	Data Sources	Indicators
1. Financial returns for shareholders, owners and lenders from plantation and industrial operations	Operation owners/managers Certification schemes	1.1 Biological asset value (BAV) divided by number of shares 1.2 Net profit 1.3 Return on equity 1.4 Recovery efficiency (i.e. efficiency of conversion in processing, % waste of BAV and saw mill recovery rates) 1.5 Cost per m^3 of product 1.6 Security of supply (own vs. outgrowers) 1.7 Stock to sales ratios 1.8 # of ha of trees planted (surviving after 12 months) – compared to planned area

Outcomes	Data Sources	Indicators
		1.9 Value of sales
2. Worker's income increases	Worker surveys Operation owners/managers	2.1 Income and total value of benefits reported by workers 2.2 Worker income and total benefits reported by plantation operation 2.3 Number of grievances and conflicts and subject 2.4 perception of communication in organisation
3. Worker's living conditions improve	Worker surveys Operation owners/managers	3.1 Perception of changes in living and working conditions 3.2 Availability of facilities (electricity, water, sanitation, dispensary, schools) 3.3 Characteristics of house (brick walls, tin roof) 3.4 Possession of household assets 3.5 Number of community members having own plantation, size & # trees, and their motivation to engage in plantations 3.6 Type and value of community projects 3.7 Food security: access to land, # of crops grown, extent meets family needs
4. Positive impacts suppliers	Suppliers Operation owners/managers	4.1 Security of supplies - meeting needs e.g. lead time contracting to delivery, payment terms & times, clear technical specifications 4.2 Value of business and turnover 4.3 Number of employees 4.4 Number of major inputs and timber suppliers, type (small/large scale) and status (certified/non-certified) in a year per product and location (local, national & international)
5. Employment	Operation owners/managers Community household surveys	5.1 Number of plantation operation employees (and type (skilled/unskilled, permanent/seasonal, # of repeat contracts, location of employees, sex) 5.2 Training given to employees, and perceptions of change in skills and knowledge 5.3 Number of people in village with(out) job
6. Positive impacts on customers	Customer interviews	6.1 Perception of impact of plantation operation 6.2 perception of price/quality of plantation operation products and level of client satisfaction 6.3 % of time meet delivery time agreed upon 6.4 Perception of business relationship 6.5 Number of competitors in market for similar products 6.6 % of product rejected due to quality 6.7 Availability of alternative products to meet same need (e.g. concrete poles) 6.8 Turnover 6.9 Profit 6.10 Number of employees and location (national/international) 6.11 Products as # of total purchased 6.12 Brand/product awareness of plantation operation products
7. Positive impacts on local economic development	Community household surveys Operation owners/managers	7.1 Perception of impact of plantation operations 7.2 Number of customers locally/nationally 7.3 Number of major input and timber suppliers locally/nationally 7.5 Number of people in village with(out) job 7.6 Social indicators: literacy rates, schooling facilities, attendance rate 7.7 Spill-over effects on local households
8. Increased government revenues	Government Operation owners/managers Household surveys	8.1 Change in value of taxes paid to district government and central government 8.2 Change in value/volume of timber purchased from other suppliers (government and private sector) 8.3 # of employees 8.4 Value of salaries paid to employees and their place of permanent residence 8.5 Value of services supplied per country and location of service provider 8.6 Value of products sold per country and location of buyer 8.7 Turnover as proportion of district and national GDP 8.8 Level of income 8.9 Level of consumption

Outcomes	Data Sources	Indicators
9. Improved availability and access to infrastructure	Plantation owners/managers Household surveys Community development plans Local government development plans	9.1 Number of trees & BAV planted by community/outgrowers 9.2 Value of trees sold by outgrowers 9.3 Number/ length of infrastructure provided locally (nationally i.e. roads, bridges, schools, health centres etc.) 9.4 Infrastructure which meets local development priorities# 9.5 Cumulative and multiplier impact (other plantations in region) on local economic growth
10. Improved environmental outcomes	Ecological monitoring Community interviews	10.1 Change in soil quality 10.2 Change in ground water quality and quantity 10.3 Change in surface water quality and quantity 10.4 Invasive species into landscape 10.5 Change in biodiversity 10.6 Damage caused by landslides/erosion events to community and plantation lands 10.7 Number and location of landslides/erosion events in a year
11. Climate change mitigation/carbon sink	Carbon monitoring	11.1 Changes in annual volume carbon sequestrated by forestry operations 11.2 Changes in annual volume of carbon released from forestry and industrial operations 11.3 Number and value of carbon sales
12. Good stakeholder relations	Stakeholder interviews Operation owners/managers Community household surveys	12.1 Stakeholder's satisfaction with community projects 12.2 Number of perceived conflicts and their subject with plantation operations by community 12.3 Number of perceived conflicts and their subject with plantation operations by other stakeholders e.g. int. NGOs 12.4 Perception of community members of participating in decision making related to Plantation investments 12.5 Number of fires/ value or ha/m12/value BAV destroyed by fire in a year 12.6 Perception effectiveness of firefighting 12.7 Implementation of stakeholder engagement strategies 12.8 Number of fires/ value or volume (ha) own trees destroyed by fire in a year 12.9 Perception of effectiveness of firefighting 12.10 Number of complaints / grievances
13. Increased biological asset value	Operation owners/managers	13.1 Change in biological asset value
14. Improved social outcomes	Interviews community, councils, school teachers	14.1 General perception of operations by different community stakeholders 14.2 Number of people migrating to communities near operations in search of work 14.3 Change in # of people in communities, perception of attribution to operation and other employers , reasons people stay/leave village 14.4 Perception of change in access (roads and transport) to village and role of plantation 14.5 Perception of ability of community and councils to provide services to inhabitants (basic services, water, schools etc.) and level of access to services 14.6 Change in availability of arable land per community/per person in communities adjacent to plantation operations # 14.7 Food security: access to land, # of crops grown, extent meets family needs 14.8 Perception of availability of water and its quality and attribution of causes for any changes 14.9 Ha of land registered by community with support of plantation operation 14.10 Number of disagreements over land due to purchase by plantation operation, number of people affected in total and number of communities affected 14.11 Number of people receiving compensation for land purchased for plantation or industrial operations
15. Employees work under safer and healthier conditions	Worker surveys Households surveys Operation owners/managers	15.1 Number and type of company certifications (and % of stocks under certified forest/carbon/biodiversity/safety management) 15.2 Worker perceptions on working conditions 15.3 Community perceptions on working conditions
16. Employee skills	Worker surveys Household surveys Operation owners/managers	16.1 Number/intensity of training provided per worker 16.2 Number of formal certificates awarded to workers 16.3 Existence of a formal training plan, supporting budget and staff
17. Demonstration of responsible corporate operations	Operation owners/managers Interviews local government	17.1 Number and type of company certifications 17.2 Community perceptions on responsible operations 17.3 Local government perceptions on responsible forestry and industrial operations

The impact logic presented is generic and requires adaption to specific context of each investment, a well-recognised practice in impact evaluation (Blamey and Mackenzie 2007). Outcomes and impacts are expected to differ depending upon the type of investor(s) and owners . Trade-offs are likely between revenues, employment, and environmental outcomes. Another factor expected to make a major difference in the level of outcomes is how forest operations are run. In this impact logic, it is assumed that operations adhere to responsible forestry practices. Certification is assumed as representing the best available forest management practices and hence will lead to more positive impacts, based on recently published evidence of social and environmental benefits (Cerutti *et al.* 2014, RESOLVE Inc. 2012, Romero *et al.* 2013). In contrast, an impact logic based on conventional silvicultural practices is anticipated to have not only different objectives but also outcomes for different groups of stakeholders, illustrated by cost benefit analyses of different forest management approaches (Arets and Veeneklaas 2014).

PROPOSED APPROACH TO THE IMPACT EVALUATION AND DATA COLLECTION

As noted, assessing the impacts of the industrial and plantation activities of large and small scale forestry firms requires an evaluation of social, environmental and economic aspects. In turn, each of these impact types and related indicators may require a different evaluation method.

The following ordinal scale is proposed to indicate the quantitative rigour of potential methods of data analysis (with 1 indicating the most rigorous quantitative assessment method and 4 indicating more qualitative assessment), where feasibility of each method depends on data availability:

1. Statistical analysis of pre- and post- investment (i.e. before and after the start of forestry and industrial activities) data including data for perception-based indicators. Possible research designs are (a) Regression discontinuity (if there is a clear threshold that defines eligibility of plots, trees, communities, etc., such that those who are just not eligible can be used as controls for those who are just eligible; see e.g. Imbens and Lemieux 2008); (b) Difference in Difference analysis (a reference and beneficiary group with similar baselines are identified; the impact is determined by subtracting the changes in outcomes for beneficiaries from the changes in outcomes in the reference group; Rosenbaum and Rubin 1983); (c) Difference in Difference analysis with Propensity Score Matching (matching beneficiaries with comparable non-beneficiaries). This could also be used for environmental monitoring data.
2. Statistical analysis of post-investment data only, using a reference group. This could be done using, for example, propensity score matching or a sample selection model such as Heckman's (1976) two-step estimation procedure.
3. Conduct before-after comparison of environmental, social and economic indicators using statistical analysis (e.g. frequency, mean, standard deviation). If a control or reference group cannot be used, it might still be possible to compare the situation of beneficiary or potentially impacted stakeholders (i.e. adjacent communities) and environmental indicators before and after the investment (i.e. the start of tree planting and of industrial operations).

4. A quantitative analysis of attribution is not possible, but a qualitative analysis can provide insights about impacts that can be attributed to the forestry and industrial activities, based on the impact logic and using a counterfactual.

Quantitative methods can be complemented by qualitative methods to triangulate some of the results of the quantitative analysis and obtain a better in-depth understanding, particularly on more sensitive topics (such as incomes and working conditions), contextual factors and unintended effects.

In addition to the methods described above, economic simulation models can be used to assess the BAV (Tassone *et al.* 2004). For large-scale forestry and industrial activities, the effects of timber supply from the plantations on timber product markets can also be assessed using a partial equilibrium model for the regional timber market. The results of the model can be fed back into the BAV model for assessing effects on asset value and implication for forest management. Uncertainty about future market developments can be considered by developing scenarios in consultation with key market participants in combination with Monte-Carlo simulation of important model parameters.

To evaluate the impacts of forest activities, data needs to be obtained from a range of sources. This includes individual, corporate and publically available primary and secondary data. Company data is likely to be commercially sensitive, which means that collaboration with the concerned plantations and industrial enterprises is critical. Statistical analysis of pre- and post-investment data requires multiple rounds of data collection. Household (survey) data from villages adjacent to plantations, community plantations and outgrowers and in control areas (if a difference-in-difference evaluation or sample selection model is used) implies collaboration and engagement of stakeholders in both the conduct and sharing results (Shanley and López 2009). Choices are inevitable in obtaining sufficiently detailed and accurate data to enable robust impact evaluation, against the costs of data collection and analysis. Environmental data particularly needs to be site specific, to be of value and therefore is likely be to both more costly and difficult to obtain, than some data on community and socio-economic indicators which may be publically available.

The timescales for measuring outcomes are likely to vary between the three main sets of indicators. Environmental outcomes may have longer time scales, ranging from four to over twenty years, depending upon tree growth and cutting cycles. Social impacts may be seasonal, associated with silvicultural activities such as planting, and may vary significantly between the early stages of establishing plantations and when trees in plantations are mature, and dependent upon product development and marketing. After establishing a baseline, a period of three to four years is estimated as required to detect changes in many of the indicators, determining the period when an impact evaluation could be conducted.

CONCLUSIONS AND OUTLOOK

Pragmatic indicators and evaluation methods to measure the economic, social and environmental outcomes of investments in (sustainable) plantation forests are proposed. These aim to meet the needs of public and private sector investors in small and large scale planted forests in Africa that provide both timber and non-timber products as well as ecosystem services and products. The primary users of the impact evaluation are expected to be financial institutions and other entities investing in plantation forestry (such as governments and donors) as well as forest user and owner associations, and certification bodies. Small scale outgrowers may also benefit. By collecting and assessing impact data, enterprises should be able to illustrate not only positive impacts and their business investment cases, increasing their access

to finance, but also where support and collaboration is required, for example concerning negative and landscape level impacts. Given the long timescales involved in developing plantation forests and associated industrial operations, sharing the indicators, evaluation methodology and insights, can positively refine the development of much needed impact evaluations of investments in sustainable forestry in both East African and other areas of the world. Stakeholders with an interest in impacts and indicator frameworks include plantation and timber processing companies, investors, the FAST working group (which include investors, banks, and organisations such as the IFC and FAO), and organisations interested in the impact of certification and sustainable forestry, such as the ISEAL Alliance and the Global Impact Investing Network.

It is recommended that these indicators are tested, using the quantitative and qualitative data collection and methods of analysis described. The indicators proposed and their meaningfulness for the full range of stakeholders involved in plantations needs to be explored, for example in pilot tests in a range of ecosystems - including both dry and humid forests - and social contexts across Africa. It will be important to track the costs, advantages and disadvantages, feasibility, effectiveness and efficiency of gathering data on the indicators. Data collection protocols can aid this process.

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