Biodiversity change and livelihood responses: ecosystem asset functions in southern India

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September 2012

Working paper, Centre for Development, Environment and Policy,
SOAS, University of London

Summary

We investigate the livelihood responses of two ethnic communities in a village in southern India to changes in biodiversity arising from the invasion of forest by Lantana camara. The invasion of forest by Lantana has led to changes in the attributes and functions of four key livelihood assets: forest grazing, bamboo for basketry, palm leaf collection, and wild foods. We observe that differences in households' and individuals' ability to substitute important functions of lost or declining assets affects their ability to adapt to changes in resource availability and attributes. A focus on change in the attributes of key livelihood assets provides a useful lens through which to look at impacts of environmental change. Analysing changes in attributes for different user groups encourages the social effects of environmental change to be disaggregated, thus acknowledging social differentiation of impacts.

Key words: assets, biodiversity, India, livelihoods.

Acknowledgements: This research was funded by Ecosystem Services for Poverty Alleviation (ESPA) Project Framework Grant on Human Adaptation to Biodiversity Change (NE/I004149/1). ESPA is a programme funded by the Department for International Development (DFID), Economic and Social Research Council (ESRC) and Natural Environment Research Council (NERC). We thank Kumar Chinmayee for assistance in the field and staff at ATREE, Bangalore, for support: Ramesh Kannan, Harisha RP, Narayan and Madesha. We are grateful to Patricia Howard and Rajindra Puri for comments on an earlier draft. The views and any errors or omissions are the authors' sole responsibility and do not represent those of any other parties.

Introduction

Rapid loss of biodiversity has potentially devastating impacts for communities in which livelihoods are directly dependent on natural resources, but these impacts are dependent on interactions between exogenous processes driving biodiversity change and complex and variable livelihood responses. In this paper we investigate these interactions in two ethnic communities in a village in southern India where natural resource based livelihoods are threatened by the changes in biodiversity precipitated by the invasion of the notorious weed *Lantana camara*. To explore communities' and households' responses to biodiversity change we characterise biodiversity change in terms of quantitative and qualitative changes in assets providing services within people's collective and individual livelihoods. We then examine how these changes, and people's perceptions of them, affect both the roles which assets play in peoples' livelihoods and, with other assets, the ways that people adapt and craft their livelihoods in response to change.

Methodology

The study used an 'ecosystem asset function framework' (Kent and Dorward 2012) which combines categorisation of different functions of assets in livelihoods (for example Swift 1989; Dorward et al. 2005; and Davis 2011) with the Millennium Ecosystem Assessment categorisation of ecosystem services provided by natural resources (MA 2005). This brings natural and other resources together in a common framework where all livelihood assets can be conceived as serving one or more of a variety of functions (Table 1). Analysis using this framework not only promotes the integrated analysis of natural and other assets, it also encourages a more holistic consideration of diverse asset functions in livelihoods.

Examination of assets' functions requires investigation of the livelihood contributions of different assets and of the attributes that enable them to provide different functions. Although some asset attributes are innate, others are shaped by context, perceptions and other resources available to their users. Hence, the functions and attributes of an asset differ between people. Consideration of environmental change as change in the attributes of affected livelihood assets in relation to identified functions then enables analysis of the social and cultural specificity of change impacts.

Data collection for the case study comprised interviews and observations conducted during two periods residence in the village during July/August and December 2011 for a total of nine weeks. Data collection tools included the use of historical matrices, spending checklists, group interviews and oral histories. All qualitative data (field notes, interview transcripts, photographs and film) collected during the field period were managed and later coded and analysed using NViVO.

Information on the functions of assets and their important attributes was obtained indirectly though interviews and observations around livelihood activities and directly though semi structured interviews which questioned what a particular asset was for (for example 'why do you need cattle?') and why it was valued (for example 'what is good/bad about broomstick collection?'). In this way asset functions and attributes were explored both inductively (drawing on perceptions expressed by respondents) and by employing *a priori* categories, derived from other work (Siegal and Alwang 1999; Dorward et al. 2005).

Study area

The study village, Kombuddikki, lies in the Male Mahadeshwara Hills forest reserve in Chamarajanagar, the southern-most District of Karnataka. The village is linked to the town of Deverahalli (also known simply as MM Hills) by a tarred road, a journey of approximately 9km regularly serviced by jeep. The town itself is the site of an important Shiva temple and receives many thousands of devotees each year. Deverahalli therefore has excellent transport links with other districts and urban centres, but outside servicing these pilgrims has limited trade or commercial activity. The community in Kombuddikki is comprised of two ethnic groups who reside in different

areas of the village. There are approximately 30 Soliga households (an indigenous group) clustered at the southern end of the village and 80 Lingayat households dispersed across the village lands (the numbers given here are approximate given the difficulties of counting joint households).

Livelihoods in both communities are based on a mix of permanent agriculture (mainly millets as a food staple and some cash cropping of cassava, maize, castor and sunflower), labour migration to quarries, payment for the collection of forest products, basketry from forest bamboo, and livestock rearing (forest grazing).

Most households engage in crop production on holdings of between one and five acres. Land preparation is largely by draught cattle, though rental of tractors is becoming more common, and households utilise a combination of family, hired and exchange labour. Households supplement subsistence crops with leaves and tubers from homegardens, fields and forest especially during the rainy season. The Soliga also consume small game such as jungle fowl and lizards.

The main forest products collected for a fee under contract in the Kombuddikki area are gooseberry (*'amla', Phylanthus emblica*), *'siga'* (*Acacia concinna*), soapnut (*'antwala', Sapindus emarginatus*) and wild date palm leaves (*Phoenix loureiri*) known locally as *kasagalu (broomstick leaves)*. Gooseberry and soapnut have a short season (one to two months), whilst palm leaf collection continues up to six months (January-May). Bamboo for basket making is collected from the forest as needed. Under the Forest Rights Act villagers can apply for a pass that enables them to collect bamboo for artisanal use.

Both communities thus make regular use of the forest for grazing livestock, bamboo for basket weaving, wild foods (leaves and tubers), and the collection of palm leaves and forest fruits under contract. Bamboo and timber are also harvested for household construction needs.

Impact of lantana on forest use

The invasion of *L. camara* in the MM Hills is considered to be 'relatively recent' (Aravind et al. 2006 citing Ganeshaiah and Uma Shaanker 2001), but by 2001 it was estimated that it has invaded almost 80 per cent of the 290km^2 forest reserve (Uma Shaanker and Kannan 2010). Densities of *L. camara* in dry deciduous forest, the principal vegetation in the reserve, reach up to 2000 stems/ha (Aravind et al. 2010). Elderly informants recalled that *L. camara* first appeared after the bamboo extraction that followed the bamboo flowering in the 1970s. *Lantana* has been a presence in the forest ever since, but a range of different informants expressed the belief that in the past four to five years *Lantana* has become a significant problem.

Lantana is highly competitive, forming dense thickets and thus displacing native understorey vegetation especially in disturbed forest (Aravind et al. 2006; Sharma et al. 2007). Due to these effects on vegetation composition, the invasion of *L. camara* has potential impacts on all livelihood activities that utilise forest resources.

Four broad themes emerge from interviews and observation relating to the impact of lantana on the forest: changes in forest vegetation; obstruction of people and animals; increased time taken and distances travelled for collecting activities; and problems relating to wild animals.

Changes in forest vegetation

All forest products used by villagers (fodder grasses, small bamboo '*kibidru'*, broomstick, wild foods) are perceived to have declined in recent decades. These declines are generally attributed to the lantana invasion although other pressures such as grazing by elephants, harvesting and the effects of reduced rainfall were all noted. Soapnut (antwala) was the only product reported to be unaffected by lantana.

Obstruction and travel times

A frequent complaint about the presence of Lantana is that it prevents people entering the forest: 'we cannot enter the forest' or 'we cannot move in the forest'. Apart from physical obstruction the thorns on the Lantana also cause injury and make it difficult to push through or gather forest products without incurring cuts and scratches. This combines with the problem of lantana covering paths to make moving in or through the forest difficult.

The density of lantana in the forest close to the village means that it is now necessary to travel much further into the forest and this has had impacts on forest use especially in regard to collection of forest foods.

> *'We are not at all going to collect muste [a type of leaf] and sonde [a fruit] nowadays. You have to walk all the way to the foothills and spend the whole day – so we are not getting it anymore. Only lantana is there now'.*

This also has potential impact on how children learn to use the forest since short 'causal' trips in to the forest near the village are less likely.

> *'In my childhood we used to go in the nearby forest. Now we are going over the hill'*

Problems with forest animals
In any conversation about Lantana the increased risk of animal encounters, especially elephants but also bear and leopards, was raised. In the past, encounters with elephants could be largely avoided by keeping a safe distance, however now the extent of Lantana in the forest presents visibility problems: 'Before you could see an elephant on top of the hill. Now even if it is standing next to you, you don't see it'. Furthermore, because lantana inhibits movement in the forest moving away from animals is more difficult. The obstruction of smaller forest paths by lantana means that humans and animals are sharing the same routes thus increasing the likelihood of encounters.

A fear of encounters with wild animals was a reason offered for no longer using the forest:

> *'we are not collecting [greens] because elephant is there and lantana is everywhere. You can't see them, …elephants can lie inside lantana'*

or collecting broomstick leaves:

> *'we do not like doing it [broomstick collection] because it is in the forest and there are elephants, snakes and lantana'.*

Wider livelihood changes
In addition to changes in the forest environment, households in Kombuddikki have experienced significant social and economic change in the past 20-30 years that have implications for the relative importance of different assets and activities in livelihood strategies. These are outlined below:

Labour migration: The most common source of cash income for households is labouring at stone quarries in Andra Pradesh, Tamil Nadu, and elsewhere in Karnataka. Men practice periodic migration to quarries, typically leaving for a month at a time 3 or 4 times a year. The importance of quarry labour has increased for most families in recent decades.

For many Kombuddikki households, quarry labour is a seasonal activity that it is taken up when demands at home (on the farm) are low. However, decisions on frequency of migration are influenced by landholding and family organisation. Households who have no or very limited land holding will alternate quarry labour and basket making or other, local, labour opportunities.

Some informants link the growth in 'outside work' to the decline in the forest and lantana:

> *Because of the lantana we cannot lead life. We cannot enter the forest with our cattle. [If we could] then we would not need to go outside for work. But here the forest is no good. If the forest was good the cattle and goats could be grazed and we would live here only.*

Others explained that it is the higher returns to quarry labour lay behind decisions to go 'outside'.

Reduction in landholdings: Contemporary Google earth images suggest that the village lands delimited in the 1901 land survey map follow the current village boundary. The restrictions placed on cultivation in reserve forest means that there has been no expansion in village lands since this time. We assume that population growth in the village over the past century will have severely reduced the availability of land for cultivation. Descriptions of land holdings reduced in the current generation to less than one acre illustrate the point (names have been changed):

> Doddamma has six sons. She and her husband farmed four acres at the start of their marriage. Now in her seventies she is supported by her last son. Her remaining sons are married but remain local and have built houses close together on the family land. They each have less than 1 acre to farm. Asked how her grandchildren will manage she replies: 'they will do coolie [labour]'.
>
> Doddappa had 2 acres which he has shared between his six married sons who have built houses side by side on the family land. He says he only has enough to give them a space to put a house. Once the land is gone he says the men will go for quarry work and the women for *kasagalu* [broomstick] collection.

Decline in the availability of land has an impact on the ability of households to pursue agriculture-based livelihoods in Kombuddikki. However, income from non-farm activities also enables some landless households to rent land for crop production.

Public Distribution System (PDS): An important change in the lives of Kombuddikki residents has been the introduction of food rations through the Public Distribution System. Although widely criticised for failing to reach target populations elsewhere in India, the community at Kombuddikki appears to benefit from a regular and reliable distribution of low cost grains. Households identified as Below Poverty Line receive 35kg of food grains per month. The preparation of *ragi* (finger millet) was commonly observed throughout the village even in the months leading up to harvest, suggesting that for most households the PDS provides an important supplement to household food production rather than supplanting it.

Self Help Groups (SHG) – In the last two decades there has been a huge expansion in the provision of microfinance in India. This has been largely through the mechanism of the Self Help Group Bank Linkage Scheme in which small village based savings groups are linked to formal banking institutions often with the assistance of NGO actors. Kombuddikki has been a recipient of this expansion in microfinance and at present three NGO supported SHGs operate in the village. All draw their membership exclusively from the Lingayat community.

Most households borrow money to meet consumption needs and are thus engaged in a cycle of borrowing and repaying debts. One advantage of SHG loans is their relatively low interest rates. Men and women discussed the benefits of SHG loans in these terms, suggesting that even though membership of SHGs is usually targeted at women, debts are taken on at the household level.

These broader changes facing the village reflect a pattern of change reported from longitudinal studies elsewhere in India especially in regard to the impact of labour migration opportunities and decline in land availability (Start and Johnson 2004).

Ethnic livelihood differences

Broad differences in livelihood activity can be observed between the two communities. Most evident is that the Soliga have a greater involvement in basket making. Collection of forest products also varies: for some products, such as *amla*, passes are restricted to the Soliga, whereas broomstick collection is open to all, but the Lingayat community have greater involvement.

Observations during July and August (the pre-monsoon period characterised by land preparation activity) suggest a lesser engagement with agriculture among the Soliga. During the fieldwork period all the fields in the Lingayat farms were thoroughly prepared and most were sown by mid August. In contrast not a single field in the Soliga land had been ploughed by this time, most households leaving the ploughing to when the rains began in September.

Livestock holding is more common in the Lingayat community (this could account for some of the delay in land preparation). In the course of this study 27 of 33 Lingayat households for which we have data, reported some cattle holding in contrast to only eight Soliga households. Although these livestock data were not collected as a random sample, both these and observations on agriculture, basket making and NTFP collection closely reflect findings of questionnaire surveys carried out in Kombuddikki village between 2000 and 2009 (Uma Shaanker et al. 2005; Harisha 2009). Data from these surveys also show that average land holding is greater for the Lingayat households, but due to the larger size of Lingayat households, landholding per adult is lower.

Household organisation

The smaller household size in the Soliga community can be explained by the lower incidence of extended households (households containing more than one couple) in that community. In contrast, the pattern in Lingayat households is for sons to remain in the parent household with their wives upon marriage and for the land to be farmed by the joint household together. In most cases respondents in joint households explained that the farm was worked together, but the crop was divided and sub-units of the household cook and eat separately. This presents a departure from the economic pooling sometimes assumed for extended Indian households (cf Caldwell et al. 1984) but corresponds to Rawal's (2008) definition of a joint household as one "whose members generally belong to the same family, live together in the same building or group of buildings, carry some production tasks together and jointly own a substantial part of their assets. In a joint household, the individual nuclear families do not eat from a common kitchen." In this paper we refer to joint households as any household with more than one couple that live together in the same building or group of buildings.

The significance of this observation for our discussion of livelihoods is that joint households appear to be critical to the pursuit of diverse livelihood strategies since they enable households to take up opportunities for wage labour alongside agricultural and livestock activities. In many joint households adult males are variously employed in quarry labour or grazing cattle. Both activities require the availability of additional household labour to sustain on-going agricultural activities.

One household head explained the importance of economic cooperation in joint household as follows:

> *If the land is divided in the family it is more difficult. It is better to share because if someone goes outside for quarry work the others can stay and look after the farm and get the crop. Also if someone goes they can come back and get the tractor for rent.*

Quarry labour competes with agriculture for male labour and in some cases can lead to abandonment of land. For example, the largest single holding in the Soliga community is only partially cultivated because men of the household have been migrating for quarry labour. Thus a large proportion of the land has not been cultivated for four years and *Lantana* has now invaded these fields. Within cooperative joint households periodic migration for quarry work need not be to the detriment of the farm, since this can provide money to pay for land preparation, inputs and labour. As mentioned this type of household organisation is less evident in Soliga households leading to less opportunity for diversified livelihood strategies within Soliga households.

A final note on the differences between Lingayat and Soliga households is that is that the arrangement of dwellings in the Soliga colony does not allow cattle to be kept close. Only households on farmland had cattle pens. Thus Soliga households may be less able to raise and maintain even low numbers of cattle (two-four) as is common in Lingayat households.

Differential impact of Lantana on assets and their attributes

We now consider the impact of the lantana invasion on key natural assets, and more precisely the way in which the attributes of those assets have changed over time for different groups due to Lantana and other external factors. Four important forest assets that have been impacted by Lantana are considered: forest grasses for cattle grazing; bamboo for basketry; broomstick collection; and wild foods. We consider in turn the services that these resources provide households and the attributes that enable them to do this and how Lantana has affected these. These attributes are listed in the first column of Table 2.

Forest grazing

Cattle serve a variety of important functions within household livelihood strategies: they are used for ploughing, providing manure, and threshing (productive functions). They provide small quantities of milk for consumption (consumption function). They provide income though the sale of male calves, hiring out for ploughing, and limited milk sales (exchange functions). They serve as an important reserve of value that can be sold when lump sums of cash are needed (protective function).

Forest grazing is central to cattle raising in Kombuddikki and there is widespread conviction that grazing has been negatively affected by the lantana invasion. Respondents readily describe a time when the forest was more open and spacious and 'full of grass' between trees. According to an elderly Lingayat man:

> *There was so much grass and bamboo, everyone had 30-40 cattle, and they were selling plenty of milk and ghee. We were prosperous then. Lantana destroyed the forest.*

As a result of lantana, cattle herders report having to travel further into the forest and into more dangerous steep and rocky areas. They therefore spend more time grazing every day and have to move continuously to find fodder due to a reduction in the diversity and abundance of grasses. Grazers claim that cattle come home hungry and weak, and are thus more vulnerable to disease, falls, and attacks by wildlife; several residents reported losing cattle for these reasons.

Permanent reductions in herd sizes were related to these to accidental losses and to sales to fund weddings, house building or debt repayments. Reasons given for not rebuilding herds after these events were related to the high cost of buying cattle, problems with the availability of labour, and a lack of grazing. Nonetheless, a number of households described recently acquiring cattle and others expressed a desire to do so – although 'ideal' herd sizes were more modest (less than five animals) than the 30-40 mentioned in the quote above. This suggests that an aspiration to own large herds, reported to have been common in the past, is increasingly rare.

Few households keep cattle primarily as a source of income in Kombuddikki today. For the majority, labour work at stone quarries is the most important source of cash income. However, the role of cattle as productive assets has not changed greatly; two to four cattle are sufficient for ploughing, and threshing and these numbers can be supported.

Although the relative importance of cattle as a store of wealth has substantially declined, it has not disappeared. Improved access to financial services may further reduce the salience of this function, however cattle provide collateral for loans and hence can be viewed as important assets for realising access to finance.

Physical access to fodder grasses has been impeded by lantana and the productivity of most grasses is reduced. These changes have in turn had impacts on important attributes of cattle as livelihood assets namely 'productivity', 'holding costs' and 'security'. These changes have perhaps impacted most obviously on those Lingayat households for whom livestock were previously a mainstay of livelihoods. However, even for those who may have only maintained small livestock holdings, the increased costs of maintaining cattle, coupled with their increased susceptibility to disease and accidents reduces the capacity of cattle to function as security for households thus potentially increasing their vulnerability.

Bamboo and basket making

Basket making is an activity carried out in many Soliga households, predominantly by men. Women undertake some activities but rarely carry out all of the tasks involved in production. Respondents explained that commercial basket making began during the 1970s when large-scale bamboo extraction was carried out by the paper mills and contractors were based in the village. During this time households were supplied with bamboo (*Dendrocalamus strictus*) to weave and the contractors bought baskets from them. (Note the large bamboo taken by the paper mills is *Bambusa bambos* and not the species that is used for weaving). After the contractors left people continued the practice, first selling in Deverahalli themselves and for the last 20 years to traders who come to the village. Baskets are also used within the village for barter, exchange for small items such as tea, jaggery and matches.

As described above, there is currently a marked difference in the degree to which the Soliga and Lingayat households engage in basket making. Most Lingayat informants explain that although they have undertaken basket making in the past they no longer bother following the decline in bamboo due to Lantana. Among the Soliga, men readily describe the increased time it now takes to source bamboo for baskets – but evidently it is still considered an activity worth undertaking. Why is this and what are the Lingayat doing instead?

Both communities agree that quarry labour is more remunerative than basketry. However, residence is not established at the site and the village remains home: 'if we stay there we will forget our village'. Whereas young Lingayat men may concern themselves with farm work when they return from the quarry, for many Soliga basket making will be resumed. Basket making is largely an individual pursuit (though households may go collecting together) requiring little or no investment and thus is potentially open to all irrespective of individual or household asset holdings.

Advantages of basket making include being able to remain in the village and the less arduous nature of the work compared with labouring: 'you can make them in the shade and there is not much body pain'. Basket-making can also be combined with minding cattle: we observed several Soliga who combined basket making with the grazing of cattle, both during daily trips and in cowsheds over several weeks. Indeed one of the oldest cowsheds used by the Soliga is just downslope from one of the best places to source *kibidiru*, the bamboo used for baskets.

Another important feature of basket making is that the traders make advance payment for baskets; in some cases the relationship between traders and weavers is such that traders will forward significant sums (up to 5000 rupees) and therefore act as an important source of loans as well as regular income. This function of basket making needs to be taken into consideration in an assessment of its value as a livelihood activity. All households interviewed in the course of the research regularly borrow money and avoiding the high interest rates of moneylenders is one of the primary benefits of the SHG membership. However, the Soliga as a group have not been successful in initiating or sustaining the institutions necessary to access these new forms of credit. Therefore it can be argued that the relationship with basket traders is one worth maintaining and one that will continue to be valued where sources of finance on favourable terms (such as SHGs) are not available to the Soliga.

In addition to being a low return activity (compared to quarry work), basket making may be viewed by Lingayats as a low status activity. The Soliga are described by the Lingayat as a people who 'do not work', survive on hand-outs, and roam about the forest. Lingayat informants were keen to distinguish themselves from their Soliga neighbours by their attitude to work, their shunning of meat and their status as priests. The explanation from one woman that the Lingayat would go blind if they make baskets can be seen as an assertion of difference. Among the Lingayat there is therefore a possible stigma associated with basket making as an activity primarily of tribal people.

In summary basketry and therefore bamboo, serves different functions between the two communities. For the Soliga basketry provides income and access to credit; it is compatible with other income earning activities and does not require access to other assets (land, labour, capital).

Broomstick collection

Largely due to its long harvest period (up to 6 months), broomstick (*Phoenix loureiri*) collection is potentially the most remunerative of the forest products extracted under contract. When the contract is issued women typically work 4 days per week cutting broomstick leaves. Payment is per bundle and in arrears, reportedly 8 days following collection. Incomes ranging from 400-1000 rupees/ week for the duration of the contract were reported by Lingayat women.

Broomstick collection is carried out mainly but not exclusively by women. This was explained by the higher labour rates that men can expect to earn out of the village. For work in the village women receive a daily rate of 50 rupees per day compared to 100 rupees per day for men. Broomstick collection is valued as one of the few income earning options available to women in the village and it pays well compared to field work. In recent years women's cash income has gained significance as it facilitates participation in SHGs; it was regularly discussed in reference to the role it plays in providing income for the regular savings required of SHG members.

There is a perception that *Phoenix loureie* is in decline due to *L. camara*, and it was noted that collection times are longer. Women repeatedly expressed concern about the future of this source of income.

During the present study, men and women in both communities confirmed the findings from an earlier survey (Uma Shaanker et al. 2005) that broomstick collection was less important among the Soliga. Interviews with seven Lingayat and seven Soliga households to consider why people engage, or not, in broomstick leaf collection gave surprisingly contrasting responses. In brief, Soliga respondents could find little positive to say about broomstick collection in contrast to the Lingayat respondents who readily recounted why it was a good activity for women, emphasising its compatibility with domestic tasks and its relatively good remuneration. Collection is also undertaken in the dry season when agricultural activity is lower. The negative aspects of palm leaf collection put forward by the Soliga related to having to enter the forest. Concerns were raised about snakes and

elephants and women explained they would prefer to earn less doing wage labour in the village and stay close to home. Lower incentives for income earning by women in the Soliga community may also contribute to less interest in palm leaf collection.

In summary, broomstick serves an important exchange function for both groups. But for the Lingayat women this also represents an asset important for savings and access to credit, thus fulfilling productive and protective functions also.

Wild food plants
Households supplement agricultural production and PDS rations with wild foods such as green leaves and tubers. Both are collected in the forest, mainly during the rainy season and leaves are also collected from agricultural land. In the absence of purchased or cultivated vegetables, wild greens provide an important source of dietary diversity. Respondents explained that the availability of these foods in the forest has declined significantly in recent years. Much of this decline is attributed to the lantana invasion which has altered the understory vegetation where they are found and has made it very difficult to enter the forest.

The primary function of these assets is consumption; they are not collected for sale. Their consumption may contribute to a cultural identity (especially among the Soliga) but they are not used for ritual or religious purposes. Wild foods may also serve a buffering (protection) function, providing supplementary seasonal foodstuffs when crops are not around.

Summary
The changing attributes of broomstick, bamboo for basketry, and wild foods are summarised in Table 2. Here we have indicated where changes in attributes differ between groups. For some attributes (productivity, holding costs, risks, physical access), changes can be attributed to *Lantana camara*'s spread in the forest while for others (complementarity, productivity and substitutability) changes are linked to wider changes in the community or wider economy (for example increasing land pressure, increased off farm employment outside the community as migrant labourers, the public distribution system). Some of these attributes vary between social groups (for example between members of two different ethnic groups and between men and women within these groups). Differences in attributes between groups reflect households' and individuals' ability to substitute important functions of lost or declining assets and hence their vulnerability to the impacts of Lantana invasion.

Discussion
This paper has used an analysis of changes in asset functions and attributes to examine livelihood responses in a southern Indian village affected by forest biodiversity change following the spread of *Lantana camara*. We conclude with a discussion of the insights this analytical approach has brought to the study.

The study has examined how the invasion of forest by *Lantana* has led to changes in the attributes and functions of four key livelihood assets, with explicit consideration of the wider functions of assets beyond income generation. In this we also take into account trends in the wider social and economic context and interactions of these with differences in asset functions and attributes between two ethnic groups and between men and women. A key observation is that differences in households' and individuals' ability to substitute important functions of lost or declining assets affects their ability to adapt to changes in resource availability and attributes.

The analysis suggests that Lingayat households are better able to adapt to the loss of forest assets due *in part* to a pattern of household organisation which means that periodic labour migration (the principle alternative to forest based activity) can be taken up with less detriment to existing livelihood activities. Joint households permit flexibility in labour allocation and allow households to

successfully diversify livelihood strategies. Lingayat households are more likely to maintain small cattle holdings despite loss of forest grazing, and through investment in agriculture continue to meet some or all household consumption needs (and in a few cases realise income from cash cropping). In contrast, the Soliga appear to be in a more precarious position. Periodic migration has contributed to the neglect of agricultural land and leaves cattle holding problematic for small households. Thus for one community, migration provides a means for sustaining agrarian lifestyles (see Mosse et al., 2002), whilst for the other it may contribute to its decline, with some evidence that the absence of male labour has caused abandonment of land and its subsequent loss to Lantana.

Basket weaving is considered unviable by most Lingayat due to declining stocks of bamboo, however, it remains an important income earning activity for Soliga men as one which requires few complementary assets and is compatible with migration. Basket weaving also functions as a source of credit to Soliga households, helping to meet both day-to-day needs and larger expenses. We hypothesise that this function is not similarly valued by the Lingayat who have access to other sources of credit.

As suggested above, some of the livelihood differences observed between the two groups may be explained in part by a more individualised social organisation among the Soliga. This may reflect an emphasis on individual autonomy which is widely considered to be characteristic of forager (or formerly foraging) societies (Gardner, 1991). It could be argued that this trait is also reflected in the Soligas' preference for pursuits with immediate return and low investment in agriculture. Thus, an apparent 'failure' to accumulate or sustain land and livestock holdings within the Soliga community may reflect cultural values in this group (as has been explored in other south Indian former foraging societies e.g. Norstrom, 2003). However, whilst acknowledging cultural differences between groups we must also consider the external relationships that may reproduce or reinforce inequalities.

Differences in access to credit illustrate ways in which institutional differences between Lingayat and Soliga communities also affect asset attributes and functions and the impacts of biodiversity change: the introduction of SHG groups has assisted the adaptation of some households, but not in both communities. While SHGs have been initiated in both communities, only in the Lingayat community have they continued to operate. Social barriers prevent those Soliga who wish to participate in SHG from joining established Lingayat groups. Individual Soliga must then rely on moneylenders or the basket traders for finance.

The review of contextual influences on and interactions between changes in asset attributes also suggests that because women are less likely to migrate they are potentially less able to adapt to loss of certain forest assets as compared with men, whose income earning largely takes place outside the village. This suggests that a further decline in the abundance of *Phoenix loureiri* (broomstick) will have a significant impact on women's income earning potential. However decline in broomstick may have broader implications for households than might be suggested from its income contribution alone since current access to regulated microfinance is largely through women's SHG membership which depends to a degree on broomstick income under women's control.

The case demonstrates that analysis of changing asset functions and attributes and their interactions in people's livelihoods can provide a useful framework for exploring the impacts of biodiversity change on those livelihoods. A focus on change in the attributes of key livelihood assets provides a useful lens through which to look at impacts of environmental change because functions and attributes are in part the product of their social-cultural context. Analysing changes in attributes for different user groups also encourages the social effects of environmental change to be disaggregated, thus acknowledging social differentiation of impacts.

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Table 1. Asset functions – definitions (Source: Kent and Dorward 2012)

Asset function category	**Description**
Consumable assets	Assets that have a direct use value. For example direct consumption (foods) or assets used for fuel, or shelter.
Social/ cultural assets	Assets that may have social value for example as symbolic of status, or they may be used to establish social relations and fulfill social or religious obligations. They may have a social function relating to group identity.
Productive assets	Those that generate new resource flows. These assets may represent an investment by the holder.
Exchange assets	Assets or processes that fulfill an exchange function, generating exchange value and serving as convertible income or savings. Exchange or convertible assets may also provide a buffering function, and thus be important for reducing vulnerability (providing insurance) or for consumption smoothing.
Savings assets	Assets or processes that allow accumulation and/or storage value over time. May be associated with temporal transformations or convertible assets / functions or protective (insurance) assets / functions .
Protective assets	Assets or processes provide protection or insurance against shock may either spread risks through diversification across assets or provide claims which can be drawn on following adverse shocks.
Regulating assets	Assets / functions that control patterns and limits with regard to, for example, climate, floods, temperature, chemical composition, sediment loads, disease, wastes, water quality, plant and animal species balances, etc.
Supporting assets	Assets / functions that support other assets through processes such as soil formation, photosynthesis, and nutrient cycling.

Table 2. Changes in asset attributes for three forest products

	Mountain date palm	*Bamboo/basketry*	*Wild foods*
Asset Functions	Exchange (income used for consumption, savings, and investment)	Exchange (income); Protective (access to credit)	Consumption; Protective (buffer); Cultural
Asset attributes			
Complementarity	Good but declining. Increased travel times (due to Lantana) make it harder for women to combine collection with other tasks For men competes with quarry work.	Compatible with migration activities. Low barriers to use (few complementary assets required)	Peak availability is during rainy season which is likely to be a low time for stored foods (crops). However, availability of PDS rations reduces the relative importance of wild foods to diets
Convertibility	Convertibility good but entirely dependent on issue of contract.	Market for baskets appears strong. Traders will take all that are made.	Not traded
Use costs	Low – no management activity undertaken by users Accessibility has declined therefore requires further travel into forest – costs of access are higher (time)		
Productivity	Reduced due to lantana invasion		
Reproduction	Reduced due to lantana invasion		
Access, control	No change in rules but physical access constrained		
Security (future availability of resource)	Future availability very uncertain, perception that it will be gone in 2-3 years.	Some informants suggested that decreased presence of forestry officials and police have increased use of resource by outsiders. Impact of lantana and grazing by elephants, possible reduce security of future access	Future availability very uncertain due to Lantana dominance of understory.
Cultural value		Basketry may be increasingly viewed as a Soliga/tribal activity Availability of other income sources may reduce the status of this activity further (Lingayat)	Consumption of wild foods has identity value for Soliga 'this is our food' – less so for Lingayat (possibly even negative value)
Substitutability	For women income (exchange function) not easily subsitutited. Men have labouring opportunities outside village	No viable substitute for bamboo in current basket trade Income function substituted by labour outside village. Credit function possibly substituted by financial services (SHGs) but not currently available to Soliga	PDS rations substitutes buffering role (protective function) of forest staples (tubers). However, fruits and leaves less easily substituted especially in poorest households. Role of foraging in cultural identity (Soliga) not easily replaced
Risk	Risk from wild animals perceived to have increased due to lantana invasion.		