Tanzanian timber markets provide early warnings of logging down the timber chain

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Abstract

The forests of the Eastern Arc Mountains in Tanzania contribute in many ways to the welfare of local, regional and global communities, but they are under threat by on-going deforestation and degradation linked to agricultural expansion and forest and non-timber forest product extraction. In this paper we undertake and assessment of the timber flows and values, which is highly complicated as timber extraction occurs within a largely illegal system. In the absence of easily available timber sector statistics, we use market surveys and household census data to estimate extraction volumes and economic values. The estimated economic value of hardwood from the Eastern Arc amounts to more than USD 10 million per year based on market prices of planks, and twice as much in terms of final hardwood products. Hardwood forms an important source of income for people living near forests and drives an industry that creates jobs in transportation, processing and manufacturing. However, the analysis of the value chain indicates that a large proportion of profits is enjoyed by people who are not directly dependent on other forest uses, which, in combination with the illegal nature of the sector, may increase the rate of logging beyond sustainable harvesting levels. Our market data gives some clear early warning signals of unsustainable hardwood harvesting. We argue that without considerable changes to harvesting within natural forests, and the development of additional plantation forests, the supply of hardwood into the future may become erratic. However, continued harvesting at current levels will have further negative consequences on the supply of other ecosystem services including energy and drinking water supply to a large proportion of the urban population.

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1. Introduction

Many Sub-Saharan African countries are experiencing robust economic growth (World Bank 2013). Increasing domestic demand, related to increasing urbanisation and population growth, has spurred economic development, part of which is fuelled by natural resources (ibid.). However, the need for green economic growth and sustainable development requires that the benefits of preserving natural resources, for the sake of carbon emissions reductions, are recognised in governance (UNEP 2011, Financial Times 2013).

Existing policy initiatives, both national and international, have so far not been able to combat illegal resource take. An estimated 15-30% of international wood trade and 50-90% of timber harvests in tropical countries may be illegal (Nellemann 2012). Illegal logging has been recognised as a policy issue of international importance, and was made a priority area of the British presidency of the G8 in 2005. The IMF-World Bank meeting in 2006 initiated the *G8 Illegal Logging Dialogue* in order to address corruption and promote good governance as well as poverty reduction.

In this paper, we look at the extraction of natural resources (timber) from a forest and woodland ecosystem with important biodiversity values located close to (upcoming) cities, and a well-developed policy framework to ensure sustainable forest management is in place. The Eastern Arc Mountains (EAM) in Tanzania are one of the most biodiversity rich forests in the world (Burgess et al. 2007), yet they are under severe pressure from conversion for agriculture and degradation due to extraction of firewood, poles, charcoal and timber (Ahrends et al. 2010, Hall et al. 2009). Population growth, development of infrastructure and competition over resources and agricultural land are among the main drivers of forest degradation and deforestation. As a result, forest cover in Tanzania is lost at an increasingly rapid rate (Hosonuma et al. 2012).The EAM have lost around 70% of their natural forests (Burgess et al. 2002), which implies that many species are now threatened (Burgess et al. 2007).

Tanzania has a long story of forest management. In colonial times, forests were considered as a resource and logging took place at industrial scales. Forest reserves were established for the purpose of production. This practice continued in the EAM through the colonial and post-colonial periods, with industrial logging in the East Usambaras in the 1970s and early 1980s (Hamilton and Bensted Smith 1989). In 1985, however, the Tanzanian government acknowledged the threat to remaining forests and biodiversity, and implemented a ban on logging in the central government (catchment) Forest Reserves of the EAM. The 2002 Forest Act is currently being updated to incorporate concepts of biodiversity, catchment forests and nature reserves, and recognises the potential of REDD and PES financing of conservation. In total, 75% of the forested area of 4,000 km^2 in the EAM have been gazetted, i.e. have some protected status (Platts et al. 2011, UNEP-WCMC 2009).

However, there is a clear lack of adequate policy enforcement. Only an estimated 13-26% of timber royalties are collected by the government (Indufor 2005, Milledge and Kaale 2005), although this percentage may be as low as 4% (Milledge and Elibariki 2005). Wherever illegal trade is more profitable than legal trade, and there is a lack of policy enforcement, illegal resource use and illegal markets are likely to arise (Brack and Hayman 2002). Many illegal activities in forestry sectors around the world take place in countries with high levels of corruption (FAO 2001), which either allows logging to occur illegally or results in no action against transport, trade and manufacturing of the (illegally) harvested logs. Indeed, timber harvesting is known to happen on a daily basis across

the EAM in protected and unprotected areas (Burgess et al. 2002, Makero and Malimbwi 2012). Since timber and charcoal demand from the capital of Dar es Salaam has largely depleted coastal forests (Ahrends et al. 2010, Milledge and Kaale 2005), pressure on inland forests has increased, including the EAM which still contain some highly valuable timber species.

Illegal logging generates higher private rents for extractors by avoiding the costs of licences and less-intensive harvesting. The opportunity to generate private rents may lead to higher extraction rates than is optimal for social welfare maximisation (Palmer 2001). Other forest stakeholders are not compensated for the negative impacts of illegal logging. The 'externalities' of timber harvesting include negative effects on ecosystem services of global importance such as biodiversity, carbon emissions and eco-tourism. Other externalities relate to direct forest uses such as harvesting of non-timber forest products, soil conservation and pollination, and cultural values, which are mainly of local or regional importance.

Enforced regulation of the timber industry will come at the cost of some and the benefit of others. The timber trade creates jobs and cash income which are vital to people in rural communities in Tanzania, many of whom live near the poverty line, and provides material resources to urban people. But the current rate of forest conversion casts doubt on the sustainability of resource take, in terms of welfare maximisation and distribution over stakeholders and time. The illegality of the sector is a major management problem, as there is little information to inform decision-making, to understand the severity of the problem, let alone the distributional effects of policy interventions.

The objective of this study is to assess the socio-economic value of timber harvesting from forests and woodlands in the EAM. Building on publicly available information and stakeholder interviews, we provide an estimate of the overall volume of timber consumption from the EAM and assess the sustainability of this resource flow and the distribution of benefits throughout the commodity chain. The study shows how markets provide indicators of the sustainability of hardwood extraction, both in terms of ecological sustainability (e.g. which species are harvested most intensively?) and socio-economic sustainability (e.g. how are timber revenues distributed across different stakeholders?).

2. Methods and data collection

In many countries, research on hardwood extraction from natural habitats is complicated by the illegality of the sector. A major methodological challenge lies in data collection (Gavin et al. 2009). The absence of reliable data and the complications of primary data collection mean that estimates of total volume are generally hard to generate. National statistics of the contribution of the forestry sector to GDP do not reflect the large illegal proportion of the timber trade. Reliable quantification of the volume of timber trade through interviews with dealers or entrepreneurs tends to be problematic (Shayo 2006), due to strategic bias. Respondents may criminalise themselves by providing information about illegal activities, and cooperation with projects to reduce illegal harvesting also reduces their income opportunities. Therefore, we used a combination of techniques that complement and triangulate one another, and for which we could use information that either was publicly available or would be possible to obtain through interviews in a relatively reliable manner. We conducted three lines of analysis to assess the volume and value of hardwood extraction and its sustainability in the woodlands and forests of the EAM.

First, we estimated the overall volume of hardwood extraction by modelling the demand for hardwood by Tanzanian households supplied by the EAM. Household data from national census (NBS 2011) was used to estimate the demand for hardwood per household, combined with informed assumptions of the effects of wealth and location on demand. Assumptions were validated by forestry experts in Tanzania.[1] The identification of timber markets supplied by the EAM was based on estimates of the timber transport distances we obtained during interviews. GIS information included a population map (Platts 2012), land cover and road maps (see Swetnam et al. 2011). This part of the assessment could rely on relatively reliable sources of data.

Second, to understand the timber commodity chain, we needed information about the typical what, how, where, who and why questions: what is the production process, which species are targeted and what volumes are extracted, where does extraction occur, who is involved in the various stages of the value chain from extraction to consumption, how are benefits distributed, why does illegal extraction persist, etc. Direct questioning techniques were employed to gather information from stakeholders directly involved in the timber commodity chain. Aware of the strategic bias that may influence the results from such interviews, we also performed direct observation activities and background research on law-enforcement records for triangulation purposes (Gavin et al., 2009).

Finally, for an assessment of the sustainability of timber extraction in the EAM, we collected a number of market indicators. There are different ways in which markets will react to increasing scarcity: prices will increase, substitute use will increase, product design may change and harvesting may shift to new areas. This type of market data is generally not very sensitive to reporting bias. Thereby, markets provide early warning signals of ecological sustainability of the timber trade.

An initial study was conducted in 2009, when over a period of two weeks data on plank prices and sizes was collected for hardwood and softwood at various locations in the central and southern part of the study area. In July and August 2011, we visited the main urban areas where timber is supplied by the EAM, and a number of towns that act as trading places that were selected based on expert information. We interviewed 50 carpenters, four pitsawyers, 20 timber dealers, a chainsaw technician and two sawmill owners, using in-depth semi-structured surveys. At furniture markets, we also carried out direct observations. A further 11 interviews were conducted with forest officers, and four interviews with sector experts.

Time-restrictions implied that most of the dealers and sawyers had to be contacted through district forest officers, but the officials were not present during the interviews. We also interviewed some dealers and sawyers without the help or intervention of officials, although this practice is complicated in Tanzania due to cultural and political rules that require that meetings are arranged in advance through local leaders. Convenience sampling was used to select carpenters, as these are in practice often clustered around the main roads of towns.

The main topics of the interviews included: species used, harvesting locations, transport routes, prices, timber volumes processed, timber requirements for furniture, forest management and enforcement, and changes in species availability and harvesting locations over time. Interviews

[1] We compared our estimates of demand volume with estimates of the overall extraction, based on expert informed estimates of the number of pitsawyers, and survey information on the annual extracted volume per pitsawyer, but we put more trust in the demand-based volume estimates.

would start with neutral, 'safe' questions, and more sensitive issues were dealt with only if the respondent showed willingness to participate. The district and regional forest officers were interviewed for cross-validation and to give an overview of the timber commodity chain at the larger scale and the policy context.

Timber values are species dependent. We used the timber classification by Ahrends (2011) adapted from several datasets and reports. This classification defines five main categories of timber based on a conservative assessment of their commercial importance. Class I to Va contain commercially traded species that are used for furniture and household items, with class I containing the highest quality species. Subclasses Vb and Vc are other species which are mainly used locally. Price information of species was classified according to this dataset.

3. Analysis of volumes and benefits across different actors in timber value chain

3.1 A short description of the timber trade in Tanzania

Based on interview information as well as studies by Shayo (2006) and Wells and Wall (2005), we were able to characterise the timber industry in Tanzania. Hardwood extraction in the natural forests and woodlands in Tanzania is an informal industry with low capital investments. Most of the timber is pitsawn (Wall and Wells 2005). Pitsawyers are usually local farmers who want to earn additional money in-between agricultural seasons. They work either individually or for timber dealers and operate deep in the forest where the chances of being caught are low. They spend a few weeks in the forest to select and fell trees. Then, they cut the logs into planks using handsaws. The planks are transported out of the forest to a collection point by carriers on foot or by bicycle, often by night via backroads to avoid police and forest officers. Some planks are transported onwards to local markets and sold to carpenters. The most valuable timber is transported to urban areas where the purchasing power of the population is higher. Unlike softwood, which is openly displayed and relatively cheap, hardwood is mainly delivered on demand. It is only publicly displayed or transported when converted into furniture, so that the official hammer mark obtained from the local forest officer (as an indication of legality) can no longer be checked.

The production chain can be organised in different ways (Wells and Wall 2005, Shayo 2006). Some chains are relatively short and involve local timber pitsawyers that also operate as dealers and sell directly to carpenters, and in other cases carpenters organise the harvesting. Longer routes exist for more expensive timber, where larger dealers, either from local or urban areas, have (in)formal agreements with (groups of) pitsawyers. They deliver in response to bids from larger contractors and retailers. In some cases, there are intermediate dealers involved.

There are a number of licences that legal operators need to obtain. Harvesting licence fees vary with species and are higher for more valuable and commercial species. Permission from the village representative is required, and a ward forest officer has to check if the sought trees are available. In addition, dealers need transport licences that should indicate volume, species and harvesting location. Dealers also need be registered as a tax paying company and Natural Resource trader. This licensing system is far from watertight and provides a series of opportunities for private rents. Given the high number of illegal traders, the profit margins on legal trade are low or negative.

3.2 Volume of timber consumption by households and by timber class

The hardwood extracted from the EAM is mainly turned into furniture. The total annual benefits of hardwood extraction from the EAM that accrue to the final beneficiaries can therefore be approximated by assessing the annual timber consumption per household and the value of that timber, taking into account that the latter varies across species. To estimate annual household demand for hardwood, we assumed that timber use is a function of location (urban/rural), income stratum, and furniture ownership per household. Household census data was available for furniture ownership (NBS 2009) and was combined with assumptions about furniture items for which these statistics were unavailable. Statistics on income strata across regions was available from NBS (2011). We assumed that richer households have more purchasing power and therefore own more furniture and bigger houses. Carpenters stated that most of their customers were middle and high income households, justifying this assumption. Carpenters produce household furniture, including tables, chairs, doors, doorframes and beds, and provided information about the timber volume of these items. Per household estimates vary between 0.0367 and 0.0515 m3 per year for rural and Dar residents respectively, assuming a lifetime of 25 years, comparable with published estimates in Wells and Wall (2005).

The value of timber depends on the class of timber and we therefore needed to split the total demand of hardwood into volumes per hardwood class and softwood volumes. We assumed that wealthier households generally prefer higher class timber species over softwood or lower class species, whereas poorer households can only afford softwood and lower class species. Carpenters' statements about their customer characteristics justified such a wealth-based stratification. Next, we assumed that softwood is only supplied to urban areas, whilst rural areas are assumed to use class III-V hardwood as cheap option.[2] Moreover, we observed a wider range of low class timber species in markets in the northern part of the study area[3], and learned from interviews that there are fewer plantations. Therefore, we assumed that softwood use is lower in the north among the lowest quintiles. Table 1 gives an overview of the resulting timber use assumptions per quintile.

Table 1. Timber use per quintile

			Class I	Class II	Class III-V	Softwood
Quintile V (wealthiest)		Urban	40%	40%		20%
		Rural	40%	40%	20%	
Quintile IV		Urban		25%	25%	50%
		Rural		25%	75%	
Quintile I-III (poorest)	North	Urban			75%	25%
	South	Rural			100%	
	North	Urban			50%	50%
	South	Rural			100%	

Finally, to assess the population of beneficiaries of EAM hardwood and select the towns and cities supplied by EAM timber, we used interview information about buying and selling locations and transport routes. Median transport distances vary little between classes (between 63 and 69 km,

[2] We merged classes III-V because during the interviews, carpenters and dealers did not distinguish between these classes, and no price differences were observed.

[3] The northern part is defined as the mountain blocks between the cities of Arusha and Tanga (see Figure 1).

based on 113 – 150 observations per class), but class I timber comes from a wider area with 25% of routes (not reflecting volume) longer than 120 km, compared with 100 km for lower class species. Based on this information, we assumed that:

- all demand of rural households in the EAM and its 8k buffer is met by EAM production;
- the EAM provide 75% of demand in urban areas inside the EAM (the cities Iringa and Morogoro); additional supply comes from lowland areas outside the EAM and forests in the south of Tanzania and in Mozambique;
- the EAM provide 25% of demand in larger settlements (>5,000 inhabitants) between 8k and 25k of the EAM boundary (rural and urban);
- the EAM provide 25% of timber demand in major cities (>100,000 inhabitants) within 100k of the EAM;
- the EAM provide 10% of Dar's hardwood consumption (beyond 100 km from the EAM).

This results in an estimated overall demand met by the EAM of approximately 45,000 m3 timber (softwood and hardwood) per year, equivalent to 2.2 million planks, which includes 76% hardwood from EAM forests and woodlands and 24% softwood from plantations (see Table 2).[4] This approach also allows for a breakdown of consumption across different consumer groups, where we identify rural and urban residents in settlements inside and outside the EAM and its 8k buffer, and in Dar es Salaam. The results show that the largest proportion of benefits of timber class I are enjoyed by the rural population of the EAM (both in total and per household). This is because the rural EAM population is relatively wealthy compared with other rural areas in Tanzania and is therefore able to afford class I furniture items.

Table 2. Total annual consumption (in m^3) of hardwood and softwood from the EAM blocks

	# house-holds	Hardwood				Softwood (m^3)	*Total (m^3)*
		Class I (m^3)	Class II (m^3)	Class III-V (m^3)	*Total (m^3)*		
Rural households in EAM + 8 km	*810,347*	3,226	5,115	19,742	*28,083*	0	*28,083*
Rural households > 8 km from EAM	*106,144*	92	152	860	*1,104*	0	*1,104*
Urban households in EAM + 8 km	*59,960*	37	129	997	*1,163*	1,265	*2,428*
Urban households > 8 km from EAM	*157,327*	33	92	1,064	*1,189*	2,549	*3,738*
Households in Dar es Salaam	*621,108*	1,194	1,245	66	*2,505*	7,092	*9,597*
Total	*1,754,886*	4,852	6,733	22,729	*34,044*	10,906	*44,950*

[4] As a cross-check of the volume, we estimated the volumes extracted by carpenters and pitsawyers. Based on interviews with carpenters, pitsawyers and forest officers, the total number of pitsawyers in the EAM is estimated to be between 15,000 and 66,000, who harvest on average 150 planks per year (varying between 30 and 60). The estimated number of carpenters ranges from 23,000 to 165,000 who use around 110 planks a year (varying between 45 and 410). Volumes based on these estimates vary from 53,000 up to 428,000 m3. The estimated household demand volume falls just below this range and may therefore represent a conservative estimate of the total extraction.

3.3 Value analysis

To support the economic valuation of timber flows we developed a price model of timber planks based on data from interviews with carpenters, dealers and sawyers as well as direct market observations. The results indicate that market prices (expressed as the price equivalent of a plank size of 1"*10"*12ft) for planks vary between classes and across space, with higher values in urban areas, and a price premium in the capital of Dar es Salaam (see Table 3). Prices are lowest in remoter places near forest edges. Prices increase with distance to urban areas reflecting costs of carrying planks out of the forest, fuel costs for transport to urban areas and various bribes that have to be paid along the way. Furthermore, planks of class I species are sold at significantly higher prices than lower class species, but there is no significant difference between the latter groups (class 2 - 5). Hardwood is sold at higher prices than softwood. Figure 1 presents the mapped model results of prices per plank for class I timber.

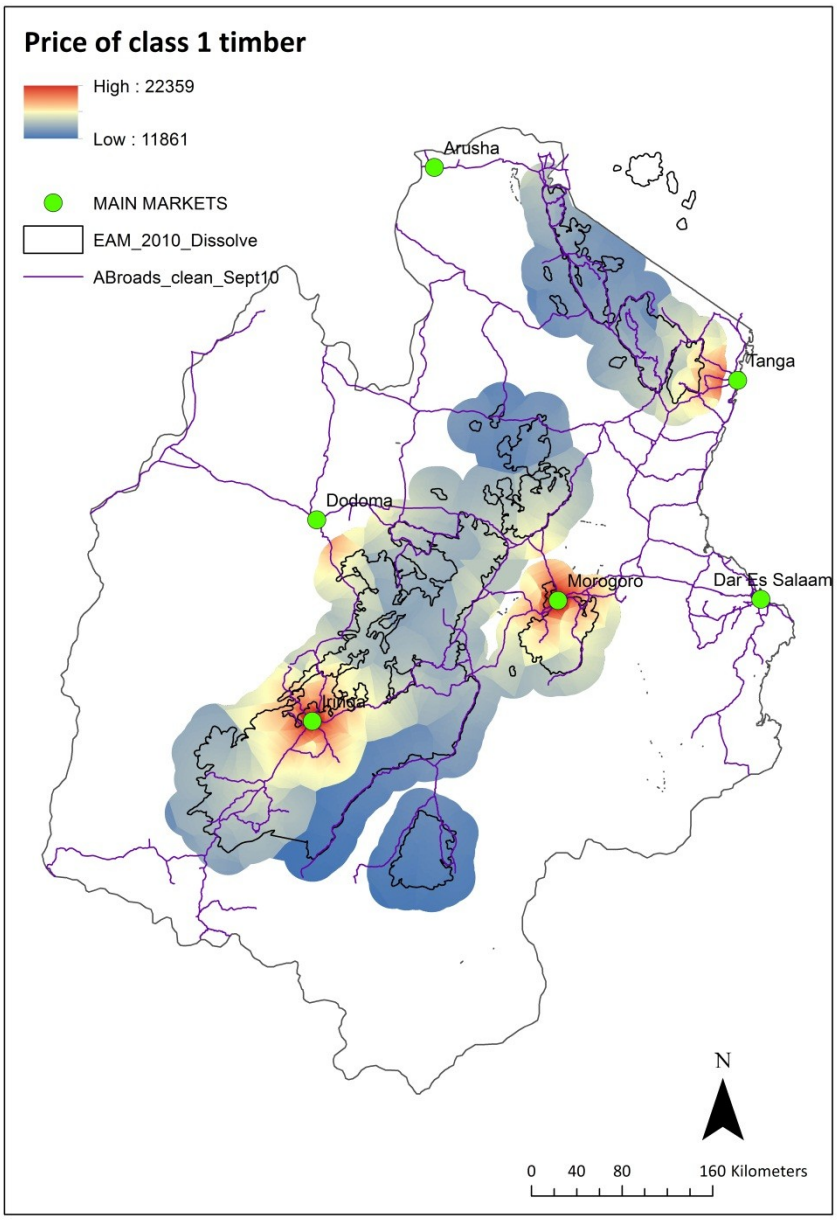

Figure 1. Map of price per plank of class I timber in and around the EAM (in TSH 2011).
The wider study area reflects the three river basins of which the rivers originate in the EAM and covers about 1/3 of Tanzania. Prices reflect market prices for a plank of size 1"*10"*12ft.

Table 3. Price model

Dependent variable: ln (price per plank, in TSH)	**Coef. (t-value)**
class1 (dummy variable: class I species = 1; otherwise = 0	0.771*** (12.66)
class25 (dummy variable: class II-V species = 1; otherwise = 0)	0.261*** (4.72)
Dumdar (dummy variable: record from Dar es Salaam = 1; otherwise = 0)	0.298*** (5.36)
Lndispri (ln (distance to nearest major city (>100,000 inhabitants))	-0.104*** (-11.87)
Constant	9.244*** (171.85)
Number of observations	*599*
R^2	*41%*

The combination of the consumption statistics (Table 2) and the plank price data (Figure 1) shows that the rural population in the EAM and its 8km buffer are estimated to spend over USD 7 million annually on hardwood harvested in the EAM (see Table 4). The next major beneficiaries are the population of Dar es Salaam who consume the equivalent of USD 1.7 million in hardwood annually. Other urban areas (Arusha, Dodoma, Tanga, Morogoro, Iringa) spend USD 0.8 million annually on hardwood, whilst and rural households beyond the EAM spend an estimated USD 0.3 million on EAM hardwood. The total value of hardwood from the EAM is estimated at USD 10 million annually. Softwood use by these households represents another USD 3.8 million per year.

Based on our modelling assumptions, the value of class I at the market is approximately USD 2.4 million, which is in the same range as the value of class II timber (USD 2.0 million) despite the difference in volume (see Table 1). Lower class timber species generate an estimated USD 5.6 million.

Table 4. Value of timber sales based on plank prices (USD)

	# hh	Hardwood value (USD*1000/yr)	Total timber (including softwood) (USD*1000/yr)	Hardwood value (USD)/hh/yr
Rural households in EAM + 8 km	810,347	7,134	7,134	8.80
Rural households > 8 km from EAM	106,144	332	332	3.12
Urban households in EAM + 8 km	59,960	357	660	5.95
Urban households outside EAM	157,327	465	1,203	2.96
Households in Dar es Salaam	621,108	1,687	4,478	2.71
Total	**1,754,886**	**9,975**	**13,808**	**5.68**

3.4 Commodity chain analysis & benefits distribution

The values in Table 4 represent the market prices of planks. However, most households buy hardwood in processed form, as furniture. Figure 1 shows that prices of planks differ greatly between the forests where they are harvested and the cities where they are consumed. Analysis of the timber commodity chain gives insight into the nature of payments that various actors receive and the distribution of revenues among the actors throughout the production process (Ribot 1998). The relevant primary actors include pitsawyers, carriers, timber dealers, officers (village, police, forest), saw millers, carpenters, and finally furniture consumers. Our data suggests that some payments vary little per timber class, such as payments to carriers, pitsawyers, and loading. Other payments, such as road transport and bribes and margins of middlemen, vary with classes.

Pitsawyers stated that they receive a fixed price per plank of USD 1.67 (median, n=19), varying between USD 0.44 and USD 5.33, comparable to previous reports (e.g. Shayo 2006). In addition, dealers will often provide food for the days spent working in the forest, especially when payments are not upfront. Based on an annual production of 1.44 million hardwood planks (based on an annual production of 34,044 m3, and a plank size of 1"*10"*12ft), the total financial revenues of pitsawyers for hardwood production are estimated around USD 2.4 million per year.

Local villagers are involved in transporting planks out of the forest to the nearest collection point and loading the planks onto the dealer's truck. There are an estimated 66,000 people[5] involved in carrying the planks, who earn on average USD 0.67 (median, n=16) per plank, and an additional USD 0.044 per plank for off and uploading (median, n=6). This generates another USD 1 million in cash income to these villagers (USD 16 per carrier per year).

Further costs incurred by dealers include equipment, transport costs, some official licensing costs and other transaction costs. Equipment costs are minimal given the simple equipment used. Median transport costs per plank are USD 0.0074/km (n=27) and medium distances are 65 km for hardwood to reach the final market (USD 0.7 million). This means that the overall costs are about USD 4.1 million, excluding bribes, licensing and other transaction costs.

Dealers stated that some payments have to be made to village officials to be granted access to village forests. These payments also have to be made when a dealer wants to get a licence for harvesting village forests. These payments are around USD 0.33 per plank and are negotiable (median, n=4). One dealer operating without licences admitted to paying another USD 0.53 per plank to forest officers in order to avoid high fines. This implies another USD 0.5 million that is paid into local village representatives, and USD 0.8 million to forest officers. However, dealers profits are hard to estimate and probably depend on the number of encounters with officials between the point of harvesting and sales. All dealers and experts commented that it was hard if not impossible for dealers to make a profit when all required licences were obtained. Even with the right paperwork, transporters and dealers reported that payments to police and forest officers were necessary to continue transport and avoid confiscation.

Carpenters reported that their average profit margin is 25% of the final price of furniture items (n=142), but labour cost still have to be paid out of this margin. Timber inputs constitute on average about 50% of the overall furniture prices (n=163), and higher for furniture made with class 1 species

[5] Based on 2% of the population in a 8 km buffer around the EAM and 10 km buffer around forests.

(58%) than lower class species. Other costs (25% of furniture price) include transport, inputs such as nails and varnish, and rent of sawing and smoothing machines. Hence, at a total annual hardwood plank consumption of USD 10 million (see Table 4), representing the costs of carpenters' timber inputs, carpenters generate a profit of around USD 5 million, and the final consumer pays USD 20 million in terms of furniture items.

This means that dealers, who receive around USD 10 million from selling planks to carpenters, have a profit margin of about USD 4.6 million (USD 3.19 per plank), that they can either spend on getting official licences or bribes. This significant private rent is expected to raise harvesting rates beyond sustainable levels. It is also much higher than the revenues obtained by pitsawyers and carriers.

Table 5. Distribution of benefits in timber commodity chain

	USD/plank	**Total (USD million)**
Pitsawyers	1.67	2.409
Carriers	0.71	1.030
Transport	0.48	0.694
Village payment	0.33	0.476
Forest officials payment	0.53	0.765
Total dealer costs excluding payments to forest officials (including payments)	*3.20 (3.73)*	*4.609 (5.374)*
Dealer profits excluding payments to forest officials (including payments)	*3.72 (3.19)*	*5.366 (4.601)*
Dealer revenues/ carpenter timber costs		9.975
Carpenter labour and profit		4.988
Domestic expenses on furniture		19.950

Despite these low labour costs in timber prices, dealers argued that it is hard, if not impossible, to generate profit from legal timber dealing. Harvesting licence fees per cubic meter (measure over bark) for class I were USD 167/m3 in 2007/8. The efficiency of converting logs into planks determines the costs per plank: at 12 planks/m3, the licence costs would be USD 13.89 per plank, yet at 30 planks/m3 the costs would be USD 5.62. Additional licences have to be obtained for transporting timber and general timber trading, and the lower estimate for very efficient conversion is still higher than the profit per plank of USD 3.19.

4. Market signals of (un)sustainability

The economic analysis of the timber production chain and the market data in particular reveal some important information about the potential of sustained supply of hardwood from the EAM.

Price changes

Price changes are the clearest market indicator of scarcity. Compared to the results of the initial market study in 2009 in the same area, prices in Dar es Salaam in August 2011 increased by 36% for class I and 25% for class II (see Figure 2), whereas the consumer price index increased by 19 points (NBS 2012). This indicates that real prices have increased, which may reflect increased scarcity of especially class I species and to a lesser extent lower class species.

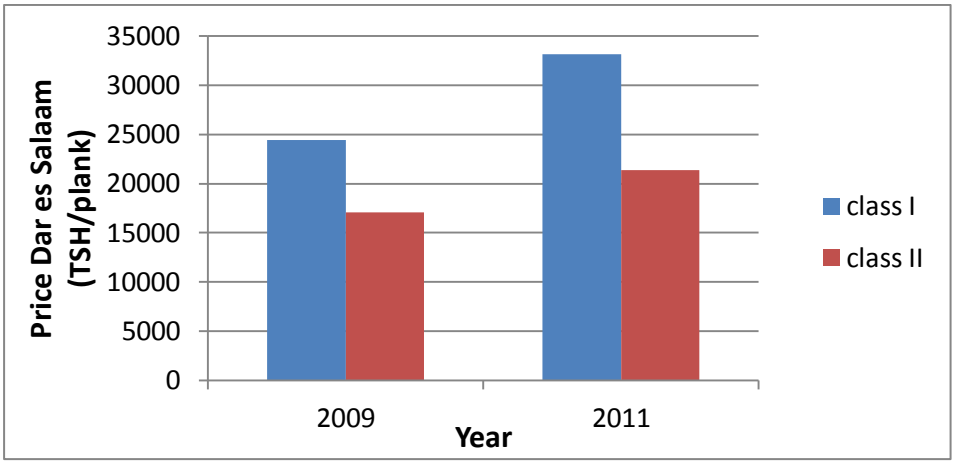

Figure 2. Price comparison between 2009 and 2011 for Dar es Salaam timber markets (n=41 and n=50)

Size of plank changes

Between 2009 and 2011, plank sizes of class I species decreased and are now smaller than for less valuable timber species. Respondents reported that sawyers are making smaller (narrower) planks (1"*10"*12 feet instead of 1"*12"*12 feet), so that they can get more planks from a single tree and harvest immature trees. According to the interviewed sawyers and merchants, most large commercial trees have been harvested, and only immature, smaller trees are left in the EAM forests and woodlands. This downward trend in the size of harvested trees has been observed elsewhere, e.g. in coastal forests (Ahrends 2005).

Availability of species

Carpenters, sawyers and dealers were asked if the most frequently used species were still available in the EAM forests and woodlands. Respondents indicated how difficult it was to get these species. The 325 species-specific statements were used to build an availability score for the different classes between 0 and 1, using 0.75 for statement "available but very difficult to get", 0.5 for "available but difficult to get" and 0.25 for "available but a bit/sometimes difficult to get". The results suggest that class I species are more often unavailable or hard to obtain, and this holds to a lesser extent also for class II, whereas class V species are generally available across the study area (see Figure 2).[6] In class I, mkangazi (*Khaya anthotheca*), mpangapanga (*Millettia stuhlmannii*), mninga (*Pterocarpus angolensis*) and mvule (*Milicia excels*) are particularly difficult to find. In class II, mkola (*Spirostachys africana*), mkulo (*Ocotea usambarensis*), msani (*Brachystegia microphylla*) and podo (*Podocarpus usambarensis*) are increasingly scarce, with mkongo (*Afzelia quanzensis*) also becoming more difficult to get. Some of these species are found in forests, whereas others are mainly growing in woodlands. Similarly, the further away from forested areas, the lower the availability is in the market and the harder it is to obtain valuable timber.

[6] Class III and IV were excluded because of the low number of species and observations.

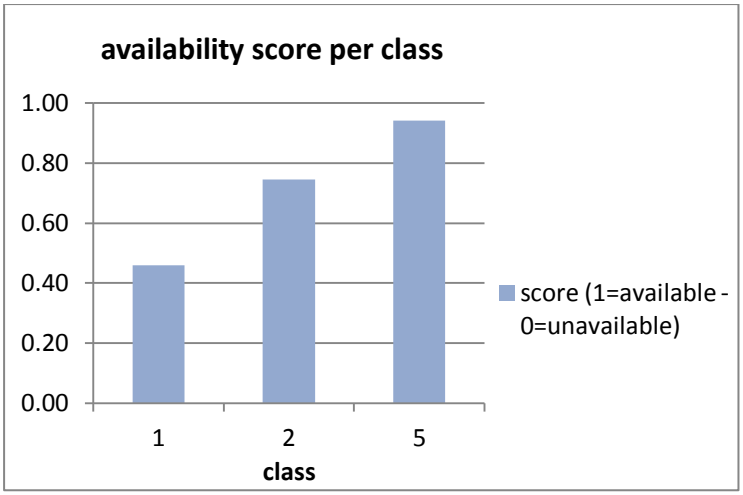

Figure 3. Availability score per timber class

Changes in products

Increasing scarcity and prices of timber class I species may lead to an increase in demand for substitutes. In the furniture shops, changes in species from class I to class II and V for furniture production were observed. Because of timber price increases, carpenters in Dar reported to increasingly use softwood and class II species to bring costs and prices of the final products down. However, using softwood and class III-V species as cheaper substitutes for class I and II species brings down the quality, prices and profit margin. Carpenters argued that customers prefer better-known class I and II species and are unfamiliar with class III-V species and therefore not willing to pay as much.

A shift in species seemed to have occurred already in the northern part of the study area, where a noticeably wider range of hardwood species was used in the compared to the southern area. In the north, the supply of softwood from nearby plantation was lower, because fewer forests remained and the softwood plantations were closed after management problems. Hardwood supply also decreased as the substitution of class I by class II has put pressure on the availability of class II species (e.g. in Tanga Region). Class I and class II species are being replaced by class V including fruit trees (coconut, jackfruit, mango). A survey of the Korogwe Forest Office (pers. comm.) found 29 species in use that were not used in the past. In Tanga, one carpenter reported that aluminium door and window frames are becoming more popular among richer households. They are of the same price as hardwood frames.

Softwood is sold by dealers in all towns and cities, as it provides a cheap and accessible alternative for hardwood. Licence costs are much lower and softwood is mostly legal, displayed openly in timber shops. Most softwood (eucalyptus, cypress and pine) is coming from Iringa and Mafinga, where the large plantations of Sao Hill and Mgololo are located. In the northern EAM, there are more small scale plantations than in the south, because people have planted (mainly teak) trees since the colonial era. However, the revenues from private tree plantations are low: revenues are around TSH 6000 for a tree that takes 10-13 years to grow.

Changes in source

Alternative supply of hardwood can come from outside the EAM and imports. Within the EAM, not much evidence was found for a shift in harvesting areas despite the increasing scarcity (see Figure 3).

At least five dealers and carpenters reported that they could no longer get timber from the places they used in the past, and harvesting had relocated from Korogwe and Muheza (inside the EAM) to Handeni (outside the EAM).

The demand for timber from Dar es Salaam is increasingly being met by hardwood from coastal forests in the south of Tanzania and Mozambique. Improved infrastructure has led to an increase in harvesting rates in the south to supply Dar es Salaam (Milledge and Elibariki, 2005). Since the opening of the bridge across the border with Mozambique, transporting timber has become much easier. Mozambique is one of the main suppliers for hardwood to Dar es Salaam, especially for mninga and mkongo. Occasionally, Mozambican timber is also used in Iringa and Morogoro. The higher imports from Mozambique have increased the supply and competition in the timber market, but prices have not gone down. In addition to imports from Mozambique, also Malawi, Zimbabwe and Congo were mentioned by respondents. Carpenters and dealers in Dar argued that the quality of the imported timber is higher, because the trees are bigger and more mature, allowing for longer and wider planks. In addition, there are fewer harvesting regulations and control in Mozambique and border controls are minimal.

5. Discussion and policy recommendations

The demand-based assessment of the volume of hardwood extracted from the Eastern Arc Mountains to supply rural and urban households throughout Tanzania shows that the forests and woodlands provide a valuable source of financial revenues. The estimated value is about USD 10 million annually, based on the price that the final consumers pay for planks, onto which carpenters add another USD 10 million related to processing these planks and producing household furniture. This value only reflects domestic use of hardwood for furniture, doors and door and window frames. It provides a lower bound estimate of total harvesting in the EAM as it excludes timber for commercial or public buildings, and for export (although the latter category is expected to be small).

Our results indicate, however, that this flow of revenues may not be sustained in the long run. Market data show that prices have gone up and plank sizes decreased, as the largest trees in the most accessible forests have been harvested. The consumption of lower class species has reportedly increased, for instance from wild species to fruit trees, from class I to class II, or from class II to class III-V species. The most obvious substitution is observed in timber markets in the north of the study area, where forests are scarcer after intensive historical logging (Willcock 2012).

In the absence of data on harvesting locations and spatial patterns of harvesting, we can only compare the overall volume and the woodland and forest area to some basic rules of thumb of sustainable harvesting. The hardwood species found in the market are typical for both Tanzanian and woodlands. There is approximately 20,000 km2 of forest and woodland in the EAM. The annual offtake of 32,983 m^3/yr corresponds to a roundwood offtake of approximately 120,225 m^3, based on a conversion rate of 12 planks per m3 (RDFAPTF, 2002). This suggests an extraction rate of 6 m^3/km^2/yr. This is well below sustainable rates based on mean annual increment (MAI) figures published in the literature (e.g. 4.35 m^3/ha/yr, Luoga et al. 2002) which would suggest that off-take is sustainable at the level of the EAM. However, extraction rates are typically concentrated in areas closer to roads and urban areas (Ahrends et al. 2010) and higher for commercial species. Moreover, timber extraction competes with charcoal extraction over forest and woodland resources. Our

availability indicators suggest that class I is increasingly hard to find. Field studies using transect data in combination with forest stock assessments are therefore necessary to determine the ecological sustainability of timber extraction across the study area.

Consumer preferences for class I species poses a threat to protected areas. Because of the higher market premium paid for class I species, harvesting is expected to continue deeper into forests and woodlands. The market price difference between class I and lower quality hardwood species is sufficient to cover higher transport costs within the area of the EAM. Forest officers stated that the higher class I profitability overrides the risk of being arrested for illegal sawing in protected areas, and class I timber has become very scarce in general lands. This moves logging into protected areas.

Our analysis also shows that the distribution of benefits that can be earned by actors in the timber commodity chain is unequal. Local benefits include the USD 2.4 million received by pitsawyers, and the USD 1 million by carriers. Given the relative wealthy rural population (in comparison with other rural areas in Tanzania), rural consumption of hardwood provides revenues to local carpenters. Local elites may benefit from village-level bribes. However, dealers, often from outside the forest-adjacent villages, receive larger earnings of around USD 5 million, part of which may be paid out in bribes to officials. Importantly, these earnings result in much higher per capita benefits than individual carpenters and pitsawyers will receive. Since dealers and traders have the power to set prices for carpenters and pitsawyers, the higher market prices of class I species are usually not translated into higher prices per plank for pitsawyers. The high percentage of unemployment in rural areas and associated low wages implies that pitsawyers cannot demand higher wages.

Interviewed experts estimated that up to 90% of timber logging in the EAM is illegal. Dealers, sawyers and carpenters deliberately declared various ways to avoid regulations, sometimes by bribing local and district officials and policemen. They described how they ensured that harvested planks were not confiscated, or how they 'laundered' timber, for instance by getting a cheap licence and harvest larger volumes than allowed and more valuable species or by using the same licence multiple times. Overall, the risk of illegal timber trade is perceived to be low whilst it is relatively easy to trade illegal timber, which increases the supply of cheap illegal timber. Together with the low purchasing power of many Tanzanians, this drives market prices down and makes legal trade unprofitable.

The scale and illegal nature of hardwood harvesting negatively impacts on social, economic and ecological systems. The current level of forest regulation enforcement fails to correct timber prices for externalities in prices and stimulate lower harvesting rates through market-effects. It implies that many of the forest benefits do not go to forest owners and forest-adjacent communities. Unsustainable timber harvesting will have negative impacts on other forest uses, including charcoal production, pole and firewood harvesting, and other NTFPs such as thatch, mushrooms, plant-based medicines and bushmeat. Charcoal, pole and firewood harvesting accounts for around 12-15% of the income of rural communities in the EAM, and the poorest households rely most on these forest resources (Schaafsma et al. 2012). Ongoing illegal harvesting may therefore reduce the potential of forests to contribute to poverty alleviation. In terms of ecosystem services, unsustainable timber harvesting has further negative impacts on the carbon sequestration and storage capacity of the forests (Willcock et al. 2012), as well as wild species diversity, and water supply to urban areas at the EAM foothills and further downstream, including the capital Dar es Salaam.

Policy recommendations

Continued population and economic growth will further increase the demand for timber for construction of new housing, commercial and public buildings. Better regulation and enforcement may partly help to address unsustainable harvesting. But the EAM forests and woodlands cover a vast area and the budgets at operational levels of forest departments are small. At the moment, 95% of the funds go to the Forest and Beekeeping Department at national level, and only 5% stays in the district (REM 2009). Local forest offices are structurally under-funded and unable to afford regular patrolling. As a result, public (government) revenues remain only a fraction of the total harvesting revenues under full enforcement of the Forest Act. Stricter enforcement will therefore require a change in the financial structure of the governing agencies at national and district level. Moreover, since illegal or semi-legal logging is part of a wider economic system in Tanzania, with multiple beneficiaries at various scales, addressing illegal activities requires far-reaching changes in the institutional frameworks which regulate forest access and use (Colchester et al. 2006).

Secondly, reducing current logging rates through stricter enforcement has to be combined with alternative timber supply. Population growth and economic development are likely to increase future demand for hardwood in Tanzania, and increase the pressure on forests. Larger-scale government plantations are fulfilling an important role in timber supply, but a recent report by Indufor (2010) warns that this supply is expected to collapse due to severe overharvesting and lack of replanting. The number of private plantations is rising, although the long pay-back period related to low market prices currently discourages investment. Policies that provide incentives for private plantations may help to meet the timber demand gap.

Furthermore, revenue sharing mechanisms under REDD+ or in the form of Payments for Water Services, will be necessary to ensure that the losses that local communities may face initially under stricter enforcement do not increase poverty levels. Such policies in combination with forest decentralisation have the potential for local communities to derive benefits from sustainable forest management, but their success is dependent on good local governance (instead of elite capture), acceptable transaction costs, as well as forest conditions (Strassburg and Vira 2012).

Given the progressive rate of timber extraction and forest loss, national-level policy makers need information to inform more sustainable forest policy making on the level of hardwood extraction. This paper presents a rapid, demand-based assessment of hardwood extraction in the Eastern Arc Mountains. There are clear market signals that hardwood harvesting in the study area is ecologically unsustainable, leading to logging down the value chain, with negative impacts on a range of other ecosystem services and biodiversity. Future work into the spatial distribution of extraction rates may help to direct governance efforts to those areas where timber extraction has the most negative impacts on societal welfare and equity.

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