Biomass and Bioenergy 114 (2018) 55–62

Contents lists available at ScienceDirect

Biomass and Bioenergy

journal homepage: http://www.elsevier.com/locate/biombioe

Short communication

Understanding marginal changes in ecosystem services from biodiesel feedstock production: A study of Hassan Bio-Fuel Park, India

Evelien de Hoop

[a] Eindhoven University of Technology, Department of Industrial Engineering & Innovation Sciences, IPO Building, Het Eeuwsel, Eindhoven, The Netherlands
[b] Utrecht University, Copernicus Institute, Innovation Studies, Heidelberglaan 2, 3584 CS Utrecht, The Netherlands

ARTICLE INFO

Article history:
Received 21 July 2016
Received in revised form
7 June 2017
Accepted 10 June 2017
Available online 14 July 2017

Keywords:
Biodiesel
Millettia pinnata
India
Ethnography
Ecosystem services
Hassan bio-fuel park

ABSTRACT

Small-scale biodiesel production with a high level of community involvement has been associated with a number of benefits. These include relatively low environmental impacts, lack of competition with food production, strong poverty alleviation effects and enhanced access to energy. This Short Communication provides a qualitative analysis of the effects of the cultivation of biodiesel oilseed tree crops (mostly *Millettia pinnata*, along with *Simarouba glauca*, *Azadirachta indica*, *Madhuca lungifolia* and *Jatropha curcas*) in such a small-scale project, the Hassan Bio-Fuel Park in Karnataka, India. This extensive ethnographic research and using the ecosystem services approach to synthesize the findings suggests that the changes in both the flows of ecosystem services and different constituents of human wellbeing are marginal. While the ecosystem services approach can be useful to synthesize various forms of knowledge on biofuels to inform policy, this particular case study highlights the importance of being open about the different, often implicit, priorities and values of research projects and the various kinds of actors involved in biofuel production. Finally, it is crucial to understand not just which impacts are generated but especially how those impacts are generated.

1. Introduction

India's biofuel policy came out in 2009, 6 years after India's Planning Commission presented the National Mission on Bio-Diesel. The Mission kick-started national interest in biodiesel production, while arguing that biodiesel and ethanol will "contribut[e] to energy security, climate change mitigation, apart from creating new employment opportunities and leading to environmentally sustainable development" [1]. The extent to which these claims can be materialized in the case of biodiesel production arguably depends on the organizational model that is deployed.

Firstly, there are large-scale block plantations that sell feedstock on national or international markets. However, this model has been associated with low environmental sustainability, employment opportunities for a limited number of people, and even land-grabbing [2–4]. Outgrower schemes, on the other hand, may face difficulties gaining farmers' acceptance and could impoverish those farmers that do not have good access to resources such as water, pesticides and fertilizers [2–7]. A third model are small-scale schemes with high community involvement in growing/processing the feedstock and using the biofuel. In such schemes, biodiesel feedstock may be grown as hedges around the main cropland or other locations designated as suitable by the community [6–12]. It has been argued, particularly by the FAO and Energia, that such schemes have the potential to contribute towards rural development (especially for women), as well as improve local energy access [8,9]. In India, these projects include, among others, the Ranihedra rural village electrification initiative of Winrock international India and the biodiesel project in Mohuda, Ganjam district, Orissa, initiated by CTxGreEn and Gram Vikas. However, it is unclear whether this potential can be realized in practice.

This Short Communication presents and discusses the impacts of a small-scale biofuel scheme with high community involvement in the state of Karnataka, called Hassan-Biofuel Park. Besides being an illustrative example of a small-scale scheme with high community involvement, it also informs and legitimizes the Karnataka State Biofuel Policy [13]. This study adopts the ecosystem services approach as adapted for biofuels by Gasparatos et al. [13,14] and Stromberg et al. [15] from the ecosystem services conceptual framework of the Millennium Ecosystem Assessment [16]. This conceptual framework has been selected because it aims to

E-mail address: e.dehoop@uu.nl.

http://dx.doi.org/10.1016/j.biombioe.2017.06.006

generate a cohesive body of knowledge for policy-makers that links environmental change to human wellbeing [17].

2. Methodology

Hassan Bio-Fuel Park started in 2006 and promotes the small-scale production and use of biodiesel in Hassan district, Karnataka State, India (Fig. 1). It aims to encourage farmers to grow oilseed trees. Seedlings of various species, mostly *Millettia pinnata* (Pongamia pinnata, locally referred to as honge), *Simarouba glauca*, *Azadirachta indica* (neem), *Madhuca lungifolia* and *Jatropha curcas*, are offered to interested farmers free of cost.

By planting the seedlings around (rather than on) the main cropland, the researchers who run the project argue to avoid the food-fuel conflict and the diversion of agricultural inputs such as water, fertilizers and pesticides. So far, the project has reached out to half of Hassan district's 2593 villages and has interacted with approximately 100,000 farmers [18,19]. The project has its own oil expelling and transesterification facilities and supplies biodiesel to the Bangalore Metropolitan Transport Corporation at a maximum rate of 3 m^3 per month (3000 L per month). Existing literature describes the project as potentially beneficial, particularly for women and rural poor [10,11].

Hassan Bio-Fuel Park's office and research station is located along a highway that connects the cities of Bangalore and Mangalore. The district headquarters are located in Hassan city, which is in the centre of the district and about 20 km west from Hassan Bio-Fuel Park office and research station. The villages participating in the Hassan Bio-Fuel Park project are located throughout the district.

This Short Communication offers a qualitative assessment of changes in ecosystem services due to the activities within the Hassan Bio-Fuel Park project, and the effect of these changes to key constituents of human wellbeing [12,14,16]. It draws primarily on ethnographic research spread across 14 villages (Table S1, Supplementary Electronic Material) carried out between September 2013–March 2014, and in October 2015. The actual names of the villages are not mentioned because some of the information discussed in this research is confidential and sensitive.

This ethnographic research consisted of informal, open-ended conversations with farmers (more than 200 in total) and participant observation while doing farm work or collecting and decorticating honge seeds. This fieldwork was documented on a daily basis, creating extensive ethnographic field notes [20]. In addition, the results presented in this Short Communication draw on over 1000 photos and about 100 short videos of farmers, fields and farming activities. The author also participated in a conference organized by the Karnataka State Biofuel Development Board (KSBDB) and carried out 10 expert interviews with policy-makers, scientists and activists (Table S2, Supplementary Electronic Material). Lastly, unstructured interviews were held with 13 traders of biodiesel oilseeds to understand the overall value chain as well as the current/past availability of these seeds.

Content analysis of this material was done manually and consisted of three rounds. During the first round, research data on specific ecosystem services and aspects of human wellbeing were identified and categorized following the categories proposed by Gasparatos et al. [12,14]. In addition, data on the impact of Hassan Bio-Fuel Park project that could not be categorized in the proposed categories, were collected in a separate file. The second round of analysis consisted of an iterative process during which factors that contributed to each of the impacts were identified in the field data. The third round consisted of analysing the interaction between all of the identified factors.

3. Results

3.1. Impact on ecosystem services and biodiversity

Tables 1 and 2 show that the Hassan Bio-Fuel Park project has very little impact on all the identified ecosystem services and constituents of human wellbeing. A marginal increase was found for cultural ecosystem services and biodiversity. With respect to human wellbeing, only rural development increased slightly due to increased knowledge among farmers. This was mostly related to the uses and marketing options of oilseed species that were already present in the area, particularly *Millettia pinnata* (Pongamia pinnata, or honge), and about the agronomic properties of some new tree species such as *Simarouba glauca* and *Madhuca lungifolia.* However, it should be noted that farmers considered collecting honge seeds, instead of doing more remunerative work, as a lack of rural development.

In addition to the changes documented in Tables 1 and 2, it should be noted that some farmers played a particularly active role, mediating relationships between the Hassan Bio-Fuel Park project field staff and their village. These farmers claimed that they benefitted from the Hassan Bio-Fuel Park project because it allowed them to widen their network, which they felt could be helpful in the future to access government support schemes or to join interesting agricultural programmes offered by companies in the area. This particularly applies for the villages that were identified as the most keenly participating by Hassan Bio-Fuel Park field staff (villages nr. 1 and 2, Table S1 of the Supplementary Electronic Material). Yet farmers in these villages were not particularly active collecting honge seeds in practice.

As argued in Section 3.2, the lack of impacts from the project (whether positive or negative) stems from the fact that there was barely any increase in the availability of oilseeds suitable for the production of biodiesel. Throughout the period of fieldwork, only 4 farmers (out of the more than 200 farmers who were interviewed) indicated that they had seedlings which survived the first year after planting. Some of these farmers could only be identified after specifically asking other farmers whether they knew anyone in the village whose biodiesel seedlings had survived. Furthermore, none of the farmers who were interviewed had started collecting more oilseeds as a result of their involvement in the Hassan Bio-Fuel Park project, though some sold their oilseeds directly to the project's field staff rather than to traders.

Traders and Hassan Bio-Fuel Park field staff offered farmers the same price per kg of oilseeds, which fluctuated between 0.17 and 0.21 € (Rs. 13–16 at a conversion rate of 1 € = Rs. 77) kg^{-1} at the time of the research. To obtain oilseeds for the production of biodiesel, Hassan Bio-Fuel Park's field staff bought oilseeds from traders. However, all interviewed traders testified they would have sold the bulk of their seeds to soap producers if they had not sold them to the Hassan Bio-Fuel Park field staff.

3.2. Understanding the lack of significant impact on ecosystem services

To understand the reason behind the lack of significant impact on ecosystem services and human wellbeing (whether positive or negative), this section follows the process of biodiesel production. This includes all the different stages from the moment field staff from the Hassan Bio-Fuel Park project enter a village, until seeds reach the Hassan Bio-Fuel Park's biodiesel production facilities at the office and research station where they are processed into biodiesel. Doing so will particularly highlight the decisions farmers (including elderly and children) have to make at each stage and the considerations that they may entail. These findings are summarized

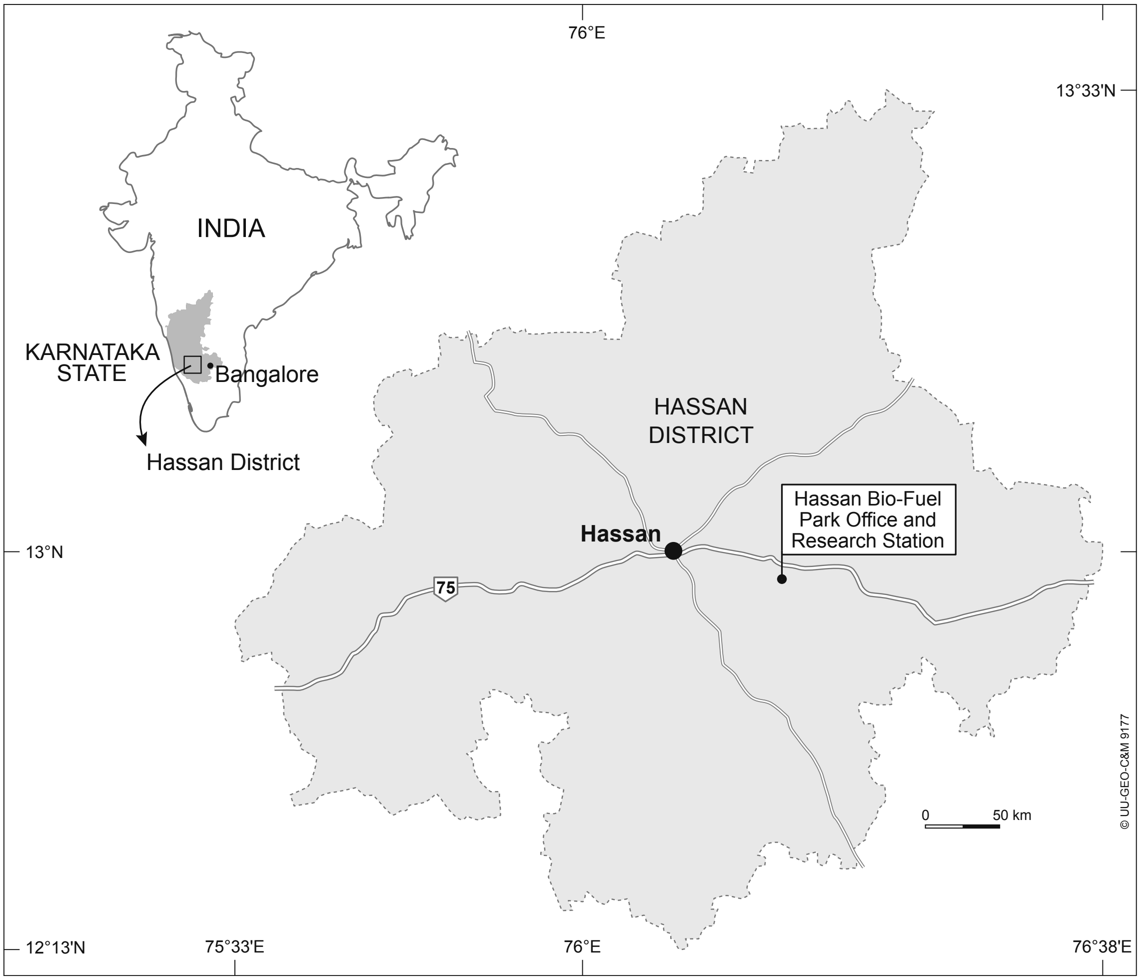

Fig. 1. Map of Hassan District and the location of the Hassan Bio-Fuel Park office and research station.

in Figs. 2–3. The Supplementary Electronic Material contains photographs (Figs. S1–S6), which visually represent some of the issues discussed in this section.

With the exception of one out of the 14 villages studied (village nr. 10, Table S1, Supplementary Electronic Material), farmers were enthusiastic when field staff from Hassan Bio-Fuel Park visited their villages to explain the project and how farmers could participate. In the village where farmers were not so enthusiastic, this was mainly due to negative prior experiences with a company that supplied jatropha bushes and promised to return to buy the seeds, but never showed up afterwards. In all other study villages, the seedlings supplied by the field staff were generally well received. Most farmers planted 5–15 seedlings around their lands, sharing this space with mature honge trees, timber species such as teak and silver oak (*Grevillia robusta*), fruit trees (e.g. mango and jack fruit) or sometimes neem trees. Except honge and neem, the distributed seedlings were largely new to the area.

Honge was the most popular species among farmers, while simarouba also gained popularity throughout the course of the project as it was promoted by scientists unrelated to Hassan Bio-Fuel Park that were interested in its medicinal value. In all, farmers usually planted one or two seedlings of the new species and neem, and 3–5 honge seedlings, though the exact composition of the set of seedlings planted by individual farmers varied a lot. Neem trees are also traditionally present in parts of Hassan district, for example around Arsikere in the north-west of the district. However, they were not popular in the study villages with trade flows in neem seeds being at least an order of magnitude lower than trade flows in honge seeds. Many farmers said that they planted the new kinds of trees simply for the sake of experimenting and being able to witness how the tree would develop. They usually had some space available where such experimentation could be done.

Giving those seedlings the amount of care that they required during the first dry seasons was difficult. Farmers rarely planted the seedlings around irrigated land, where they used the edges of the land to plant rows of profitable trees such as coconut. Carrying water during dry spells, from scarce water sources to the seedlings planted around dryland areas, was something most farmers were unwilling to do. They often asked "*how can we water our plants, if we do not even have drinking water for ourselves*?" They also added that they would have made more effort if the trees had large long-term cash benefits (e.g. timber) or very clear direct use- and cash value (e.g. fruit). Several farmers suggested that if they had been given fruit or timber seedlings, they would have planted those rather than the seedlings supplied by the Hassan Bio-Fuel Park project.

As discussed in Section 2, the Hassan Bio-Fuel Park office and research station produces biodiesel from honge seeds collected from mature trees. Collecting such seeds was a long-standing practice in the area and there was an existing market as these seeds are often used for soap production. However, the number of

Table 1
Changes in ecosystem services and biodiversity due to activities in Hassan Bio-Fuel Park.

Category	Ecosystem service	Trend	Comment
Provisioning	Oilseeds (for biodiesel feedstock or soap)	Marginal increase	Seedlings were provided for free by the Hassan Bio-Fuel Park project staff. Despite the increased planting of oilseed trees, very few of them reached maturity. As a result, feedstock production in the landscape increased only slightly. However, farmers collected and sold oilseeds in the same quantities as they would have done had Hassan Bio-Fuel Park not been active in the area. The project's presence did not make it more attractive for farmers to engage in the labour-intensive practice of collecting and decorticating oilseeds.
	Food	No observed change	Currently, oilseed trees are not grown on the main cropland, but on the boundaries of farms so they do not compete directly with the farm's main crops. Food productions could show a slight decrease if farmers would have planted fruit trees instead of oilseed trees on farm boundaries (e.g. if oilseed trees were not handed out for free by the Hassan Bio-Fuel Park project). Farmers were generally more interested in planting fruit (and timber) trees than oilseed trees if free seedlings had been available.
	Water	No observed change	Oilseed trees are not under irrigation. As a result, their increased cultivation has not diverted freshwater from other human or natural uses.
	Timber	No observed change	Currently, oilseed trees are not grown on the main cropland, but on the boundaries of farms so they do not compete directly with the farm's main (short-term) crops. Timber production could show a slight decrease if farmers would have planted timber trees instead of oilseed trees on farm boundaries. Farmers were generally more interested in planting timber (and fruit) trees than oilseed trees if free seedlings had been available.
Regulating	Climate regulation	No observed change	Direct changes in carbon stocks due to land use change effects from the cultivation of biodiesel oilseed trees are unclear. This is especially the case considering that farmers might have preferred to plant different fruit trees or timber varieties if available at no cost. A full lifecycle assessment is necessary to calculate potential climatic effects.
	Erosion regulation	No observed change	Very few of the trees that were planted reach maturity, and those that did reach maturity were in locations where erosion was not, or hardly, a problem (land with vegetation and little water shortage).
Cultural	Appreciation of the landscape	Slight increase	There are cultural associations with the honge tree, namely the belief that the 'best breeze' can be found under this tree. Hassan Bio-Fuel Park also re-popularizes the use of honge oil for sacred lamps used for religious ceremonies, as a substitute to other oils that are available on the market.
Biodiversity	NA	Slight increase	Hassan Bio-Fuel Park projects introduces new tree species, some of which survive. They do not seem to compete with any rare indigenous species in the location where they are planted, and can therefore be considered an enrichment of the area's biodiversity. Also, they can possibly act as habitat or provide food for some bird and insect species, although this possibility would have to be studied in depth to make any statements on this.

Table 2
Human well-being outcomes of changes in ecosystem services flows from activities in Hassan Bio-Fuel Park: following Gasparatos et al. [12,14].

Constituents of human well-being	Trend	Comments
Rural Development	Slight increase	New knowledge about the uses and marketing options for oilseeds and some new tree varieties
Energy security and access to energy	No observed change	Small quantities of biodiesel (max 3000 L per month) are produced at the Hassan Bio-Fuel Park facilities, but very little is used within Hassan district.
Food security and access to food	No observed change	A slight decrease is possible in case farmers would only grow biodiesel species around their land and no longer grow fruit trees on the land or the oilseed trees suppress food crop growth (reduced food availability).
Health	No observed change	Nothing related to people's health changed as a result of Hassan Bio-Fuel Park's activities.
Land tenure	No observed change	Hassan Bio-Fuel Park encouraged farmers to plant seedlings on the edges of their own land, so land tenure rights were not affected. One case was observed in which a farmer asked Hassan Bio-Fuel Park to supply seedlings to be planted on a small part of the village's common lands. In this case, nobody objected to this initiative. However, if common lands on which some inhabitants depended for fodder, firewood and other products had been used to plant biodiesel seedlings, alterations to customary rights of access would have to be made.
Gender issues	No observed change	People did not change their oilseed collection practices in response to the Hassan Bio-Fuel Park project. Currently, collecting seeds is mostly considered to be a women's task. This means that making collecting seeds more remunerative is likely – though not necessarily – to increase women's workload and perhaps their access to cash.

honge trees in the area declined sharply over the past decade according to both farmers and seed traders. While many farmers said they had 3-15 of these trees in the past in their family farms, most only had one or even none by the time of fieldwork (Figs. S1–S2, Supplementary Electronic Material).

Farmers and traders identified brick makers as the main reason for the decline of honge trees because they regularly visited the study villages to buy fuelwood from these species, which they then used as fuel in bricks kilns. While the seeds of honge trees are freely available for anyone to collect (i.e. the benefits of the a honge tree seeds accrue to the seed-collector), the benefits of cutting the honge tree accrue entirely to the tree's owner. Furthermore, farmers complained that honge trees' large canopies and root structures create shade and obstruct the growth of their main crops. According to farmers' accounts, this characteristic of the honge tree was acceptable to their parents and grandparents, as the tree was traditionally valued for its leaves, which were mixed with the soil for extra fertility. However, this practice had declined in the past decades with the increased promotion, availability and use of synthetic fertilizers.

As a result, apart from enjoying the shade of the honge tree, its seeds are now the only benefit to farmers. Yet, collecting honge seeds is a labour-intensive task that not every farmer is willing to engage with. When men collect honge seeds, they climb the tree and, using a stick, force all seeds to fall down to collect them at once (Fig. S3, Supplementary Electronic Material). However, women collect most honge seeds, but they can only collect whatever they find lying on the ground or reaching from the branches. Therefore, women can only collect a few seeds from a single tree at once. The surface under honge trees is often uneven and may in many cases be overgrown with thorny bushes, increasing the difficulty and time required to collect the seeds (Figs. S4–S5, Supplementary Electronic Material).

After collecting the seeds, they need to be dried and

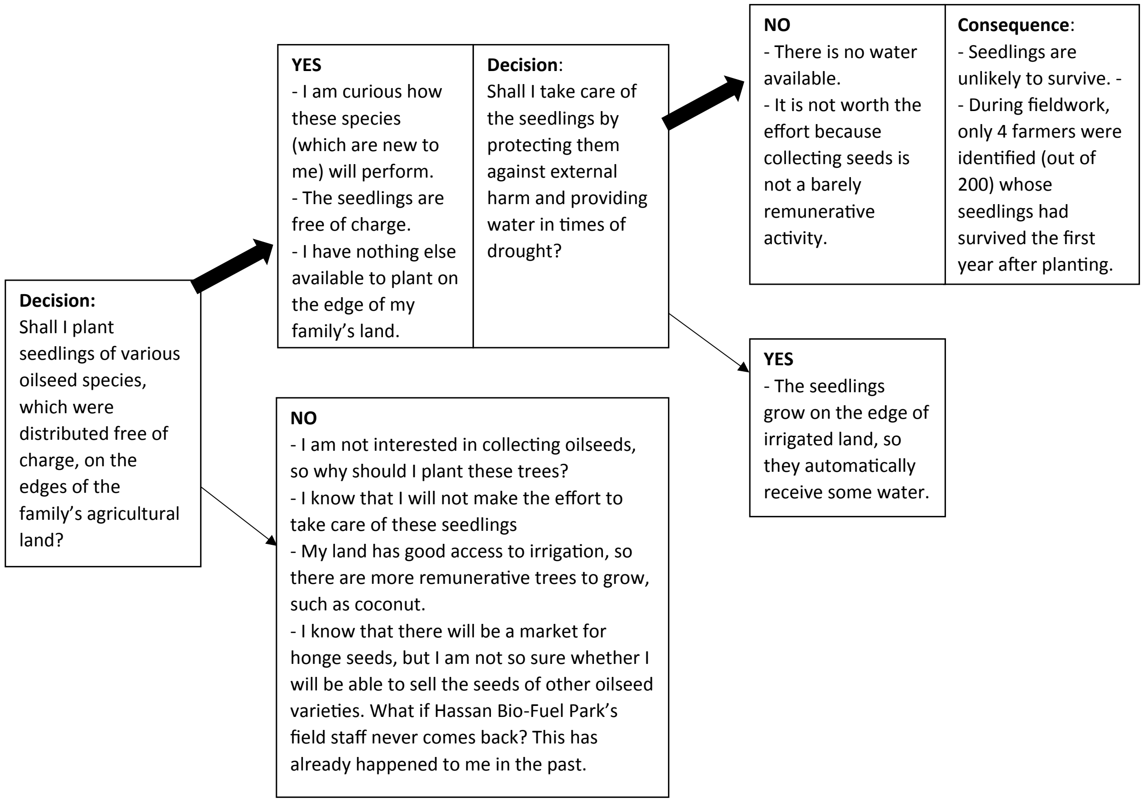

Fig. 2. Farmers' considerations and decisions when adopting oilseed species for biodiesel feedstock. Note: The size of the arrows is roughly proportional to the number of farmers taking a particular decision.

decorticated. Seeds weigh only a couple of grams, and have to be hit with a stick or stone to break the coat, and then to separate the seed from the coat (Fig. S6, Supplementary Electronic Material). All farmers testified that a day of work as daily wage labourer was a few times more remunerative than collecting and selling honge seeds. During the honge harvest season (March–April), which partly overlapped with the harvest of other important crops such as finger millet (*Eleusine coracana*), adults, except elderly, could easily earn 2.6 € d^{-1} (Rs. 200 at a conversion rate of 1 € = Rs. 77) per day as daily wage labourer for large farms doing other agricultural work. On the other hand, spending half a day collecting honge seeds may result in approximately 10 kg of seeds. Drying and decorticating takes another half a day and reduces the harvest to around roughly 3 kg according to the farmers, which is worth 0.51–0.63 € (Rs. 39–48 at a conversion rate of 1 € = Rs. 77).

These observations are strikingly different from calculated expected yield and labour opportunities presented in the 2003 National Mission on Bio-Diesel [21]. The yields assumed in the Mission document were made at a time when peer-reviewed literature on non-edible oilseeds suitable for biodiesel production was scarce. These estimates are very different not only from the results of the present study from Hassan Bio-Fuel Park, but from studies throughout India [5,22,23]. Furthermore, the Mission document assumes the need to create employment opportunities and overlooks the cumbersome process of harvesting seeds, as it largely focuses on the work involved in setting up plantations.

As a consequence of low yields and the labour-intensive process of seed collection, the quantity of seeds sold is not very large. Actually, most villages had a hard time getting at least 200 kg together, which is the minimum amount for Hassan Bio-Fuel Park field staff to be willing to buy directly from a village. For most farmers, selling a few kilograms of seeds at a time at weekly farmers' markets at the same price, was more attractive because it provided a little bit of cash to pay for basic items such as soap. In one village, mature honge trees grow along the riverbank, so almost every household was able to collect roughly 200 kg or more per year (village nr. 7, Table S1, Supplementary Electronic Material). During the harvest season, the village inhabitants brought together the harvested seeds from all households and called Hassan Bio-Fuel Park's field staff to buy the seeds. This saved the farmers the difficulty of transporting the seeds to the market.

Despite the low seed output (and eventually sales), the Hassan Bio-Fuel Park project did distribute a large number of seedlings and is able to produce biodiesel from seeds purchased at existing seed markets. Hence it was able to present this at conferences such as the National Conference on Accelerating Biofuel Programmes in India, in Bangalore (22 February 2014). From interviews with politicians and other stakeholders during and before this event, it appears that these actors continue to be attracted by the project claims of producing biodiesel that can address climate change and rural poverty without affecting food production.

4. Discussion and conclusions

Using the ecosystem services approach for the Hassan Bio-Fuel Park project, this Short Communication shows that despite the extensive effort to promote tree oilseed crops, there is practically no change in the flow of provisioning ecosystem services (whether positive or negative) (Table 1). Furthermore, there are only marginal changes in cultural ecosystem services and biodiversity. These translate into marginal change in only one constituent of human wellbeing, namely rural development (Tables 1 and 2).

Understanding how these effects/impacts manifest (i.e. mechanisms of change), or not, is very important for appreciating the

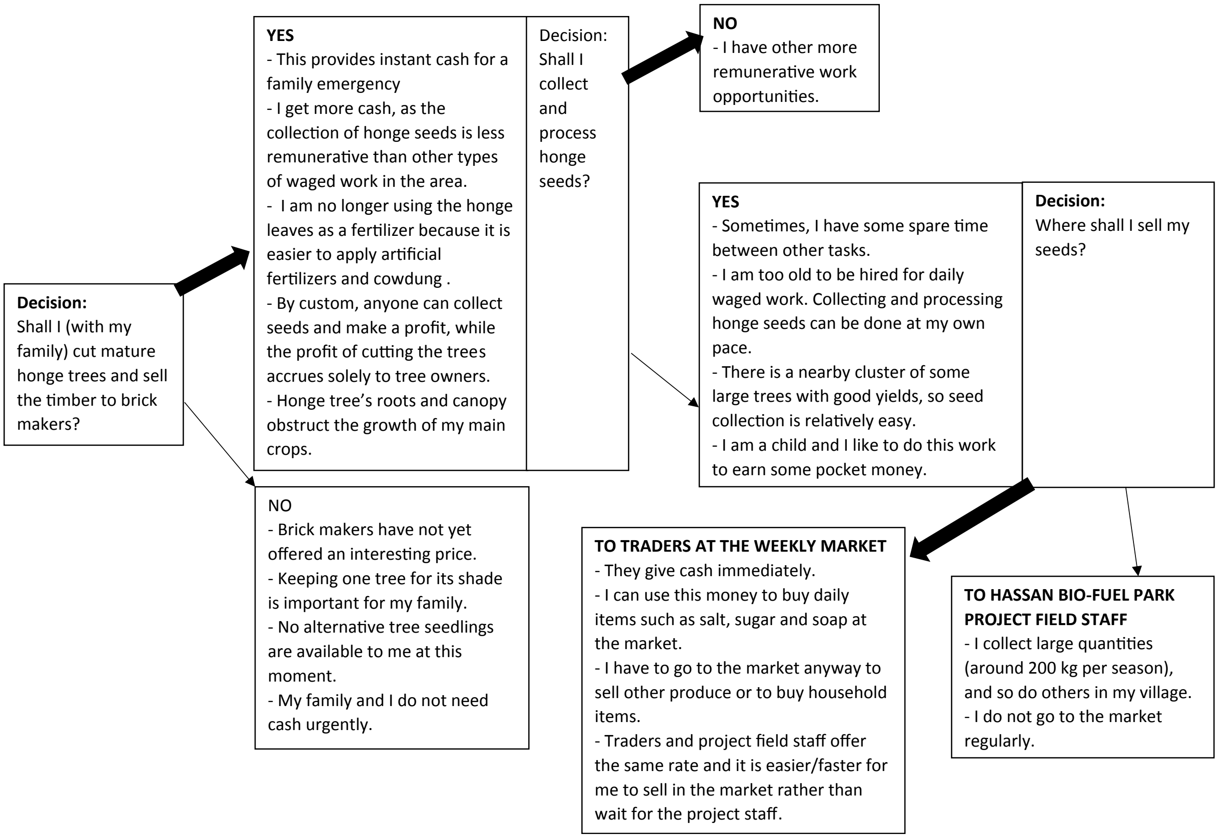

Fig. 3. Farmers' considerations and decisions in relation to the benefits to be derived from mature oilseed trees. Note: The size of the arrows is roughly proportional to the number of farmers taking a particular decision.

performance of biofuel projects. This is especially true in developing contexts where local communities are highly reliant on ecosystem services for their livelihoods [24]. Figs. 2–3 and the results in Section 3.2 constitute a first attempt towards this. They show that there are a number of important factors, which act synergistically to create the low impact of the Hassan Bio-Fuel Park project.

Currently, policy-makers dismiss the underperformance of Hassan Bio-Fuel Park project in terms of generating feedstock (a provisioning ecosystem service), and creating a positive on human wellbeing. The main relevant argument is that 'farmers need to be better informed', and that 'high-yielding varieties will solve the present-day problems'. According to the prevailing mindset, such issues can be solved, and therefore the interest in Hassan Bio-Fuel Park remains high.

However, the factors responsible for this lack of impact according to this study are very different, and include (a) environmental factors (e.g. water scarcity), (b) preferential use of other ecosystem services (e.g. fruit and timber from trees that could be planted instead of honge and other biodiesel trees), (c) the plant characteristics of honge trees (e.g. their wide canopy and extensive root systems that obstructs the growth of other crops, thorny bush undergrowth), (d) wider landscape modification (e.g. road widening), and (e) market issues (e.g. low market prices for honge seeds, brick-makers buying honge trees for fuel). Some of these factors will be very difficult to address, particularly farmers' unwillingness to nurture their honge trees and collect their seeds in the face of far more remunerative farm activities and employment opportunities. These findings were identified through long-term engagement with the project, and would not have been identified in similar detail using a quantitative survey-style approach. The findings also raise serious concerns for the viability of similar small-scale projects as documented for example by Energia and FAO [8–9.].

Furthermore, focusing on how impacts are created also allows for a brief evaluation of 'what could have been' if the Hassan Bio-Fuel Park project did manage to enhance feedstock production. It is highly possible that food and timber provisioning ecosystem services could have declined, because there is competition for land between fruit/timber tree species and oilseed tree species on the edge of agricultural fields. Water availability could have decreased if young seedlings were irrigated during dry spells. On the other hand, fuel provisioning and local energy security as an aspect of human wellbeing may have increased, although that would have depended on whether the produced biodiesel in Hassan Bio-Fuel Park would have been used locally. The climatic effects of using biodiesel instead of fossil diesel would have depended on the specific growing methods used. Thus, a full life cycle assessment considering the potential land use change effects of oilseed tree expansion would have been required to fully quantify the possible climatic effects [25]. When it comes to human wellbeing, rural development may have decreased if farmers decided to forego more remunerative employment opportunities in order to collect larger amounts of biodiesel oilseeds. Food security could have been reduced, if biodiesel trees instead of fruit trees or if the canopy and roots of honge indeed reduced the growth (and thus the yields) of food crops. Lastly, if the additional honge seed collection was done by women (who collect most honge seeds at the moment), it may not only have increased their income but also their workload, which is already very heavy. In any case, significant empirical research would be needed to unravel such effects.

It must be noted, however, that not all the effects of the Hassan Bio-Fuel Park project could easily be presented through an ecosystem services lens. Examples include the competition with soap production and the benefits that some farmers gained from acting as mediators between the field staff of the Hassan Bio-Fuel Park and their village. Despite the fact that the ecosystem services approach is open to methodological pluralism [17], this case study shows that pre-defining 'relevant impact categories' may limit the range of observations that can be documented. In addition, the meaning of pre-defined categories (e.g. ecosystem services, constituents of human wellbeing) can be different for different stakeholders. For example, to the researchers from Hassan Bio-Fuel Park, rural development meant being able to gain an income from collecting honge seeds (a provisioning ecosystem service). However, for most farmers, rural development actually meant moving away from that practice.

These findings give rise to a word of caution, which resonates with (and builds on) the debate between Gasparatos and Stromberg, and Lehtonen on the desirability of unified appraisal frameworks for biofuel sustainability such as the ecosystem services approach [17]. They jointly conclude that "*unified synthesis frameworks can be appropriate in "structured" policy situations, when facts are relatively certain and policy priorities consensual*" [17, p. 79]. However, at this point in time the priorities among biodiesel stakeholders are highly diverse in India and Karnataka, while existing knowledge is highly fragmented and debatable. For example, while India's national and Karnataka's state-level biodiesel policies set blending targets as their main priorities, the Hassan Bio-Fuel Park project is heralded by policy-makers for its intention to contribute to the eradication of rural poverty without affecting food production. Within this setting, it is unlikely that the creation and dissemination of knowledge, however well-organized, will be able to inform policy-making in a linear fashion, as has repeatedly been demonstrated by policy studies [26,27]. Therefore, biofuel studies using the ecosystem services approach should start with the identification of the priorities among the different actors involved, before documenting the impacts of biofuel production according to those priorities. This would create more openness regarding the values at stake when policy decisions are being made, and the way those values can inform the different understandings of biodiesel impacts (cf [28,29]). Indeed, to take this one step further, this Short Communication shows that the process of research is characterized by a wide range of choices (e.g. on what to measure or observe and what methodology is used to do so). For example, it would have been very difficult if not impossible to thoroughly understand why farmers cut their mature honge trees, why they barely take care of their newly planted seedlings and why they hardly collect honge seeds during the harvest season using quantitative research methods. Research outcomes are thus partly the result of these choices made by the researcher, and these choices are debatable [30,31]. As such, openness about such knowledge politics (these choices, the values that undergird them and the ways in which they form an integral part of research outcomes) would strengthen the Ecosystem Services Approach.

Finally, the lack of change created by the Hassan Bio-Fuel Park project (despite being considered to be a success-story in policy circles) raises questions regarding the extent to which other small-scale biofuel schemes that have also been documented as success-stories actually live up to their claims [8,9].

Acknowledgements

The authors would first of all like to thank all members of farming families in Hassan district who participated in this research and the staff of Hassan Bio-Fuel Park. Furthermore, this paper benefited from the constructive comments from two anonymous reviewers and Alexandros Gasparatos. This research is part of the research programme 'Biofuels: sustainable innovation or gold rush?', funded by the Netherlands Organisation for Scientific Research (NWO), award number 313-99-210.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.biombioe.2017.06.006.

References

[1] Government of India, National Policy on Biofuels, New Delhi, India, 2009.
[2] V. Kesari, L. Rangan, Development of *Pongamia pinnata* as an alternative biofuel crop – current status and scope of plantations in India, J. Crop Sci. Biotech. 13 (3) (2010) 127–137.
[3] S. Lahiri, Losing the Plot: the Threats to Community Land and the Rural Poor Through the Spread of the Biofuel Jatropha in India, Friends of the Earth Europe, Belgium, 2009.
[4] J. Baka, R. Bailis, Wasteland energy-scapes: a comparative energy flow analysis of India's biofuel and biomass economies, Ecol. Econ. 108 (2014) 8–17.
[5] P. Ariza-Montobbio, S. Lele, Jatropha plantations for biodiesel in Tamil Nadu, India: viability, livelihood, trade-offs, and latent conflict, Ecol. Econ. 70 (2) (2010) 189–195.
[6] J. van Eijck, H. Romijn, E. Smeets, R. Bailis, M. Rooijakkers, N. Hooijkaas, P. Verweij, A. Faaij, Comparative analysis of key socio-economic and environmental impacts of smallholder and plantation based jatropha biofuel production systems in Tanzania, Biomass Bioenergy 61 (2014) 25–45.
[7] S. Arora, H.A. Romijn, M.C.J. Caniëls, Governed by history : institutional analysis of a contested biofuel innovation system in Tanzania, Industrial Corp. Change 23 (2) (2014) 573–607.
[8] FAO, Small-scale Bioenergy Initiatives: Brief Description and Preliminary Lessons on Livelihood Impacts from Case Studies in Asia, Latin America and Africa, Food and Agricultural Organization, Rome, 2009.
[9] Energia, Biofuels for Sustainable Rural Development and Empowerment of Women: Case Studies from Africa and Asia, Energia, Leusden, 2009.
[10] A. Chandrashekar, L. Naranapur, S. Mahesh, B. Gowda, P. White, Sustainable biofuel strategy in Karnataka state a review, Manag. Environ. Qual. Int. J. 26 (2) (2015) 288–300.
[11] A. Narayanaswamy, B. Gowda, J. Clancy, Biodiesel – a boon or a curse for the women of Hassan district, India? EnergiaNews (December 2009) 24–27.
[12] A. Gasparatos, P. Stromberg, K. Takeuchi, Biofuels, ecosystem services and human wellbeing: putting biofuels in the ecosystem services narrative. Agriculture, Ecosyst. Environ. 142 (2011) 111–128.
[13] Task Force on Bio Fuels, Recommendations of Task Force on Biofuels, Government of Karnataka, Bangalore, 2010.
[14] A. Gasparatos, L.Y. Lee, G.P. von Maltitz, M.V. Mathai, J.A. Puppim de Oliveira, K.J. Willis, Biofuels in Africa: Impacts on Ecosystem Services, Biodiversity and Human Well-being, UNU-IAS Report, Yokohama, 2012.
[15] P.M. Stromberg, A. Gasparatos, J.S.H. Lee, J. Garcia-Ulloa, L.P. Koh, K. Takeuchi, Impacts of Liquid Biofuels on Ecosystem Services and Biodiversity, United nations university: institute of advanced studies, Yokohama, 2010.
[16] MA, Ecosystems and Human Well-being: Synthesis, Island Press, Washington DC, 2005.
[17] A. Gasparatos, M. Lehtonen, P. Stromberg, Do we need a unified appraisal framework to synthesize biofuel impacts? Biomass Bioenergy 50 (2013) 75–80.
[18] http://vlist.in/district/574.html date last accessed: 01-07-2016.
[19] Project Coordinator, Hassan Bio-Fuel Park, interview conducted with author on 10-10-2013.
[20] R.M. Emerson, R.I. Fretz, L.L. Shaw, Writing Ethnographic Fieldnotes, The university of Chicaco press, London, 1995.
[21] Planning Commission, National Mission on Bio Diesel, Government of India, New Delhi, 2003.
[22] K.M. Findlater, M. Kandlikar, Land use and second-generation biofuel feedstocks: the unconsidered impacts of *Jatropha* biodiesel in Rajasthan, India, Energy Policy 39 (6) (2011) 3404–3413.
[23] W.M.J. Achten, L. Verchot, Y.J. Franken, E. Mathijs, V.P. Singh, R. Aerts, B. Muys, Jatropha bio-diesel production and use, Biomass Bioenergy 32 (2008) 1063–1084.
[24] G.P. von Maltitz, A. Gasparatos, C. Fabricius, A. Morris, K.J. Willis, Jatropha cultivation in Malawi and Mozambique: impact on ecosystem services, local Hum. well-being, poverty alleviation 21 (3) (2016) 3.
[25] H.A. Romijn, Land clearing and greenhouse gas emissions from Jatropha biofuels on African Miombo Woodlands, Energy Policy 39 (2011) 5751–5762.
[26] A. Jordan, D. Russel, Embedding the concept of ecosystem services? The utilization of ecological knowledge in different policy venues, Environ. Plan. C Gov. Policy 32 (2014) 192–207.

[27] C.A. Dunlop, The possible experts: how epistemic communities negotiate barriers to knowledge use in ecosystems services policy, Environ. Plan. C Gov. Policy 32 (2014) 208–228.
[28] A. Stirling, “Opening up” and “closing down”: power, participation, and pluralism in the social appraisal of technology, Sci. Technol. Hum. Values 33 (2) (2008) 262–294.
[29] C. Hunsberger, S. Bolwig, E. Corbera, F. Cruetzig, Livelihood impacts of biofuel crop production: implications for governance, Geoforum 54 (2014) 248–260.
[30] E. Turnhout, the politics of environmental knowledge, Inaugural lecture on 02-06-2016, Wageningen University, the Netherlands.
[31] B. Latour, Politics of Nature: How to Bring the Sciences into Democracy, Harvard University Press, Cambridge MA, 2004.