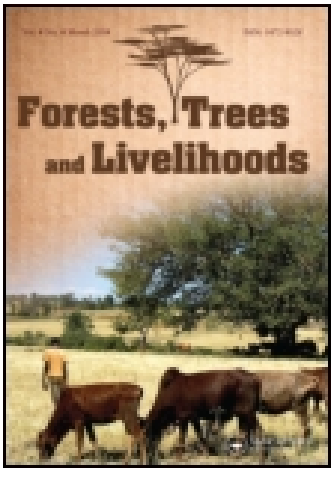

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Allanblackia, butterflies and cardamom: sustaining livelihoods alongside biodiversity conservation on the forest-agroforestry interface in the East Usambara Mountains, Tanzania

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Allanblackia, butterflies and cardamom: sustaining livelihoods alongside biodiversity conservation on the forest–agroforestry interface in the East Usambara Mountains, Tanzania

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Win–win outcomes for biodiversity conservation and poverty reduction are the holy grail of integrating conservation and development and are rarely met. Domestication of valued local species and introduction of high valued crops can help prevent depletion of wild resources. We compared three commodities from the forest–agroforestry interface of the East Usambara Mountains in Tanzania at different stages of domestication: (a) *Allanblackia stuhlmannii*, a local tree with valuable edible kernel oil; (b) butterflies, with an international market chain for pupae sold to butterfly gardens and (c) cardamom (*Elettaria cardamomum*), an introduced shade tolerant spice from India with established global markets. Data on production systems, institutional set-up and profitability were collected through focus group discussions, interviews with key individual informants and literature review. Cardamom has become a major support for rural livelihoods, generating 9 million USD for 750 tons of product in the area, or 850 USD per year for 10,600 households. Allanblackia and butterflies generate only 1% of that income for the landscape. For Allanblackia (around 20 USD per year for 5000 households), the transition from a forest product collected from the wild to being an agroforestry commodity is in an early but critical stage, where the slow growth of the trees and inadequate research attention to production systems, as well as modest farm gate price, currently limit farmer interest but are the focus of ongoing research. Butterflies (approximately 200 USD per year for 350 households) have had the fastest domestication pathway, with continuous innovation into new products and use, linked to international markets. There is gender-sensitive integration with household tasks and compatibility with homegarden agroforestry systems, while due attention is given to institutional arrangements of its local business scheme. Cardamom's economic success has made it a 'villain' to forests conservation, as forest transformation to cardamom agroforestry retains only half of the forest trees, and is a step towards further change. Differences in institutional settings of these three domestication pathways relate to their potential to reconcile biodiversity and livelihood concerns and suggest that a socio-ecological system approach to domestication is a prerequisite for a biological–technical one to achieve societal goals.

Keywords: agroforestry; domestication; forest conservation; value chain

Introduction

Conservation of natural forests and improvement of rural livelihoods are often at odds throughout the tropics. Integrated conservation and development programs have tried to reconcile the two (Stocking & Perkin 1992), with 'emission reduction' as the current entry

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point for international finance (Minang & van Noordwijk 2013). Domestication and commercialization of selected forest resources has been promoted as one of the few 'win–win' solutions that can maintain the biological richness and simultaneously reduce rural poverty. However, such a use-it-or-lose-it approach (Kock 1995) can have a pandora box effect if it attracts newcomers to the forest margins with expectations of easy income (Tomich et al. 1998) or fail to reduce rural poverty if the returns to labour remain too low. As planting, caring and managing trees and shrubs cost labour, domestication can have higher returns to labour than harvesting from the wild only if the wild resource is hard to find and/or effectively protected, and when harvesting the domesticated resource is easier than harvesting the wild one (Martini et al. 2011; Leakey et al. 2012).

The economics of domestication of many commodities have not been fully understood and major new efforts on the biological side of domestication are sometimes made without adequate *ex ante* impact analyses. A wide set of drivers or factors that cause loss of forests, biodiversity and/or impoverish people living in the tropical forest margins have been identified in previous research (Chapin et al. 2000; Tilman et al. 2002; Geist & Lambin 2005; Kaimowitz 2005; Steffan-Dewenter et al. 2007). Of the multiple drivers of biodiversity loss and impoverishment, the contest for space to farm or graze, or otherwise make use of the landscape for economic gains, and that for habitats to preserve species and genetic diversity may well define the ultimate trade-off in many cases.

Yet, local 'win–win' solutions through domestication of wild resources may be feasible in landscapes where this spatial competition does not override other processes affecting land use and livelihood choices. The chances for identifying and successfully implementing win–win solutions are enhanced if there is enough interest in and investment from the stakeholders, such as government agencies, communities, NGOs or external interventions to promote alternative development pathways, and there is supporting institutional environment and stable/reliable access to markets for the commodities. Slow emergence of rules and other means for effective control of utilization, unfair value chains of commodities produced by the small-holders and lack of investment in promoting domestication of valuable forest resources are thus potential targets for interventions that seek to enhance sustainable livelihoods in forest margins. This is especially so if they can lead to attractive returns to labour that simultaneously deflect pressures on conversion of forests or other tree-based systems to more open land uses.

In this paper, we present a case study of a landscape with three commodities in various stages of domestication: (1) oil-yielding seeds of a native tree, Allanblackia (*Allanblackia stuhlmannii*), (2) butterflies and (3) cardamom (*Elettaria cardamomum*), a spice with global markets. The three commodities are common produce of the forest–agroforestry interface in the highland zone of the East Usambara Mountains, Tanzania. We compared the three commodities in terms of three timescales that (should) influence decisions (Jackson et al. 2012): the efficiency timescale of micro-economics, the sustainability time where resource depletion is a major concern and sustainagility timescale where resources for change matter. Through this comparison, we hoped to identify further lessons that can be used in *ex-ante* evaluation and improvement of new domestication conceptual proposals.

Conceptual framework of domestication

Based on Wiersum (1997), Michon and De Foresta (1997) and Michon et al. (2007), we interpret domestication as a two-dimensional process (Figure 1) where human control over the reproduction of the biological resource is linked to the inter-human regulation of

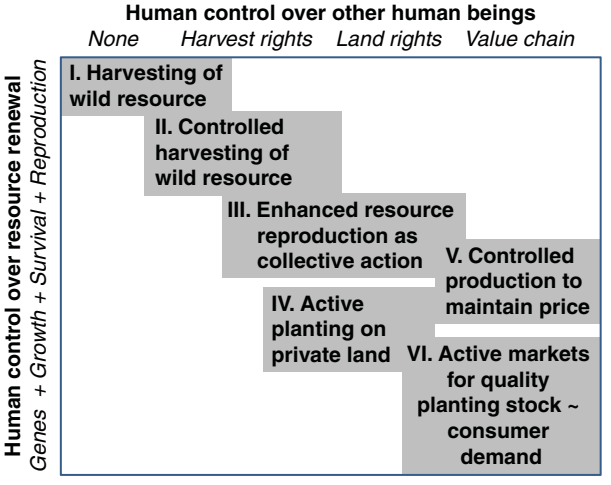

Figure 1. Domestication of wild resources as a two-dimensional process involving human control over the reproduction of the biological resource (*Y*-axis) and inter-human regulation of resource access between 'open resource', 'club good' and 'private good' with increasing degree of exclusivity [modified from Wiersum (1997)].

access to resources as open access, club good or private good. The latter process usually involves the articulation of exclusivity on rights over market access, harvesting, land, genetic resources and further steps in the value chain. Stages in domestication typically reflect shifts in both dimensions.

Materials and methods

Study site

The East Usambara Mountains are located between 4°48′ and 5°14′S and 38°32′ and 38°48′E, in the northern-east corner of Tanzania (Figure 2). The East Usambara Mountains are recognized as an important conservation priority site due to high numbers of endemic, near-endemic and threatened tree and vertebrate species (Burgess et al. 2007; Mpanda et al. 2011; Gereau et al. 2013). There are at least seven endemic vertebrate species and 40 endemic tree species (Leonard et al. 2010). The area also harbours global heritage agroforestry systems (Kitalyi et al. 2013). The cardamom agroforest and spice-based agroforests are important as habitat for local flora and fauna (Leonard et al. 2010), adding to the conservation value of the remaining forests.

The mountains contain more than 3450 species of vascular plants, one quarter of which is endemic or near-endemic, and many are listed as threatened (Iversen 1991; Burgess et al. 2007; Gereau et al. 2013). Rainfall distribution is bi-modal peaking between March and May and between September and December. The dry seasons are from June to August and January to March. The highlands of the East Usambara receive a mean annual rainfall of 1918 mm with up to 2262 mm near Kwamkoro on the Amani plateau. The mean annual temperature at about 900 m altitude is 20.6°C with a mean daily maximum temperature of 24.9°C and a mean daily minimum temperature of 16.3°C (Hamilton & Bensted-Smith 1989). Altitude ranges between 300 and 1174 m a.s.l. (Hamilton & Bensted-Smith 1989). One of the challenges facing the East Usambara Mountains has been forest fragmentation into small blocks, separated by tea estates, infrastructure development, human settlements and cultivation (Newmark 1998).

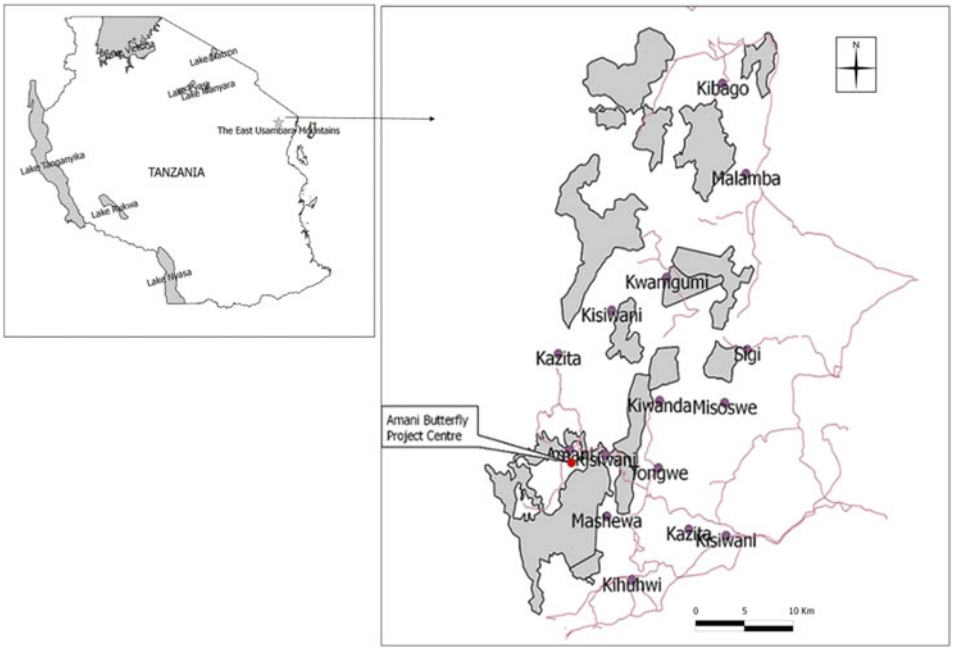

Figure 2. Location of the East Usambara Mountains, Tanzania.

The East Usambaras have, over the past century, witnessed a transition in external and local appreciation of forest that may be unrivalled in East Africa, but yet be symbolic for the changes elsewhere. During the colonial rule, the highlands of the East Usambara mountain forests were seen as useless wilderness and partly cleared for establishing coffee plantations between 1885 and 1914 (Moreau 1935), owned by only few companies. Still, large tracks of forests remained standing on the companies' land (Mihalyi 1969; Koponen 1994; Conte 2004), as coffee did not turn out to be profitable. In 1902, the Amani (the southern and largest forested block of the East Usambara Mountains) area emerged as a centre of excellence in agricultural and medical research, with a large botanical garden testing hundreds of plants from around the tropics. The station focussed on the agricultural and economic development of an area that was deemed to have high agricultural potential and low use (Sandy et al. 1997; Maunder 1999). Post-independence shift towards local smallholders made the area into a backwater of development, allowing the remaining forests to gradually gain recognition as containing globally relevant biodiversity. The current landscape contains elements that date back and refer to these different stages in the way the forest–development relationship was seen.

Study species

A. stuhlmannii (Engl.) Engl. (Clusiaceae), hereafter called AS, is a dioecious tree species (reaches 45–50 m in height) endemic to the Eastern Arc Mountains of Tanzania (Brenan & Greenway 1949; Mathew et al. 2009). The species is listed as 'Vulnerable' on the IUCN Red List 2012 because of its restricted distribution and human threats to the forest in which it is found (Lovett & Clarke 1998; www.iucnredlist.org). The AS seed yields oil (composed of triglycerides of stearic and oleic fatty acids) used by local people for centuries for food and soap production. The oil was reportedly used as substitute for butter

during World War I by the German soldiers in the region (Mdemu 2002; Mathew et al. 2009). The oil was promoted to commercial scale and enjoyed its glory between 1972 and 1984 with involvement of local state-owned and community-led organizations such as the General Agricultural Produce Exporters (GAPEX), Tanga Region Cooperative Union and Usambara Cooperative Society. Afterwards, the AS oil business gradually declined, although the GAPEX continued to engage in AS seed collection until late 1980s. The period of early 1990s to early 2000 witnessed total collapse of the AS oil business except for very few pockets of collection. Revival of the AS seed business was witnessed in 2004 with collection of 4 tons and it rapidly recovered to 500 tons in 2010, thanks to the newly developed interest in international markets. Up to 70% of AS seeds involved in the current market comes from the East Usambara Mountains, Tanzania. An ambitious programme was initiated to select productive germplasm and develop technology for earlier production of newly planted trees linking East and West African production areas to a major global supply chain.

Butterflies involved in the Amani Butterfly Project include 30 different species, although up to 55 have been considered to be potentially suitable in the East Usambara Mountains (Morgan-Brown 2010). In 2001, a feasibility study on the local species and their markets was conducted, followed by establishment of a butterfly business in 2003 through a conservation and development project (Morgan-Brown 2007). The project became operational following various awareness and mobilization meetings and trainings on butterfly farming and environmental education activities. It started with four pilot villages (Shambangeda, Kwezitu, IBC Msasa and Kisiwani) and included two more villages (Shebomeza and Mbomole) in 2006, making a total of six villages involving 320 farmers; by 2008 it reached about 350 farm households (Said 2009; Morgan-Brown et al. 2010).

E. cardamomum Maton ('Queen of Spices', small cardamom) is one of the world's most ancient spices, originally from the southern Indian forests of the Western Ghats, and belongs to the ginger family (Zingiberaceae) (Ravindran & Madhusoodanan 2002). The 'large cardamom' is a major form of agroforestry in the Sikkim Hiamalayas (Avasthe et al. 2011). Cardamom of both types are, on a dry weight basis, the third most expensive spice in the world, after saffron and vanilla. The lower most flowers open first and develop into fruits. It then takes 75–80 days for flower buds to form fruits ready for harvest. Fruits are small and ovoid in shape, with a green leathery husk. Each fruit has many small, round dark seeds inside, covered by a thin layer of pulp. Propagation is mostly through tillers with rhizomes (Nair & Kutty 2004). Most of the world's cardamom production is consumed in India, Saudi Arabia and South Asian countries as additional flavour in coffee and tea, and as ingredient for cooking. In Europe, especially in Scandinavia, Germany and Russia, it is used to flavour cakes, pastries and sausages. It is widely used in Eastern medicinal practices and to make perfume (Ravindran & Madhusoodanan 2002). Cardamom was introduced to the East Usambaras in the 1890s by German settlers. In 1954, the Amani Botanical Garden distributed 10 seedlings to Usambaran farmers who propagated the material for other farmers, and after one decade the cardamom business started to flourish. Cardamom mostly grows in the higher parts of the mountains (above 850 m), and is expanding to lower, less suitable sites.

Data collection and analyses

We collected information on the current status of AS, butterflies and cardamom as components of livelihood strategies. The Novel project (http://www.noveltz.org/) has

collected data on AS through field surveys and experiments conducted in the area since 2003 on seed physiology, indigenous knowledge, nursery propagation, phenology, fruit characterization, seed predation and early survival and growth of planted seedlings (Mathew et al. 2009; Seltzer C. 2010 personel. communication). A field genebank has been established with 400 planted seedlings of AS for estimating survival, and growth in terms of root colour diameter and height. We interacted with project staff and consulted archived project information. Additionally, focus group discussions were conducted with farmers to understand various issues pertaining to the AS value chain and local perceptions.

Data on butterfly farming and its supply were collected from the existing Amani Butterfly Project (http://www.amanibutterflyproject.org/) in their field office in the East Usambara. Furthermore, focus group discussion with butterfly farmers (men and women) were conducted to capture current issues relating to management and returns from this business.

Data on cardamom cultivation and value chain were collected from trials and surveys conducted in the study site during 2000–2007 (Reyes et al. 2005, 2006, 2009). Socio-economic data were collected on the local cultivation methods using a formal survey and participatory learning and action methods in four villages located in two different agroecological zones, highlands (>850 m) and lowlands (<850 m). These villages were located at the border of the Amani Nature Reserve and the Derema Forest Reserve. The sample represented 10% of the total household heads in these villages. The data were analysed with univariate and multivariate analysis of variance for clarifying the environmental and socio-economic aspects of cardamom cultivation. Farmers were grouped according to their quantitative responses, using cluster analysis of the variables. For an agroecological study, a field trial was established at the end of 2000 to clarify how two popular cash crops, cardamom and black pepper (*Piper nigrum* L.), normally grown under the natural forest cover, would perform in an intensive agroforestry system in combination with two multipurpose farm trees, *Grevillea robusta* A.Cunn. and the nitrogen fixing *Gliricidia sepium* Jacq.

Results

The main characteristics of the three forest-based commodities are summarized in Table 1.

AS: forest–agroforestry transitions

AS seeds are collected in the forest as well as from trees retained in the cardamom agroforestry systems. The AS price has increased from 0.04 USD per kg of seeds in 2004 to 0.288 USD in 2011 closing the gap with common crops such as maize and sunflower in terms of value per unit of harvested product. These are well-established commercial/food crops in terms of value to farmer experience. The AS value chain starts with a farmer in the village who during the AS fruiting season goes and collects the fruits that have dropped on the ground from up to 45 m high trees in forests or cardamom agroforestry. Fruits are opened by the farmer and seeds extracted. These seeds are dried around the farm on a raised bed, and after 10–14 days seeds are delivered to the collection centre. Collection centres open from January to May. Seeds are transported by the middlemen from local collection centres to the semi-processing oil facility where crude fat is obtained ready for export. Collection of AS seeds has been fluctuating since 2004, and its peak recorded in 2010 where 500 tons was collected and provided a gross income to farmers of more than

Table 1. Comparison of Allanblackia, butterfly and cardamom as livelihood components in the East Usambara Mountains.

	Commodities		
Criteria	Allanblackia	Butterflies	Cardamom
Introduction/domestication age/start of trade	Since 1972	Since 2003	Since 1954
Annual farmgate returns in the East Usambara Mtns (in 2008)	125,516 USD	89,200 USD	9,012,000 USD
Number of farmers involved	3000–5000	350	60% of highland farmers
Gender	About 47% women	About 55% women	No data
Villages involved	27	6	Approximately 50
Average radius around house where the commodity is available	5 km	20 m	1 km
Value chain	Farmer → collection centre → central processing (Tanga) → Export	Farmer → butterfly project office → export	Farmer → middlemen → wholesale → export
Importing countries	The Netherlands	The USA, the UK, Switzerland, Spain, France, Australia, Germany and Ukraine	Middle East, Asia, Europe, Africa and America
Age to maturity (e.g. planting to harvesting)	> 12 years to reach 30 cm dbh, fruiting age is reported to be > 8 years	3–4 weeks	3 years

117,241 USD (Figure 3). Furthermore, an additional 8276 USD was paid to village governments as levy that supports development activities in the village. In the East Usambaras, more than 5000 farmers are involved in AS seed collection depending on the fruiting season, of which more than 47% are women. To date, about 3000 farmers are involved in planting of AB across the East Usambara Mountains, for future harvesting.

Butterflies: forest–agroforestry transitions

The butterfly business has been growing over the years due to improved marketing strategies and attraction of more farmers to the scheme. Depending on the species, each pupae is worth between 1 and 2.5 USD. There has been an increase of annual sales from nearly 19,470 USD in 2004 to around 89,200 USD in 2009 (Figure 3). This has also been in line with an increasing trend of total earning per capita which indicates good prospects to the project and to farmers. A new record was reached in 2009 when an individual butterfly farmer earned 704 USD per annum. The income of participating households is estimated to have been increased by at least 15–20%, with the butterfly operations complementing other on-farm and off-farm activities.

The income from sales of butterfly pupae is distributed between the project running cost, participating villages and farmers. Normally each participating village receives 7% of the income accrued from butterfly sales for village community development, while the project retains running cost of 28% (including costs of local staff, transportation of pupae, utilities and other daily operations) and the remaining 65% is directly given to farmers.

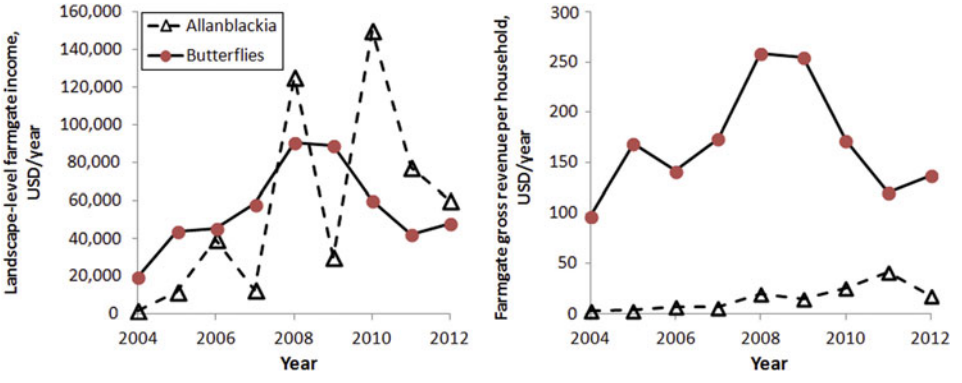

Figure 3. Trends and inter-annual variation in income from sale of Allanblackia seeds and butterfly pupae in the study area.

Butterfly farmers (mostly female, 55%) in the East Usambara Mountains depend upon the local forest as an initial source of pregnant female butterflies for eggs and as a continuing source of food for developing butterfly larvae. After initial collection of butterflies from the forest, and then rearing by farmers, some of the butterfly pupae from each farmed generation are retained by a Butterfly project station in the East Usambara so that they seldom need to catch more female butterflies from the wild after they have begun a captive population. However, there is a need to attract, through the natural pheromone signalling systems, male butterflies from the wild to maintain genetic diversity in the captive populations. The host plants of different butterfly species, at least 30 native trees, shrubs, herbs and liana species (Morgan-Brown 2010), are taken from neighbouring forests and are usually collected as young seedlings or seeds for use as food and egg laying platforms in butterfly rearing. The seed/seedlings are usually planted in polythene bags so that they can be moved easily to locally constructed screen-houses. When the plants outgrow, the polythene bags they are planted near the family homesteads in homegardens. The farm level operations are comparable (and compatible) with chicken-raising, and fit with domestic chores.

Cardamom: forest–agroforestry transitions

Cardamom expansion into natural primary forest, along with selective retention of trees considered useful has been a major way of establishing cardamom agroforestry. When farmers establish cardamom farm, they normally retain or plant 75–100 trees/ha standing for shade (Masayanyika 1995), most of them being indigenous species. This practice affects the vegetation and forest ecosystem, and the practice is illegal inside forest reserves and conservation areas. We noticed a growing trend to shift cardamom cultivation from forests to homegardens in the East Usambaras, as the public forest areas are diminishing.

About 60% of the highland farmers grow cardamom and it covers half of the total land area allocated to cash crops, contributing to about 30% to average household income. Current production is 751 tons, which generated about 9,012,000 USD (MDC, 2008) of gross farmgate revenue; shared by 60% of the households in the 50 out of 61 villages in the East Usambaras that are involved with cardamom production, this implies an average gross revenue of 846 USD per year per household involved. The labour requirement is substantial especially at harvest time as it requires handpicking of mature

cardamom capsules one by one. Cardamom farmers depend merely on household labour (Reyes et al. 2010).

Global production and consumption of cardamom have increased almost 2.5 times in the last 15 years with a projected steady increase in demand and supply in the future as well. That means the prices are expected to remain steady or even to go up (Ravindran & Madhusoodanan 2002). In the mid-1970s, the East Usambaras were producing about 20% of the total world cardamom production, 760 tons per annum, which made Tanzania the third largest producer after India and Guatemala, but this production has progressively declined while the global market increased. In 1998, Guatemala was already producing 64% of the cardamom traded worldwide, while India supplied 30% and the other cardamom-producing countries only 6% (Ravindran & Madhusoodanan 2002). Smaller producers include Tanzania, Sri Lanka, Papua New Guinea, El Salvador, Laos and Vietnam. In 2002, Tanzania produced only 560 tons, while Guatemala's production was 19,000 tons that same year. Some cheaper substitutes to real cardamom (*Amomum* spp. and *Aframomum* spp.) are also grown and used in Asian countries (Nair & Kutty 2004).

Farmers sold cardamom at about USD12.6 per kg in 2011 in the East Usambara Mountains and the price has been stable since then. A number of marketing societies and boards for cardamom have existed in the East Usambaras until 1984 (Sah 1996). Nowadays, producer associations and mechanisms to control quality for cardamom are lacking in the East Usambaras. The whole production volume is usually exported.

The annual cardamom yield in the East Usambaras in current systems is on average 80 kg/ha (Masayanyika 1995), but according to empirical evidence, under good land management and by adding manure it could easily reach about 1 kg per stump a year, or an average of 300 kg/ha. Only 15% of farmers actually use fertilizer on cardamom in the Usambaras (Reyes et al. 2010).

On-farm experiments show the potential for cardamom production in more intensively managed agroforestry systems, with yields six times higher than current average, even without the application of manure or fertilizer (Reyes et al. 2005). Cardamom agroforestry can also be a good way to rehabilitate deforested slopes, of which an estimated 13,000 ha were cleared in East Usambara Mountains only during 1992–2006 (Hall et al. 2010).

Discussion

Efficiency and economics of the production systems in Allanblackia, butterfly farming and cardamom

The three commodities play very different roles in the current economy of the area. Cardamom generated about 9 million USD as gross farmgate income for 750 tons of product, or 850 USD per year for 10,600 households in the East Usambaras. AS and butterflies generated only 1% of that income for the landscape, but in different ways: AS was a minor additional income component of around 20 USD per year for 5000 households and butterflies generated approximately 200 USD per year for 350 households. While the global turnover of the butterfly house industry is estimated to be in the order of 100 million USD (Boppré & Vane-Wright 2012), the Amani farmers currently have a small share in this, as they generate 0.7 million USD of gross income. Bullock et al. (2011, 2013) provided micro-economic analysis of the net present value of discounted cost and benefit flows of seven land use systems in the East Usambaras. The cardamom-based agroforestry system is among the most profitable among the local basket of options. Its economic success has been the basis of its environmental stigma, as it stimulated conversion of additional forest, which regulations now prohibit.

Domestication involves a transition from collecting 'open access' forest resources to taking care of the full life cycle of semi-domesticated products (Figure 1). This involves shifts in the type of labour involved and in the degree to which labour investment is needed upfront. The financial returns to labour can only be positive for domestication if there is a substantial increase in the volume that can be harvested per day of work, given the need for earlier labour investment in the production system. For butterfly pupae, the 'search time' is not economically interesting for collection from the wild, but becomes manageable in cages, with centralized egg production; for AS, this transition in the labour profile is not clear yet as most current collection is still from the wild, but maybe labour needed for early tree care of planted material can be attributed to other agroforestry components and the travel time component of current harvesting operations can be substantially reduced allowing for efficiency gains.

For any commodity to survive in the local socio-ecological system, fair and efficient value chains have to provide adequate benefits at farmgate level and yet meet uncertain (and fluctuating) market demand, exploiting the comparative production advantage of the site (in terms of quality, quantity and responsiveness). As shown in Figure 1, the butterfly enterprise is in the bottom line (V–VI) where there is controlled production to maintain price and consumer demand especially of pupae. Access to the market is controlled by the project, which maintains process deemed fair, rather than maximizing production volume and inter-village competition to lower the prices. Exploration of new markets is very important to maintain the business, and the efficiency at this stage appears to be very high. On the contrary, AS and Cardamom are still in level III–IV as much more effort is undertaken to increase their planting and productivity on farm. The demand is still very high, not to be saturated in the near future.

As most of the world's cardamom is now cultivated using chemical fertilizers and pesticides, the promotion of organic cardamom cultivation might raise the market value of the product. Market links of organic spices already exist in the area and demand appears to be high. The organic certification process, however, takes 1–3 years and may barely cover the transaction costs; yet many farmers in the East Usambara Mountains are willing to undertake it. There are opportunities to increase productivity (Forss & Lundström 2004). There is, however, a need to intensively promote traditional and new uses of cardamom (for example, in cough and cold medicines and in substitutes for cigarettes; in biscuits, candies and soft drinks). Producer associations are needed for developing more productive agribusiness and to develop new technical and economic practices.

Sustainability of forest resource conservation alongside livelihood of smallholder farmers

In the past, cardamom production in the area was mostly seen as a step in the conversion of natural forest to agroforest and further agricultural intensification (Bullock et al. 2011, 2013). With the closure of the forest frontier, sustainable production systems are needed (EUCAMP 2002; Mpanda et al. 2011).

There are high hopes that planting and retention of AS tree crops in the agricultural landscape under agroforestry systems may in future contribute towards restoration of degraded lands in the East Usambara Mountains (Jamnadass et al. 2010; www.iucnredlist.org). Little quantitative analysis or production ecology and economics has been published in public domain to support these claims, however. There obviously is a long way to go before the hopes can materialize. Farmers involved in the AS supply chain are also

actively engaged in planting of diverse tree species and they do operate their own tree nurseries either in groups or as individuals; a focus on AS alone may not serve their needs.

More than 30 native trees, shrubs, herbs and liana species are used for food and egg laying platforms in butterfly rearing (Morgan-Brown 2010), which provide another significant room to re-plant more plant species on-farm and contribute to protect those in the wild. This is similar to observations made by Morgan-Brown et al. (2010) that participation in butterfly farming increased the drive for conservation because farmers perceive a link between earnings from butterfly farming and forest conservation. While there is some debate on the possible negative consequences of butterfly agriculture as a means of counteracting human-induced habitat destruction (le Roux 2012), what the East Usambaras experience so far is positive.

AS has become a flagship species for local tree domestication, but it is only one of a broad portfolio of species that contributes to local livelihoods – although largely invisible in the economic studies done so far. A total of 56 tree species were mentioned to be used in the study of Leonard et al. (2010) by the villagers as source of local medicines, timber, poles, fuelwood, fruits and vegetables, most of them were obtained from the agroforest plots. Powell et al. (2013) identified 92 wild food species that play a role in the diets of children and mothers in the East Usambara Mountains. Wild foods obtained from the forest accounted for less than 3% of food items consumed, with most of the wild foods obtained in agroforests, on farm. While these wild foods contributed only 2% of total energy in the diet, they contributed 31% of vitamin A, 20% of vitamin C and 19% of iron intake.

Cardamom farmers have shown positive prospects for organic certification in the East Usambara Mountains which is now being tested. It is with this organic certification (a process taking 1–3 years) that farmers will benefit from premium prices from selected buyers. Farmers generally support conservation activities, as it is the forest cover in the East Usambara Mountains that provides a right microclimate and enables cultivation of cardamom and other spices. As said above, farmers normally retain or plant 75–100 tree/ha in a cardamom farm thus retaining a forest-like microclimate. The image that was presented over the years that cardamom in the East Usambara Mountains destroys forests for its cultivation (AFIMP 1988; EUCAMP 2002) is now changing due to many factors such as shrinking forested areas and shifting towards homegardens and agroforestry (Reyes et al. 2006).

Each in their own way, AS, butterfly farming and cardamom all can contribute to an increase in on-farm income-generating activities and thus pulling resources from local people to invest on their farmlands for short- and long-term benefits. This trend is very positive as there is less likelihood that investment made under stable agroforestry systems will be compromised by shifting cultivation as it used to be in the past. However, another factor contributing to re-investing on farm is the fact that there is already diminished forests in the general lands, hence nowhere to expand, as during 1993–2006 a total of 7843 ha have been taken as part of enlargement of protected forests in the East Usambara Mountains.

Sustainagility of the Allanblackia, butterfly farming and cardamom enterprises

Sustainagility aspects of continued change are essential to cope with changes in the broader context. The butterfly activity again shows the most diversified and innovative approach with recent development of a handicraft sideline for a ‘home industry’ next step of processing that makes use of established branding. In the butterfly business, the local NGO that supports the project so far plays an ‘honest broker’ role towards a market that is

environmentally/socially aware. However, with almost 99% of all produce depending on export, the locally elected committee of butterfly farmers is poised to find a way to diversify the products and promote local market. This will also open up for more incoming butterfly farmers, which for now are restricted by the current supply and demand equilibrium stricken by the existing markets.

For cardamom and AS, farmers are likely to stay in the raw material and semi-processed commodity level with fewer opportunities to innovate at least for the near future. However, as efforts to propagate AS and intensifying homegardens in the East Usambara Mountains continue, a future rise in production might trigger alternative ways to increase market value. In addition, local branding and packaging of both AS seeds and cardamom could be vital in eliminating the role currently played by chain of middlemen and raising the product value.

Recently, the government of Tanzania launched a parallel attempt to promote development of AS and Cocoa (*Theobroma cacao*) production under the Ministry of Agriculture, envisioning that the two could benefit from each other in value addition. Single source origin of processed chocolate is one of the key strategies in boosting both internal and external market of the Tanzania's cocoa, which already enjoys desirable unique flavour profile from a high-quality, fully-traceable certified cocoa (http://www.barry-callebaut.com/). AS-Cocoa value addition exploration would open up ventures for more diversified use of the two commodities, as already one local brand of cocoa is produced within the country named Chocolate Mamas and there are two more companies including Neuchatel Chocolate (a Swiss chocolate making company) which are reportedly to be planning to set up chocolate manufacturing facilities in Tanzania.

The East Usambaras have for long been a testing ground for governance approaches to combine conservation and development (Stocking & Perkin 1992; Rantala et al. 2011). The Tanzanian Community-Based Forest Management policy assumes that formalized forest tenure by village communities results in increased incentives for sustainable forest management (Rantala et al. 2012). A study by Rantala et al. (2012) suggested that management currently is effective at the village scale, but that concerted efforts will be needed to increase its long-term and landscape-level sustainability, and to create more significant incentives for the communities involved. Rantala and German (2013) posed that the current outcomes of community-based forest management in the area, favouring conservation over exploitation, critically depend on contested claims to legitimacy within intra-community social and political dynamics and will require structures for improved deliberation, representation and accountability to achieve long-term sustainability. Kaczan (2013) reported ongoing experiments to provide direct economic incentives for on-farm tree conservation in the area.

Conclusion

The transition of three commodities Allanblackia, butterflies and cardamom along the domestication continuum have overall brought lessons on efficiency, sustainability of the ecosystem and sustainagility of their use over time. Cardamon became an economic success, and as such a threat to the remaining natural forests. Butterfly pupae are a niche market product that serves a limited number of forest-edge farmers well, but may not have much further opportunities to grow. Allanblackia is in the early stages of a long road towards becoming a significant contributor to local livelihoods. Differences in institutional settings of these three domestication pathways relate to their potential to reconcile biodiversity and livelihood concerns and suggest that a socio-ecological system

approach to domestication is a prerequisite for a biological–technical one to achieve societal outcomes.

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