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Formal and informal relations to rice seed systems in Kerala, India: agrobiodiversity as a gendered social-ecological artifact

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Abstract Agrobiodiversity is an evident outcome of a long-lasting human–nature relationship, as the continuous use, conservation and management of crops has resulted in biological as well as cultural diversity of seeds and breeds. This paper aims to understand the interlocking of formal and informal seed supply routes by considering the dynamic flow of seeds within networks across the intersections of gender, ethnicity and age in South India as social categories structuring human–nature relations. This changing relationship under formal and informal institutional settings has consequences on performance for men and women in rice seed systems. Undertaking an empirical analysis of the organization of seed management and exchange, we seek to shed light on the gendered organization of agrobiodiversity as a social network. The study builds on Net-Map interviews conducted in 2012, embedded in the larger BioDIVA project in the district of Wayanad in Kerala, India. Based on network analysis, the interactive method employed has enabled identification of important actors in the seed system and the characteristics of their relationships. We look into the gendered structure of information exchange regarding seed varieties and actual seed transactions, while also examining clusters of actors collaborating regarding seed supply. Finally, we identify the institutional gap concerning seed sources left by formal and informal institutions, like the availability of varieties. We show how informal and formal seed systems coexist and overlap due to actors moving between systems and argue that the degree and areas of overlap are shaped by gendered human–nature relations.

Keywords Seed systems · Agrobiodiversity · Gender-nature relationship

Abbreviations

CBD	Convention on biological diversity
DES	Directorate of economics and statistics

Introduction: agrobiodiversity as a gendered social-ecological artefact

The production of crops for human consumption is based on the availability of seeds. To ensure food security, farmers need to have access to crop genetic resources through properly functioning seed supply systems, based upon either formal or informal seed sources (Lipper et al. 2010). This paper aims to understand the interlocking of formal and informal rice seed supply routes by considering the dynamic flow of seeds within networks across gender, ethnic communities and age, structuring human–nature relations.

Human–nature relations find their expression in symbolic interaction and social acts concerning the material environment. Humans are, on the one hand, part of nature as organisms. The body and its needs tie us in an undeniable way to our surroundings for, among other things, provision of food and shelter. On the other hand, we are simultaneously able to mentally transcend our individual

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selves as conscious, self-reflective and social beings. This continuous interplay between our materiality and our sociality results in us having a social-ecological sensibility. One material expression of the interaction between our material needs and our sociality are social-ecological artefacts, which embody our dual nature and present important objects for studying human–nature relationships. Agrobiodiversity, the great variety of plants and animals created over millennia through humans utilising evolutionary processes for breeding purposes, is one such material, but also necessarily social, manifestation (see Burandt and Mölders in this issue). To examine the intertwining of biological, social and cultural categories, among them gender, age and ethnicity we propose an intersectional perspective on formal and informal seeds networks.

Seed systems are social networks with relational processes and dynamic roles of actors (Aistara 2011). Agrobiodiversity management is a set of linked, but unequal relationships of people of different gender, ethnicity and age to their seeds, practices and knowledge, but also to other people and other species. This dynamic seed system is situated in a landscape, embedded in a cultural memory of place and the larger politics of rural development (see Harcourt this volume). The paper explores the dynamic network relations between seeds and actors as well as among actors to shed light on the asymmetries and overlaps within the rice seed system of Wayanad.

Aligning gender analysis to the study of the socio-ecological artefacts of agrobiodiversity is a means for underlining the gendered social organisation of labour and power that shape agricultural practices and knowledge. At the same time, gender constructions do continuously evolve and change; thus, agrobiodiversity and gender relations partially constitute each other (Padmanabhan 2011). Through closely examining the human–nature nexus, implicit assumptions over the nature of humans and the characteristic of nature become apparent. The lines drawn between humans and nature can tell us about different strategies of othering (Montenegro de Wit 2016), and taking a specifically gendered framing can reveal the social organisation of biological processes—be it for the reproduction of humans or seeds. By unpacking the forms and characteristics of men's and women's involvement in a rice seed system in Southern India, we want to highlight the nuanced and changing ways in which seeds are managed there in order to stress the need for differentiated policy measures. Our gendered analysis considers ethnicity and age, so as to reveal otherwise invisible actors, links and strategies within the seed system, shaped by the cultural contexts of gendered preferences regarding agrobiodiversity.

Ethnicity plays a decisive role in the orientation of Indian farmers towards either subsistence or market production. In India, colonial history has coined indigenous identity by invoking the administrative category of "scheduled tribes", which are among the most disadvantaged socio-economic groups. Embedded in a larger discourse on indigenous identity as distinctive from caste-based Hindu mainstream society, with its particular structural characteristics (Wiesgrau 2013), the so-called Adivasi people face a historical relationship with local elites and the post-colonial state (see Suma and Grossmann, Kunze in this issue) that often involves conflicts regarding status, property rights over land, and political and spiritual autonomy. At the same time, this very identity is tied closely to the use, valuation and practices regarding paddy diversity.

In our study area the cultivation of rice is increasingly being carried out only by Adivasi communities, such as the Kuruma and Kurichya, and the diversity of traditional rice varieties decreased along with a rising number of modern rice varieties (Kumar et al. 2010). Rice cultivation in Wayanad, a district in Kerala, is under pressure due to the conversion of paddy fields to non-food crop cultivation or other commercial purposes. Situated within the Western Ghats region—a biodiversity hot spot—in South-western India, decentralisation politics, the decline of paddy cultivation and an increasing involvement in off-farm labour (see Kunze in this issue) is inducing a shift in values among rural people.

We propose that the gendered outcomes of this process need to be taken into account to fully understand the ongoing social changes affecting the interplay between the formal and informal seed systems existing in the area. Consequently, the present article aims to analyse the rice seed system among Adivasi and Hindu mainstream communities in Wayanad from a gendered perspective, seeking to analyse the formal and informal relations to paddy seed sources of male and female farmers, the current status of the system and flows of traditional and modern rice varieties. The material handling of rice seeds in terms of seed production and storage as well as knowledge concerning different varieties displays a close relation to ethnicity and age. As seed exchange is at the heart of maintaining and using agrobiodiversity for Adivasi and small-scale farmers, the dynamic relations among gendered farmers with distinct identities reveals nodes and missing links of human–nature relations.

Conceptual framing: formal and informal seed systems as dynamic relational networks

The exchange of seeds is vital to agrobiodiversity as cultivars adapt to environments. Farmers have engaged in this since thousands of years in collective action in seed

networks. Social relations related to seed sources, trust between recipients and providers and the types of seed transaction like purchase, exchange, inheritance or borrowing undergo transformations (Padmanabhan 2008). With the subtle replacement of the informally governed exchange channels through a formally organised seed systems backed by the state, the interlinkage of both systems via their users in a social environment of (gendered) hierarchy, conflict and power reveals the agency of farmers and their relations to the central input.

The term "seed system" (Nagarajan et al. 2006) can be understood as a network of seed supply channels that provides farmers with seeds from different sources, depending on the required variety, price and availability. Conventionally we distinguish between two seed systems, an informal and formal one. Regulations, certified seeds, explicit property rights and assured identity of purchased seed varieties define the basis of the formal seed market. The exchange of improved and certified crop varieties takes place through research stations, governmental institutions and commercial seed stockists. In contrast to the former market based system, cultural norms and social relations determine the informal seed exchange (Hodgkin et al. 2007). Within this system, farmers exchange local varieties and non-certified improved varieties and, thus, perform in situ conservation (Sperling and Christinck 2005; Stromberg et al. 2010). Today, farmers in India rely on farm-saved seeds from within the informal seed system for more than 80% of their supply. The Government of India has been implementing several schemes to boost seed replacement rates and raise yields (Ministry of Finance 2011, 2013). However, the informal seed supply system remains vital to the livelihoods of Indian farmers and, consequently, a crucial part of small-scale agriculture (Winge et al. 2013). Both kinds of seed channels provide required seed varieties and are vital for obtaining adequate information.

Farm-saved seeds are selected after harvesting to be processed and stored (Christinck et al. 2005). Farmer's usual reasons for obtaining seeds from other sources include their need or desire to replace or improve their own seed stock, to change planted varieties—due to, for example, decreasing yields or changing tastes—or to try unknown or otherwise improved varieties. The cultivation of local landraces is decreasing because cultivators are choosing improved varieties or previously used varieties have become less vulnerable to stresses such as drought, flooding or pests and diseases. Agricultural practice may change due to lack of input factors or changes in market demand. Knowledge about available seed sources, experience with previously used sources and varieties, accessibility of sources, frequency of acquisition and distribution of seeds as well as recommendations from other farmers also help to shape the flow of seeds (Hellin et al. 2010).

The main factors that affect the accessibility of seeds for farmers are physical availability, information and costs, crop production system, production environment as well as general level of agricultural development (Lipper et al. 2010). Three kinds of information play an important role for farmers in purchasing seeds: variety characteristics (e.g. resistance to pests and diseases, tolerance of floods and drought), quality and price. All have great influence on yields and, consequently, on profitability. Unclear and incomplete information concerning seed characteristics leads farmers to exclude varieties for cultivation. Further, input markets may not be providing the required varieties for farmers or output markets may expect different characteristics and attributes of the seeds cultivated by farmers. In this study, we are interested in understanding access to seeds by and the flow of seeds between, farmers as well as how they obtain necessary information in formal and informal systems in Wayanad.

Beside seeds having the above outlined instrumental value to cultivators, they harbor intrinsic value as they are an embodiment of people's ties to their landscape and place. They have relational value as they represent a deep connection and cultural situated memory and allow for a future imagination of the place (Chan et al. 2016). In this perspective the working of nets around seeds make social-ecological change visible.

Background: the case Wayanad, land of paddy fields

Wayanad is located in the Western Ghats a mountainous region known for its diverse flora and ethnic cultures (CBD 2013). Wayanad, also called *Vayal Naad* (The Land of Paddy Fields), extends over an area of over 200,000 ha and has a population of about 800,000 people (DES 2013). Agriculture is the main occupation, peppers and paddy the most important cultivated crops, coffee and tea the major plantation crops. In Kerala, rice is cultivated during three seasons—summer, autumn and winter—except in Wayanad, where there is no cultivation in autumn (DES 2013). The area under rice cultivation in Kerala has declined from about 17,000 ha in 1999–2000 to 9000 ha in 2011–2012, while rice yields increased slightly during the same period. The gain in productivity could not, however, fully compensate for the decrease in cultivated area. Areas previously used for rice cultivation have been converted to mainly cash crops such as bananas and areca nuts, or transformed into non-agricultural land for construction, brick-making or canals (Jose and Padmanabhan 2015). The conversion of rice fields is driven by large increases in

cultivation costs (labour, chemicals, etc.) without a corresponding increase in rice prices, relative price changes in favour of competing crops, problems with labour availability and increasing demand for housing and infrastructure. These changes have also affected the diversity of traditional rice varieties in Wayanad. From 75 known local varieties, only 20 are still available to farmers (Kumar et al. 2010).

In rice cultivation, women engage as family labour or obtain income as agricultural labourers by transplanting, harvesting and weeding. The role of women in seed exchange encompasses preparation of physical seed exchange as well as supervising storage by applying different methods of seed preservation (Hoffmann 2014). Thus, women are in charge of ensuring seed quality. With rice cultivation decreasing, women are in danger of losing their income source and, therefore, becoming more vulnerable to food insecurity.

The Adivasi population of Wayanad district, at 18.5 per cent, is the largest in Kerala state. The Kurichya (see Suma and Großmann in this issue), Kuruma (see Kunze in this issue), Paniya, Adiya and Kattunaikka rank among the five dominant Adivasi groups in Wayanad. Kurichya and Kuruma are the major rice cultivating communities in the area, due to their having property rights over land, which makes them a cultivating class. The Paniyas and Adiyas, meanwhile, do not own land and, consequently, depend on rice cultivation for employment as daily labourers. These Adivasi communities are the main paddy cultivators and conserve traditional rice varieties by maintaining their cultural traditions and meeting their nutritional and economic needs. The Kuruma and Kurichya have adapted their social structures and norms to share work and resources, because paddy cultivation is labour intensive (Kumar et al. 2010). The Kurichya hold land as common property of joint families, with members of the colony cultivating together on each other's fields. They depend on unpaid family labour—especially women transplanting seedlings and removing weeds, while men do the ploughing—and rarely cultivate using mechanized tools. The chieftain of each settlement decides on cultivation methods as well as crops and varieties. In recent years, the joint family system is increasingly being replaced by the nuclear family, and collective property has been divided among family members. As a consequence, younger members are increasingly cultivating cash crops in order to secure incomes. The Kuruma, meanwhile, have exhibited an even more pronounced shift away from joint family settlements—where members share labour to reduce paid-labour costs—to a nuclear family system. They are increasingly prefering to cultivate other more profitable crops to meet rising costs of living and achieve a mainstream lifestyle. Younger Kuruma farmers are also moving away from agriculture altogether and, as a result, are losing knowledge of traditional rice cultivation methods (Kunze and Momsen 2015).

Methods for studying the rice seed system in Wayanad

Picturing seeds systems as a web between the social-ecological artefact seeds and its relationship to persons, who again interact with other seeds and persons ask for a method taking into account the dynamic social network. To capture the individual strategies of Wayanadian farmers to obtain seeds, their criteria and goals thus pursued, the participatory and interactive method of the Net-map enabled a stepwise identification of seed actors, the quality of linkages and the rationality behind these interactions. Conducted with the assistance of translators, the visualisation of social ties allowed for digging deeper into the characteristic by referring back to the emerging web between identified actors. It thus was possible to probe the different qualities and dimensions of the seed network. Taking the egos perspective gave insight into the strategic handling of two distinct seed systems. While Net-map can help focus the conversation of the emerging relational structure, it must be accompanied by in-depth discussion of the very linkages to reveal the quality of relations. With ever busy respondents the danger of just documenting the structure without the meaning needs to be carefully avoided.

The research was carried out under the auspices of BioDIVA, an Indo-German project on inter- and transdisciplinary research regarding land-use change and agrobiodiversity in South India (BioDIVA 2014; Christinck and Padmanabhan 2013). Interview partners consisted of farmers as well as officials and experts within the rice seed system. In order to analyse the current situation intersectional, the results were compared gender-wise between two different groups of respondents, according to ethnicity and age. The qualitative data collection took place between September and November 2012, using a semi-structured questionnaire and the interview-based mapping tool Net-Map. In all, we conducted 37 single interviews with farmers (see Table 1). Based on network analysis, we used the interactive method to identify important actors in the seed system as well as the characteristics of their relationships and respective power to influence the network. For making social connections visible, the method was complemented by open-ended questions, observations and field notes taken during the interviews. The qualitative data analysis and research software Atlas.ti 6.0 and the visual analyzer software VisuaLyzer 2.0 were used to

Table 1 Overview of interview partners (n = 37)

Gender	Female farmers (n = 19)			Male farmers (n = 18)		
Ethnicity	Kuruma (n = 6)	Kurichya (n = 7)	Non-Adivasi (n = 6)	Kuruma (n = 4)	Kurichya (n = 5)	Non-Adivasi (n = 9)
Age (in years)	20–39 (n = 8)	40–59 (n = 6)	60 and older (n = 5)	20–39 (n = 4)	40–59 (n = 7)	60 and older (n = 7)

analyse the data. The qualitative data collected during makes no claim to statistical representativeness. Nevertheless, we believe that the case study shows a ground-based tendency among farmers of their dynamic relationship with the two rice seed systems in Wayanad.

We analysed our results intersectional according to gender, ethnicity and age of respondents. Gender we distinguished into female or male farmer, ethnicity as the two Adivasi groups Kuruma and Kurichya or non-Adivasi origin (Hindu mainstream). To classify age we used the cohorts 20–39, 40–59 years or 60 and older.

The Net-Map tool is instrumental to understand, visualize, analyze, discuss and improve situations in which different actors influence outcomes. The tool aims at identifying actors involved in a system and to explore the quality of links between them and the nodes in the network (Schiffer 2007). The Net-map method consists of four consecutive steps: naming relevant actors, identifying the linkages between members and exploring the different qualities of that social interaction. Four kinds of links were chosen to capture the seed system more deeply: what links provided information and advice, which channels actually contributed to acquiring the material rice seeds, what kind of collaboration exists between actors, to finally reveal problems between actors. Based on this mapping of social seed-relations, the network ego highlighted influential actors in the seed system. This ranking visualised by coins distributed accordingly queried the goals of each actor in terms of conservation of traditional seeds and providing quality seeds.

From our perspective, the advantage of the Net-Map-method lay in increasing the interviewees' ability to engage in visualizing their answers during interviews by drawing and mapping out given statements. Different colours for each link and seed actor helped to keep their answers distinct and to set a baseline for discussion at the end of the interview. The responses among the interviewees to this interactive method were consistently positive and eased the communication process, despite language barriers and cultural differences (Kunze and Padmanabhan 2014). The method was limited, however, to acquiring information on seed sources and their connection to each other. To gather further insights on the structure of seed handling and management at the intersection of gender, ethnicity and age, a second questionnaire with open-ended questions was needed.

Findings: the gendered structure of agricultural practices and rice seed systems

We propose a gendered structure of agriculture practices and rice seed systems in Wayanad. We therefore describe seed management practices in terms of cultivated rice varieties and suggest a differentiated perspective on formal and informal rice seed sources and social interactions between these systems.

Taking stock of the rice seed system in Wayanad

Wayanad's rice seed system has changed over the last 20 years. The number of rice seed sources and the number of modern rice varieties used has increased, whereas the diversity of traditional rice varieties decreased. The rice seed system in 1992 basically consisted of two sources: farmers' own seed stocks and farm-saved seeds from other farmers (see Fig. 1). At that time, farmers only obtained different kinds of seeds by barter, and they primarily cultivated traditional rice varieties.

Yet the number and diversity of rice seed sources had clearly increased by 2012[1] (see Fig. 2), with the seed system including informal and formal seed sources, providing local landraces as well as improved rice varieties through non-market (barter) and market exchanges (monetary flow). Farmers now offer their farm-saved seeds to other farmers or NGOs, but no formal seed provider has traditional rice varieties in their portfolio. In order to sell any seed variety, they would need to undergo certification through an agency, which runs anyhow diametral to the productivist agenda of agricultural policy. If formal agents sell seeds without certification, they are liable to be prosecuted by the government.

Our analysis reveals that male and female farmer access crop genetic resources through various seed sources and they cultivate both traditional and modern rice varieties. Improved rice varieties are provided by different sources within the formal and informal seed sector, whereas local varieties are only supplied by farmers and NGOs. Male and female farmers do the actual cultivation and play an important part in securing the genetic resources of local

[1] Our data is from 2012, but here we will assume that the seed system in Wayanad is relatively the same as it was at that time and, thus, use the present tense.

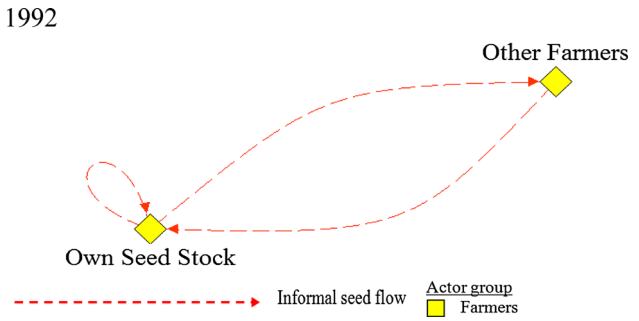

Fig. 1 Wayanad rice seed system in 1992

varieties in Wayanad. Furthermore, the ethnic community of the Kurichya especially maintains traditional rice varieties, with modern rice varieties only being cultivated rarely. In contrast, ethnic Kuruma farmers now cultivate both modern and traditional rice varieties. The majority of non-Adivasi farmers primarily cultivate modern rice varieties, as they are more profitable, but also cultivate traditional rice varieties, particularly Gandhakasala, a scented and highly valued variety, for their own consumption though rarely for the market (Hoffmann 2014).

Seed management practices in Wayanad

In Wayanad's farming households, men identify themselves as farmers, seeing cultivating land as their main occupation and duty, which also includes purchasing seeds. Women, on the other hand, describe their occupation as housewife or helping their husband or son, with cultivating paddy as their main duty. For them, this includes the following tasks: preparing fields for cultivation, sowing seeds, collecting and transplanting seedlings, removing weeds, applying fertilizers and cleaning and selecting seeds for the following cultivation period. Unlike men, women do not appear to regard their role as farmers within the farming household as minor, which reflects the differently weighted social recognition of women's and men's on-farm activities.

Farmers move away from using traditional rice varieties replacing them by modern ones instead (Table 2). In 2002, farmers used 22 different traditional rice varieties—a diversity which had decreased to 15 varieties by 2012. Meanwhile, the increasing adoption of modern varieties reflects an opposite trend. Whereas only one modern rice variety was cultivated in 2002, by 2012 the number of them had increased to 16. Overall, the range of rice varieties between 2002 and 2012 increased, whilst the diversity of used rice varieties subsided.

Farmers mention higher yield outcomes and, thus greater profits, from modern rice varieties over traditional rice varieties as an important fact for changing from the latter to the former. Also, paddy plants from modern varieties require less time to mature and have a shorter growing period. Even though farmers are increasingly

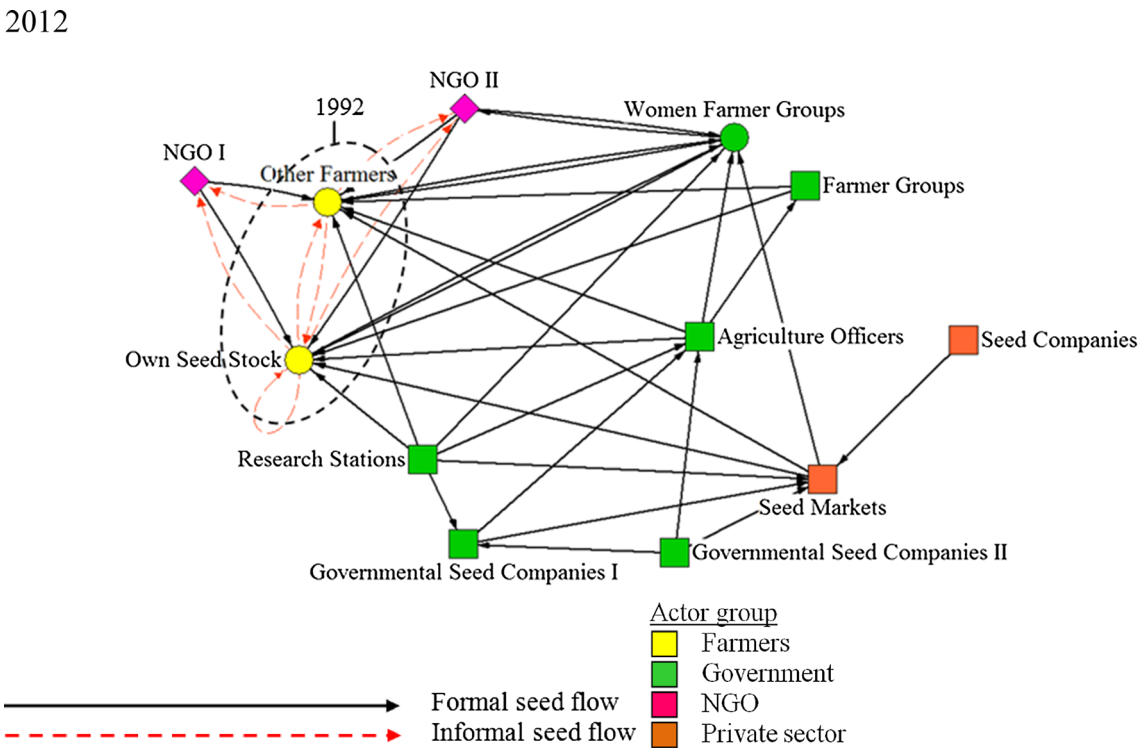

Fig. 2 Wayanad rice seed system in 2012

Table 2 Cultivated rice varieties in Wayanad in 2002 and 2012 (n = 37)

Cultivated traditional rice varieties	Cultivated modern rice varieties
2002 (n = 22)	2002 (n = 1)
Adukkan, Athira, *Chempathi**, Chennellu, Chennelthondi, Chentadi, Chomala, *Echpore**, Gandhakasala, Jeerakasala, *Kalladiyaran**, *Kothandan**, Kudaku Veliyan, *Marathondi**, Mullanpuncha, Njavara, *Palthondi**, Thondi, *Thonnooranthondi**, Unrunikaima, Valichoori, Veliyan	Uma
2012 (n = 15)	2012 (n = 16)
Adukkan, Athira, Chennellu, Chennelthondi, Chentadi, Chomala, Gandhakasala, Jeerakasala, Kudaku Veliyan, Mullanpuncha, Njavara, Thondi, Unrunikaima, Valichoori, Veliyan	Athira, Bharathy, Echpore, IR-8, Jaya, Jyothi, Kaliyani, Kanchana, Kunjuttimatta, Kurumutti, Prathyasa, Sabari, Sabari Thondi, Uma, Valichoori, Vasumathi

* Lost by 2012

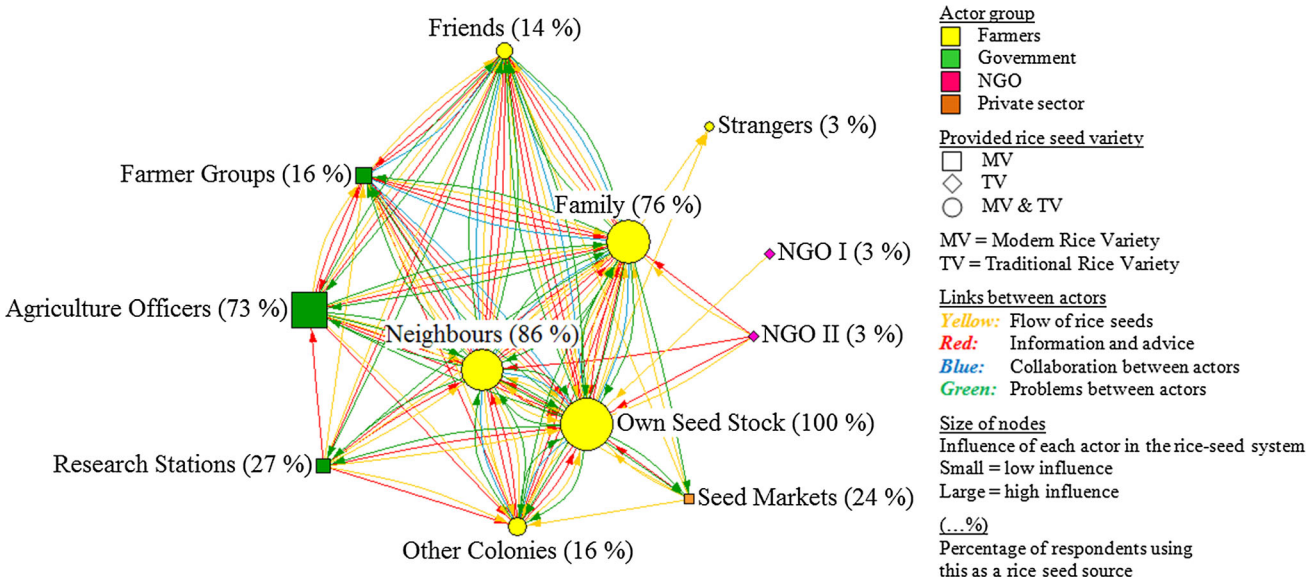

Fig. 3 Seed sources for male and female farmers in Wayanad (n = 37)

cultivating modern rice varieties, they still do grow some traditional rice varieties for their own home consumption, as they prefer their scent and taste to that of modern rice varieties. Farmers value high resistance against drought and floods and low requirements for pesticides and inorganic fertilizers which characterise modern rice varieties, lowering their productions costs.

Gender perspective on formal and informal rice seed sources

The Net-Map method helped to bring the formal and informal rice seed sources in Wayanad to light. Farmers' sources of traditional rice varieties consist of NGOs, women's farmer groups and their own farm-saved seeds. Meanwhile, a broader spectrum of sources provides modern rice varieties, ranging from governmental actors, such as agriculture officers and research stations, to farmer groups. Furthermore, the private sector, including seed markets and other farmers, also plays a role.

The main source for traditional and modern rice seeds for both male and female farmers are farm-saved seeds (see Fig. 3), followed by neighbours and family as seed providers for traditional and modern rice varieties and agriculture officers as an important source for modern rice varieties. NGOs and the private seed sector play a minor role as seed sources. Farmers prefer seeds from sources close to them (e.g. family, neighbours), as they have greater trust in such familiar sources in terms of seed quality and information. However, strangers or farmers without close relationships within their communities also purchase traditional rice varieties from informal sources.

Women tend to rely on farm-saved seeds as their main source, followed by neighbours (see Fig. 4). With the Kurichyas mainly living in joint family settlements, family as a seed source plays a larger role for them than for the

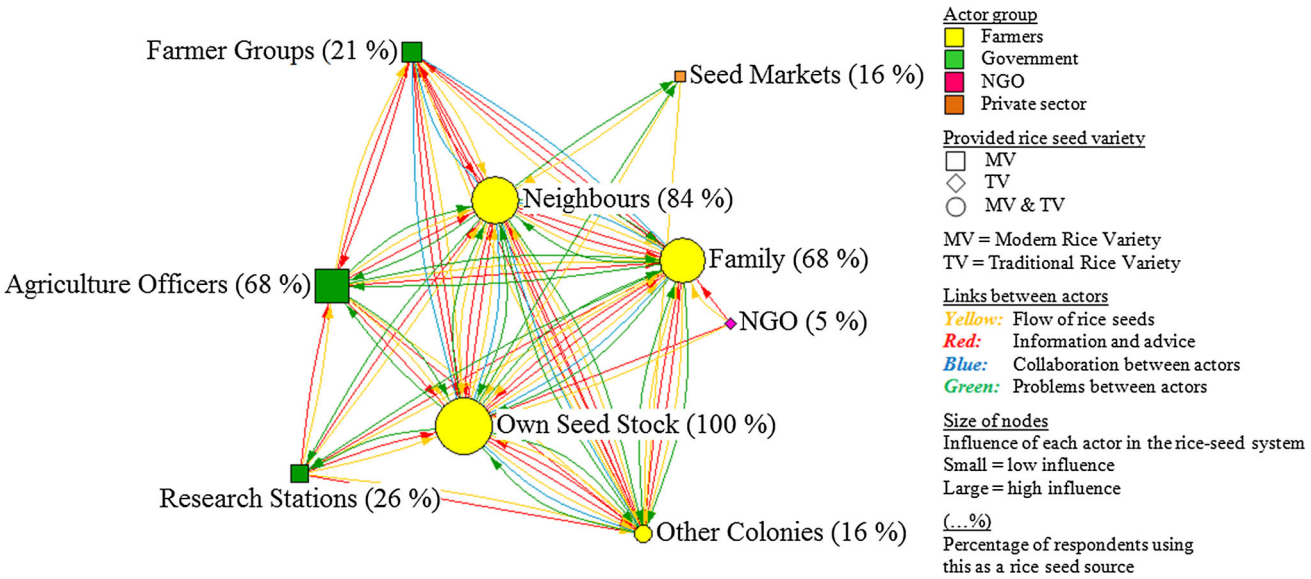

Fig. 4 Seed sources for female farmers in Wayanad (n = 19)

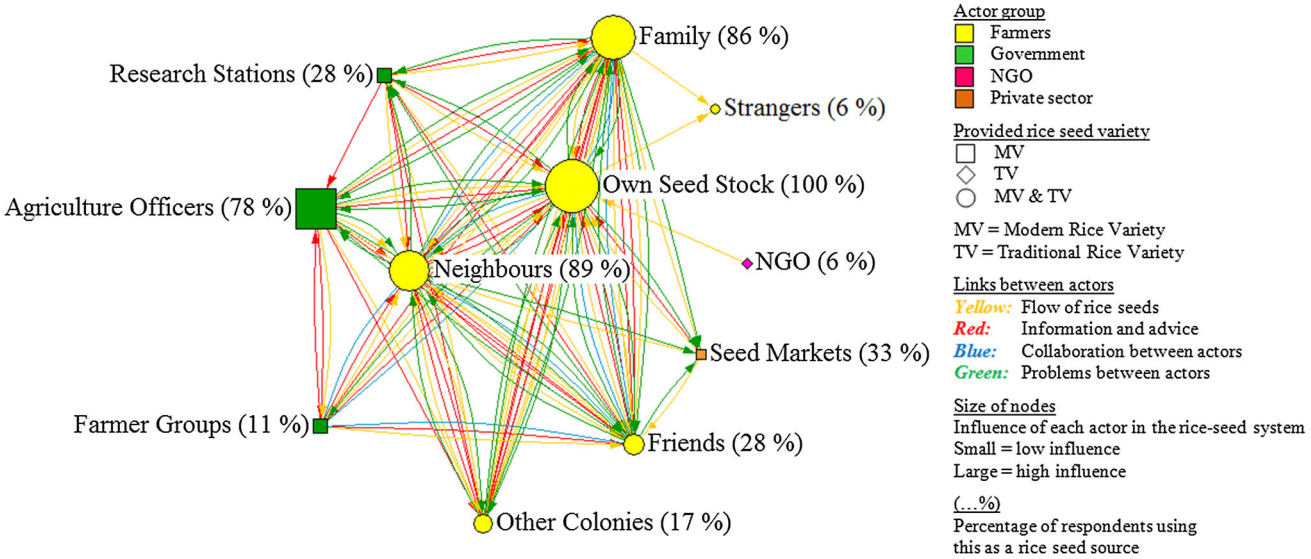

Fig. 5 Seed sources for male farmers in Wayanad (n = 18)

Kuruma and non-Adivasi farmers. For the latter, neighbours have a greater importance as seed sources, as their family systems have already changed into the nuclear type, which strengthens the role of friends and neighbours. Governmental seed sources play a subordinate role for Kurichya women, but for Kuruma and non-Adivasi farmers they are important, especially for obtaining modern rice varieties. The role of the family decreases for women between the ages 20 and 59, as they move away from their natal family after marriage. Family and agriculture officers are a minor seed source for young female farmers, but changes as they get older.

For male farmers, agriculture officers and family are of higher importance than for female farmers (see Fig. 5). Men usually interact more often with formal sources and usually own and drive motorcycles or cars to reach seed sources located at long distances. The role of the family is less central for non-Adivasi than for Adivasi farmers, as the former depend little on their families for help regarding agricultural resources and manpower. Kurichya farmers obtain rice seeds from agriculture officers less often than Kuruma and non-Adivasi farmers. Young farmers turn first to neighbours and their farm-saved seeds as seed sources, whereas farmers aged 60 and above rely on family second

and neighbours third, after their own seed stock. Agriculture officers gain in importance the older male farmers become, due to the fact that the role of agriculture and rice cultivation increases with age in the studied population.

NGOs and seed sources from the private sector, such as seed markets, play a minor role for both female and male farmers, although men do use seed markets more often because of their greater mobility. They have more interaction with formal sources than women.

The gender disaggregated analysis on rice seed sources reflects the division of labour of women and men in farming households. With men interacting or socialising more often with less familiar or formal actors, their range and number of rice seed sources is higher than those of women and includes formal and informal sources for modern and traditional rice varieties, both used about evenly. Female farmers, on the other hand, tend to procure rice seeds more within their immediate social networks, and their circle of sources is smaller when they are younger than 60 years. Farmers emerge as the dynamic link between the two seed systems as they engage equally with the formal as well as with the informal seed sources, thus representing the driving force of exchange.

Social relations in the rice seed system

Vital information regarding seed varieties and actual seed transactions in Wayanad follow a gendered structure. We thus identify clusters of actors collaborating with regard to seed supply, seed flows via exchange and purchase and problems arising between seed sources, including availability of certain varieties.

Seed flow via exchange and purchase: adivasi maintaining informal institutions

The flow of seeds in Wayanad is determined by a number of key factors, including seed management, cultivation practices and access to traditional and modern rice varieties. Seeds are purchased, bartered or handed over for free, depending on the amount required. In general men and women obtain rice seeds via the same channels, but of different magnitude and outreach. For female farmers, seed flows mainly within their own household—relying on farm-saved seeds—followed by bartering seeds with neighbours and exchange between relatives. Agriculture officers also serve as seed providers to women, especially for modern varieties (see Suma and Großmann this issue).

Adivasi women give their seeds to other farmers for free, because the requested amount is too marginal to demand any money or seed in exchange. All mainstream society women both exchange and purchase seeds, whereas indigenous female farmers choose either one of these options, depending on the amount of seed or the party they are dealing with. Adivasi farmers, especially Kurichya women, exchange seeds mainly with other farmers and purchase them less often from official sources. Kuruma women, on the other hand, are more open to official sources. Younger women generally purchase or exchange seeds with other farmers, whereas women aged 60 and above mainly exchange traditional rice varieties with other farmers and, less often, purchase modern rice varieties from official sources.

For male farmers, the main source of seed is also their own farming household, followed by exchanging or trading seeds between neighbours and family members. For modern rice varieties, agriculture officers are an important source for men as well. Men generally trade their seeds for money and obtain their seeds more often from formal sources (e.g. agriculture officers, seed markets) than women do, frequently interacting with officials and persons of power. Non-Adivasi male farmers mainly purchase modern rice varieties from official sources, whereas their Kurichya counterparts are less likely to purchase from such sources and, instead, primarily receive or provide seeds, especially traditional rice varieties, through family and neighbours in their surroundings. Exchange or trade between family members plays a minor role among non-Adivasi farmers, indicating that family members either turn to better-paid jobs or stop rice cultivation altogether. Mobility due to motorcycles or cars influences the origins and sources of rice seeds, too. While vehicles were rarely seen in Adivasi households, least of all among the Kurichya, non-Adivasi farmers usually own one of some sort. Thus, transportation is another explanation why Adivasi farmers turn to formal seed sources less often than do non-Adivasi ones.

Overall, the types of seed flow and the variety and number of seed sources vary only slightly between men and women compared to the greater distinctions found between Adivasi and non-Adivasi farmers, reflecting social-cultural differences between them. The Adivasi Kurichya and Kuruma farmers procure rice seeds from fewer seed sources, mainly within their own social networks, according to the type of family system they live in. In terms of age differences, older farmers generally tend to obtain their rice seeds from more seed sources than younger farmers do. The overall detachment of junior men from seed relations can be to different reasons. While for young mainstream men paddy cultivation competes with other sources of non-fam income, young Adivasi men are not yet in a social position to fully exercise control over seeds.

Knowledge exchange: diminishing of information and advice

Knowledge exchange has to go hand in hand with the exchange of seeds to make them valuable and assessable.

Therefore, men and women generally receive information from the rice seed sources that simultaneously provide them with genetic material as well, underlining the relational quality of seed exchange.

Women exchange knowledge predominantly among themselves and with neighbours. As women move after marriage into their husband's household in a patrilocal manner, information and knowledge coming from their side of the family decreases and neighbours become their major information source. Female farmers share their knowledge about rice cultivation, including transplanting seedlings and removal of weeds, because of their major role in cultivating rice. They rarely seek advice from agriculture officers regarding handling and cultivation methods for modern rice varieties and the use of pesticides and fertilizers. This reflects the tight parameters of the social circles in which women procure their rice seeds, along with the shared information made available in the process. Some women do not even share any information with others, since they only use farm-saved rice seeds. Adivasi women rarely obtain information from formal sources, as they generally cultivate traditional rice varieties and, therefore, seldom purchase seeds from formal sources which only provide modern rice varieties. Especially the Kurichya only seek advice from officials about handling and cultivation methods for modern rice varieties. Women of non-Adivasi origin, however, do tend to share information with both formal and informal sources. Older women, meanwhile, tend to share information with other parties, formal or informal, more frequently than younger ones do, owing to their increased status coming with age.

Men share information more often with family members than with neighbours and agriculture officers. They also interact more often with governmental actors, officials and persons outside their neighbourhoods than women do. This includes getting information about the availability of modern rice varieties from agriculture officers, and the same applies to information flows regarding cultivation methods, use of chemicals and quality-control issues related to modern rice varieties.

Knowledge exchange between farmers plays an important role among men, regardless of their ethnicity and age. Nevertheless, male farmers of non-Adivasi origin tend to share experience and knowledge about rice varieties the most. Meanwhile, Kuruma and Kuricha men rarely obtain information from officials and governmental actors, because they generally cultivate traditional rice varieties and, consequently, seldom purchase seeds from formal sources. Non-Adivasi farmers also exchange knowledge regarding sources of traditional rice seeds with others, as several old rice varieties have vanished from their households. Young farmers share information mainly with their neighbours and families, whereas agriculture officers play a minor role for them. Older farmers turn for information to their family first, seeing rice cultivation as a family business.

Gender-wise information exchange in Wayanad reflects rice seed flows, with women receiving information mainly from informal sources and men obtaining it from formal ones. The role of family ranks highly among Kurichya farmers, which likely explains their restraint towards information and actors from outside their colonies.

Collaboration in the field

Collaboration during rice cultivation aims at sharing the costs of labor or machines during peak work periods. With agriculture decreasing, due to its low profitability and the younger generation withdrawing from agriculture for better-remunerated off-farm jobs, collaboration in the field has become a strategic asset to many farmers in Wayanad.

Female and male farmers collaborate to the same extent with others, but women especially tend to join hands with neighbours, while men prefer family first, due in large part to patrilocal residence patterns. Women primarily carry out the work of seed processing and share work in order to save money on wages and bring this task to completion. Kurichya women work together with their families to a great extent and rarely with farmers from outside their social network.

Group farming and sharing labour costs has the same value for men as it does for women, but men also tend to purchase rice seeds together. Kuruma and Kurichya farmers collaborate with their families in the first place, whereas non-Adivasi farmers do so less often. Farmers from Kurichya settlements also work together with neighbours but less often than with their families. Purchasing seeds together plays an important role for non-Adivasi farmers, with most of them owning a motorcycle. Given their mobility, such farmers turn to each other in order to save money, which they otherwise would have spent on making trips themselves. Meanwhile, farmers aged 20–39 purchase seeds together more often than older ones do.

Both women and men may also abstain from collaboration for two reasons: First, they may cultivate on their own as a matter of choice. Or, more involuntarily, they may not be able to find other farmers for help, because the latter have either withdrawn from agriculture or only cultivate rice on a small plot. There does not seem to be any distinction between men and women when it comes to collaboration in the field, as they both depend on each other in order to increase their cultivate paddy mainly for home consumption.

Conflicts within the seed system

Over the last decade, conversion of paddy fields to other cash crops, decreasing paddy-cultivation productivity and

labour shortages have led to problems within the rice seed system (Jose and Padmanabhan 2015). Agriculture as the main livelihood has lost its importance due to social-cultural changes, especially with the younger generation tending to leave the joint family system and agriculture altogether.

The predominant problem for female farmers, one which they share with their male counterparts, is scarcity of water. Kuruma women specifically mentioned conflicts over water, induced by division of fields among family members, as their main cause of concern. Water shortages result from all farmers in the area cultivating various crops —including bananas, areca nuts and rice—with different water requirements at certain stages of growth. Men and women are likewise affected in cultivating rice when plots are surrounded by converted plantations or construction sites, changing the necessary ecological conditions for paddy cultivation. Women's concern about problematic and irregular irrigation underlines another fundamental problem. In the second planting season, even Kurichya women cultivate cash crops as nuclear householders. As paddy fields and areca nut or banana plantations have competing requirements for water, the collective irrigation system is undermined. Worsened ecological conditions for paddy cultivation reflect the transition of social structures from communal subsistence strategies towards livelihoods regulated via the market. This can be observed in the fact, that young women, however, face few problems with actors within the rice seed system, as agriculture is merely a side business to them.

Men have criticized the passivity of governmental actors, such as agricultural officers, whose often faulty information and instructions, combined with the low quality of the rice seeds they generally provide, is often seen to lead to poor harvests and has lowered trust in the formal seed system. Interestingly, Adivasi farmers' discrepancies with agricultural officers are fewer than those experienced by non-Adivasi farmers, due to the minor role of formal seed sources and agriculture officers for indigenous farmers. Kurichya farmers rarely face problems with other actors within the system, which reflects their situation of a closed community under the authority of a hamlet's chieftain regulating external relations. Farmers aged 60 and above mentioned not finding traditional rice varieties within their area, because they have either vanished or are of bad quality, as their greatest problem. Young farmers in the age group 20–39 cultivate rice, among other crops, mainly for their home consumption only and, therefore, have fewer problems with other rice farmers or seed providers. They mostly cultivate the Gandhakasala variety, which they use for religious festivals or traditional dishes.

Although frictions occur for both men and women within the rice seed system, one decisive difference is that men have far more problems with governmental actors and private institutions than women do, since men interact more with outsiders. The perception of problems within the rice seed system also differs with age. Older men and woman farmers identify more conflicts with farmers, private or governmental institutions, as agriculture as a livelihood still holds a higher value for them than it does for younger men and women.

Discussion: gendered relations in the rice seed system

The seed system in Wayanad is shaped by a coexistence of formal and informal seed systems that run in parallel, effectively ignoring each other at best. These systems are linked via the activities of male and female farmers for obtaining the most suitable seeds for pursuing their own cultivation strategies, actively seeking relations with seeds. As the interest of paddy farmers differ in terms of the extent that rice cultivation plays for ensuring food security, realizing home consumption, specialty rice for festivals or producing for the market, seed choice varies. Both men and women are currently struggling with poor seed quality and information received from agricultural officers, with men especially expressing strong discontent about the formal seed system.

Ultimately, in observing the interlinkages of the formal and the informal seed systems, we conclude that the two systems are only connected via the active management of social-ecological relations with the seed by men and women farmers, utilizing both sources to fulfill their needs for seed. This study has revealed insufficient, and even faulty, information and quality of seed from official sources as key problems. For women, as their contact with agricultural officers is minor, we have observed a form of double exclusion: As they do not obtain seed material and information from formal sources, they cannot consequently articulate their needs regarding quality, timing and quantities required within the formal seed system. Not surprisingly, women tend to circulate seeds and information among themselves. This double isolation also derives, in part, from agricultural science—the theoretical insights and outputs of which are to be delivered by agricultural officers—as well as from extension services, which translate it into practice. Although women's work is central in paddy cultivation, and their own body of knowledge remains the most important asset to them, at bottom we have observed a privileging of men's perspectives in the formal arena over women's.

The observed increase of seed sources points towards a strengthening of the off-farm orientation among paddy farmers in Wayanad. With a strategic mix of seed sources,

farmers have been trying to make up for the weaknesses in both seed systems. Although in the informal system information seed is easily available for women, also seed quality remains an issue. A drifting apart of women's and men's seed sources may further decouple the seed system catering to traditional varieties. Thus far, it seems that the maintenance and preservation of traditional cultivars has been left altogether in the hands and responsibility of famers from ethnic minorities. As the involvement of younger men and especially women in paddy cultivation is dwindling, the conservation of such landraces is being left to the realm of farming households. The systematic and hegemonic ignorance of the informal seed system by key actors in the formal seed sector poses a fundamental challenge to sustaining an integrated seed system. Simultaneously, growing reliance on official sources is accelerating the creation of an institutional vacuum regarding traditional varieties. As informal supply of such varieties is not at present coordinated beyond ethnic communities, and even here questions of seed quality remain, the danger exists that traditional varieties may unintentionally disappear. To maintain the diversity of rice varieties within the seed system, male and female farmers need to seek further variety ranges of traditional and modern rice seeds as well as support from the government for cultivating rice and agriculture in general.

While information exchange between farmers of all genders, ages and ethnicities works well in the rice seed system, we propose that the flow of knowledge between governmental actors and farmers deserves improvement. Instead of simply subverting traditional varieties to the official seed distribution system, a convergence of the two systems would require two fundamental shifts in conceptualising agricultural development. First, the multiple goals of farmers beyond a market orientation need to be taken into account, which would turn traditional varieties into integral building blocks of a household's reasoning. Second and central to our perspective on agrobiodiversity as an expression of human–nature relations, women's communication strategies and networks need to be acknowledged as such and not be viewed as merely a deviation from the (male) norm. Male and female farmers have already aligned their actions to integrate the two seed systems by their meandering between both. To achieve a sustainable supply of quality modern and traditional rice variety seeds in the future, the capacities and interests of cultivators have to be acknowledged in an encompassing institutional setting. This pertains first and foremost to making available gendered social spaces in an evolving overall seed system.

This article has explored the changing relationships of men and women under formal and informal institutional settings within the rice seed systems of Wayanad, India, and analyzed the organization of seed management and exchange. We show how informal and formal seed systems coexist in Wayanad to pay special attention to the relational quality within the seed system.

From a gender perspective it becomes obvious that male farmers draw on a larger number of rice seed sources than females, primarily because their social networks are broader. They also obtain traditional and modern rice varieties from various sources within the formal and informal seed systems, whereas female farmers procure rice seed by and large from within their own social networks. Women collaborate not only on the field but also in seed storage, with a focus on the informal, family-dominated sector. Men as well as women depend heavily on collaboration in their paddy cultivation and seed management strategies, with joint purchase of seeds on the formal market by pooling transport. The differentiated collaboration patterns demonstrate that paddy cultivation relies on cooperation, which we view as a consequence of ecological requirements; Talhelm et al. (2014) go as a far as proposing that a history of rice farming makes cultures more interdependent.

Ethnicity distinguishes the goals and intrinsic values attached to certain paddy cultivars. However, we cannot detect major differences across ethnicities regarding gendered patterns of seed relations. Non-Adivasi farmers obtain traditional and modern rice varieties from various sources within the existing formal and informal seed system through market and non-market exchanges and trade. Kurichya and Kuruma farmers, however, procure their rice seeds from comparatively fewer sources and, especially for the Kurichya, primarily from within their social networks. Nonetheless, in our study we were not able to observe fundamentally different patterns of gendered seed-related behaviour according to ethnicity.

The difference of the intensity of interacting with seed systems according to age groups is striking and underlining the rapid decline of importance young farmers attach to paddy and thus paddy seed systems of any kind in particular. Older farmers procure their rice seeds from a larger range of sources than younger ones do. The same applies for the diversity of rice seed sources. Farmers aged 60 and older obtain rice seeds from their own production, social networks and formal actors, whereas younger farmers rely primarily on their farm-saved seeds and social relations, underlining the diminishing importance of paddy cultivation as a source of livelihood for them. Interestingly enough, age did not reveal any noticeable difference between male and female farmers but rather indicates similar trends towards a growing off-farm labour orientation.

The divided seed system in Wayanad is shaped by gendered human–nature relations. Consequently, the performance of farmers there differs most pronouncedly in terms of their gender, with age and ethnicity as important

categories moulding motivations and relations. Our study shows that agriculture in Wayanad is, in part, being determined by changes not directly related to rice farming as such, including the increasing cultivation of cash crop, farmers turning to off-farm labour or farming households giving up rice cultivation altogether. These socio-cultural changes and hurdles to carrying on with agriculture as a form of livelihood, are affecting male and female farmers, regardless of ethnicity or age. The gendered human–nature relations expressed in the seed systems in Wayanad reflect, on the one hand, the fragmentary integration of paddy farming into commercial agriculture. On the other hand, they also underline the need for questions to be posed anew regarding the nature of agricultural development and the place of women in it.

Conclusions: gendered handling of agrobiodiversity

The social relations to seeds translate into physical handling of seeds: Approaching seed owners, handing over seeds, sharing associated knowledge and collaborating around the sowing of the grain. These actions—or inactions if abstaining from seed-relations—are shaped by gender as structure and agency. The effect of social institutions is observable in the different gendered outcomes due to structural conditions and possibilities of unfolding agency.

Farmers are the driving force of seed exchange, linking the formal and the informal sector. Women's handling of seeds is structured by a patriarchal setting, where decisions over seeds are only available to them in the context of the family farm. Though they display vast agency in sourcing seeds within informal networks, their capacity to decide upon cultivation choices is limited. With younger women less interested in paddy cultivation, the informal seed network around local varieties is bound to be cut. Men's seed handling is pronouncedly structured by engagement with the formal seed system. They display agency in collectively acquiring modern varieties, thus freeing themselves from other social obligations through market purchase. While younger Kuruma actively seek off-farm income and maintain paddy cultivation mainly for reasons of cultural identity, young Kurichya are not in a social position of seniority to make decisions upon seed varieties.

With the structural notion of men as competent farmers and women as helping hands, emphasis is paid to men's increasing involvement in the formal seed system, leaving unacknowledged the vast relations of women in the seed network. The unintended disappearance of traditional varieties may be attributed to the structural denial of women's agency in issues pertaining to paddy seeds. This renders invisible women's handling of seeds in the realm of the informal and hinders the incorporation of their active and purposeful maintenance and use in an encompassing seed system.

The described transformation reveals a seed system, which cannot be neatly separated into an informal and a formal one, or a traditional or modern one, as the active agents in the network knit it together. Rather the connection are realised by the people and their gendered handling of agrobiodiversity. This underlines the characteristic of agrobiodiversity as a social-ecological artefact, depending on the social interests of people to decide and thereby select and mould social-ecological relations.

The meaning of seeds goes beyond that of an agricultural input factor and points to place based relations, networks and initiatives, which need to be taken into account when thinking about vibrant and diverse agroecologies. Therefore further research should move beyond countable objects, varieties and exchange rates, but take the underlying cultural and affective motivations seriously including the conditions of local power dynamics within households and between generations and ethnicities. Analytically welcoming the values and interests experienced in tacit and sensory handling of agrobiodiversity enriches the analysis of social networks through which varieties are gained and lost.

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