

The social–ecological web: a bridging concept for transdisciplinary research

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Conducting inter- and transdisciplinary research requires integrative tools. The present study aims at a better understanding of social–ecological transformation processes through the lenses of indigenous women and men farmers from three different farmer communities in Kerala, South India. Central to the interdisciplinary data analysis is the development of a social–ecological web understood as a bridging concept that seeks to integrate knowledge from social and natural sciences. The social–ecological web is a useful method to highlight differences between the communities, to foster interdisciplinary analysis of both social and ecological changes, and to reflect on the challenges of integrating several disciplines and stakeholders.

Keywords: Farmer communities, interdisciplinarity, social–ecological transformation, transdisciplinary research.

In this article, we reflect on the challenge of integrating social and natural sciences during the research process and propose an innovative tool for interdisciplinary integration, which we call a social–ecological web. The development of this web is the output of a social–ecological research conducted as a baseline study in Wayanad district, Kerala, South India. The study is based on an interdisciplinary research programme that looks into social–ecological changes occurring amongst agrarian communities in Wayanad. The rural agricultural landscape of the area is currently undergoing environmental (e.g. crop and land-use conversion practices, soil degradation) and socio-economic changes (deagrarianization, farmer suicides¹), driven by agricultural intensification. These changes result in a transformation of landscapes (land-use conversion) and livelihoods (deagrarianization), which particularly affect small agricultural communities and those whose livelihood strategies were based on rice cultivation in the past. In this article, we aim to explore the ecological and agricultural knowledge of local people, as well as the social transformation processes taking place in agrarian communities in Wayanad.

The social–ecological study is an outcome of the BioDIVA research project (<http://www.uni-passau.de/en/biodiva/home/>), an interdisciplinary research programme

that brings together experts from varied disciplines such as rural sociology, ecology, spatial science, gender studies, and institutional and resource economics. Moreover, BioDIVA adopts a transdisciplinary approach that integrates non-academic knowledge in order to foster an understanding of real-world problems, such as changing agricultural practices in Kerala. The aim of the overall project is to develop strategies for the generation of transformation knowledge for sustainable agricultural future in Wayanad. Transformation knowledge is the knowledge needed for a society to move towards a more sustainable status while taking account of existing technical, social, legal, cultural, institutional and other conditions^{2,3}.

Wayanad: a biocultural diversity hotspot

This social–ecological baseline study was conducted in Wayanad, a mountain plateau district of Kerala located in the Western Ghats in South India. The Western Ghats is a biocultural diversity hotspot^{4,5}, which has recently become one of the UNESCO Natural World Heritage sites⁶. Wayanad is notable for its large indigenous population, known as the Adivasis, an umbrella term for indigenous or tribal population groups in India⁷. Wayanad has the highest proportion of Adivasi inhabitants in Kerala and also the highest level of poverty amongst Adivasis⁸. The Kerala Government records distinguish between 20 Adivasi groups in Wayanad. They can be broadly classified into farming communities, landless agricultural labourers, artisan communities and hunter–gatherer communities^{9,10}. Many Adivasi communities have traditionally been involved in agriculture and paddy cultivation in particular.

However, socio-economic trends such as the growing tourism and real estate industries and ecological changes,

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including irregular rainfall patterns are all modifying agricultural systems and affecting small-scale farming communities^{11,12}. Changing family structures and the re-organization of labour are further drivers of changes in the social organization of Adivasi communities (Kunze and Momsen forthcoming). Overall, external challenges such as the agricultural crisis in India¹³ and land-use change, limit the options for Adivasi livelihood strategies in Wayanad^{14,15}.

In the first part of this article we outline the design of the interdisciplinary study and discuss research objectives, research ethics, data collection methods and data analysis. This section concludes with the presentation of the social–ecological web. The second part of the article focuses on the results of the social–ecological study and evaluates the social–ecological web as an interdisciplinary research tool, in the context of the challenges of integrating different disciplines and stakeholders in the research process. We argue that the social–ecological web is a hybrid between social and ecological networks, which serves both as a bridging concept and as a tool for depiction and analysis of the qualitative social–ecological data.

Research design

Transdisciplinary research consists of three phases: problem identification and structuring, problem analysis, and the practical application of results². In addition, Novy *et al.*¹⁶ highlight three defining characteristics of transdisciplinary research: interdisciplinarity, problem-orientation, and an equal relationship between researchers and project partners.

The present study was planned and implemented by a team consisting of rural sociologists and ecologists. Each discipline was represented by two researchers, one German and one Indian, and an Indian research assistant (RA). We built upon the notion of interdisciplinary research by Pohl and Hirsch Hadorn² as a form of coordinated and integration-oriented collaboration between researchers from different disciplines. The questions were formulated by researchers from the two disciplines, including the RAs, who formulated questions from their own disciplinary perspective. Two main interests were at the centre of this inquiry: first, ecological knowledge and agricultural practices; second, the multiple meanings of social–ecological transformation processes in Wayanad district.

The comparative social–ecological study investigated communities of two land-owning Adivasi groups, the Kuruma and Kurichya, and one landless group, the Paniya. By comparing three contrasting Adivasi communities, we hoped to shed light on the nature and causes of the social–ecological changes occurring amongst rural communities in Wayanad.

Doing inter- and transdisciplinary study requires a sound research design, which needs to be developed

jointly by all those involved in the study right from the start. The research design included the definition of common research ethics, an interdisciplinary list of questions and objectives, the joint field site selection and procedures for data collection and analysis.

Research ethics

The research ethics was embodied in a participation agreement between the researchers and the respondents and an information sheet for the participants who agreed to participate in the study. Both documents were written in English and the local language (Malayalam) in order to make sure that the respondents understood the overall objective of the study. Once the communities had been selected, we approached the head of each Adivasi community to ask for official permission to undertake the study and handed out the information sheet and a copy of the participation agreement.

Data collection methods

This qualitative study was carried out in March till May 2011 in three Adivasi villages: Kalluvayal (Kuruma), Maanikazhani (Kurichya) and Thannikunnu (Paniya), all located in Wayanad district. Random sampling was used for the selection of the villages; the choice of participants was based on snowball sampling¹⁷. Three methodological tools were used for triangulation. First, we conducted semi-structured key informant interviews with the community chief of each settlement on ecological knowledge and management practices, and social–ecological transformation processes. Second, we asked women and men separately to prepare village maps and seasonal calendars (participatory methods). This division appeared fruitful to gain gendered perspectives on the agricultural practices and village structures. Third, we carried out three focus group discussions with (ideally) five women and five men from each community.

The process of data collection was shaped by feedback loops between Indian and German researchers and between researchers and the RAs. Reflexivity on methodology is crucial for interdisciplinary research processes^{18,19}. The constant academic exchange between the Indian and German researchers, including the RAs enabled us to critically reflect upon the whole study process and especially on the design of the research questions. Based on the feedback of RAs on the interview dynamics observed in the field, the researchers reformulated and restructured the questions accordingly, which improved the effectiveness of the interviews in the field.

Data analysis: the social–ecological web

Integration is a fundamental requirement for interdisciplinary research²⁰. The combination of knowledge from

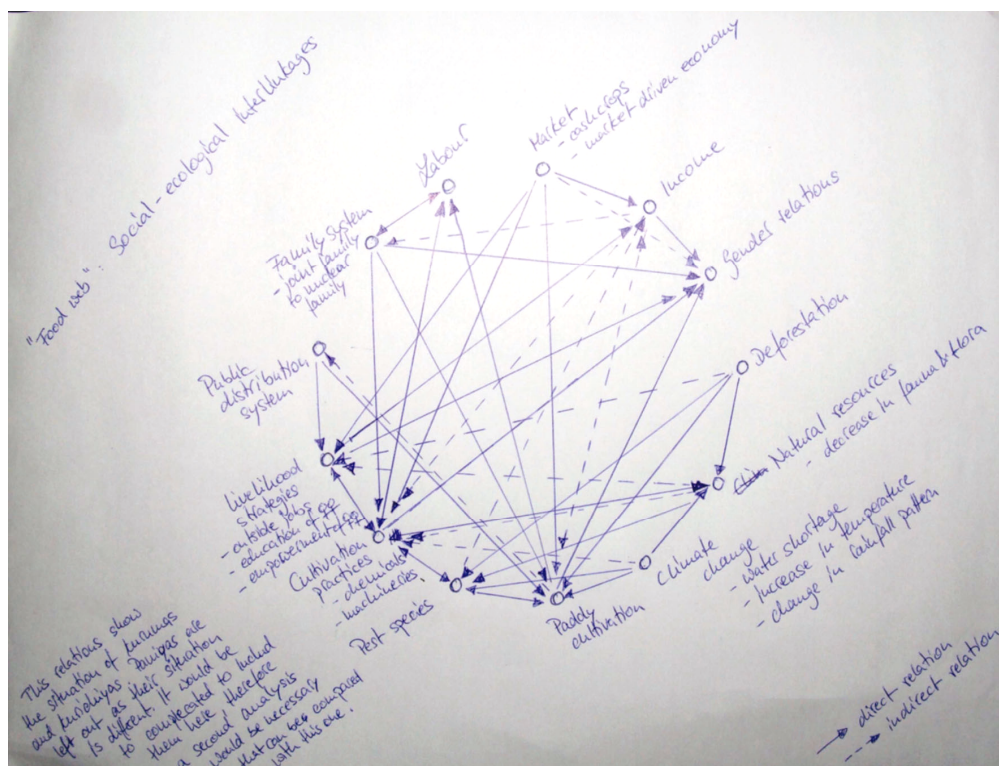


Figure 1. First sketch of a social–ecological (by L.B. in 2011).

various disciplines requires developing methods for integration and communication to overcome terminological differences. We developed the social–ecological web as a bridging concept that seeks to integrate knowledge from rural sociology and ecology. A bridging concept is a common conceptual framework that facilitates analysis. Deppisch and Hasibovic²¹ note the importance of appropriate timing in the development of a bridging concept: the decision on whether to introduce it at the very beginning or to develop it jointly in the course of the interdisciplinary process. In this study, the social–ecological web was developed during the process of analysis. Figure 1 shows the first sketch of a social–ecological web.

The social–ecological web is analogous to the food webs used in ecology to analyse trophic interactions, i.e. food relations. The basic idea of food webs is to map relationships between different species that inhabit a specific ecosystem on the one hand and to reveal the organization of this community on the other. Food webs vary in complexity, focus and scope depending on the studied system and the pursued goal²². Just as organisms interact with each other in an ecosystem, different components in an agrarian system are linked in a similar way. Therefore, we applied the ecological method of food webs to analyse the qualitative data; replacing organisms by social and environmental topics (e.g. livelihood strategies, natural resources and paddy cultivation). The initial idea was to map the complexities of the social–ecological system and to identify links between different components.

How to construct a social–ecological web

The construction of a social–ecological web is carried out in four steps. First, the components that describe the observed system are identified. All four researchers analysed the qualitative interview data and visual material collected through participatory method, from both disciplinary viewpoints, to identify key categories relevant to the initial research questions and interests. Then, each group of researchers discussed the results and their importance for an understanding of the multiple meanings of social–ecological change in Wayanad. The aim was to determine key components of the social–ecological system (dots in Figures 1–4). Second, we synthesized the disciplinary outcomes and pooled components for simplification (e.g. livelihood strategies as a composite of formal occupation, women’s education and their empowerment). Third, we identified links between the components based on different analytical procedures (lines in Figures 1–4). We identified direct relationships (component A affects component B, or vice versa) based on the interview data. This enabled us to grasp the actors’ perspectives of the complexity of the system. Indirect relationships (component C influences component A through component B) were determined from the researchers’ disciplinary perspectives. Fourth, we indicated the direction of action for these relationships by arrow heads. Direct and indirect interrelations and the direction of action indicate on-going changes in the system.

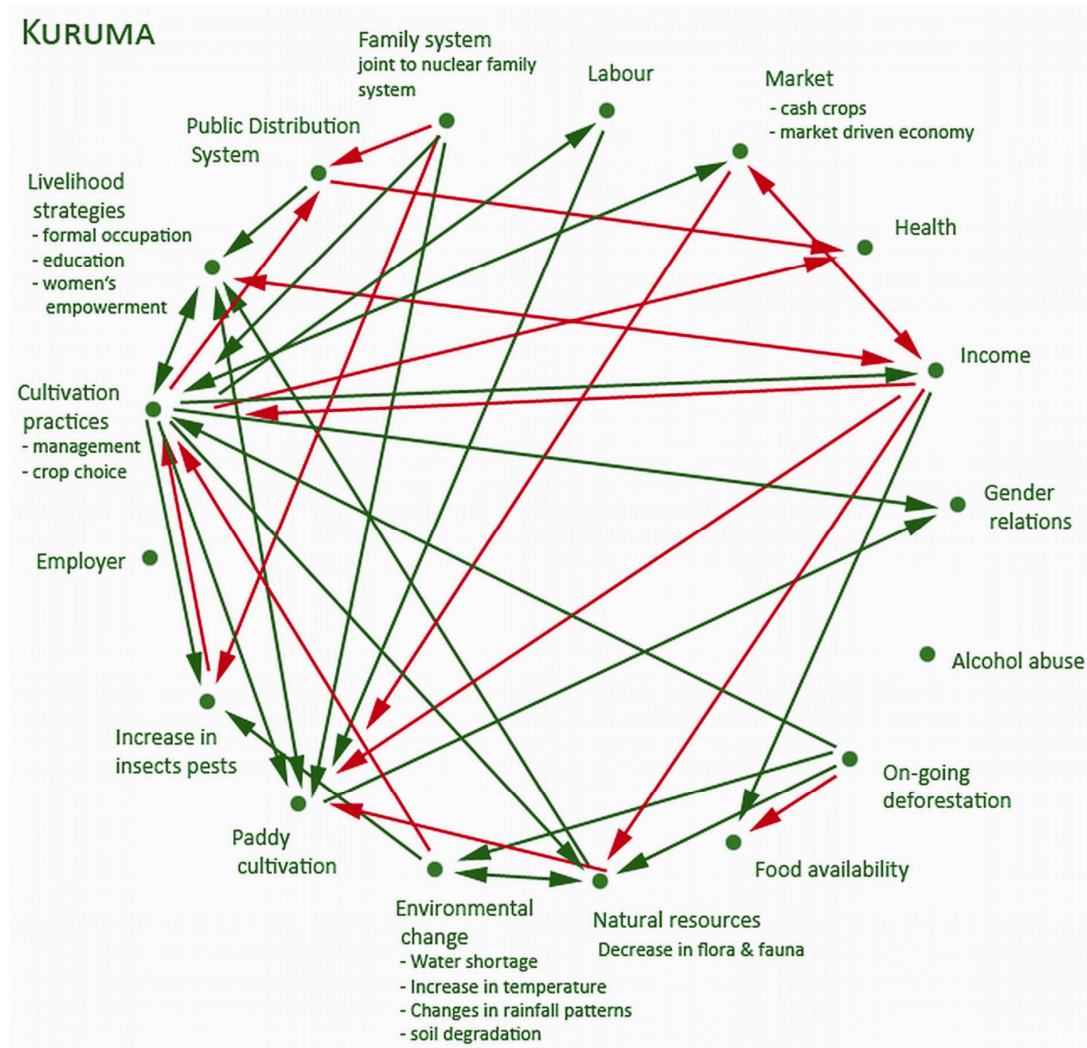


Figure 2. Social-ecological web of a Kuruma community. Dots: components important for the system derived from the data; green lines: direct interrelations between components, based on information given by participants; red lines: indirect interrelations, identified by data interpretation; arrows: direction of action, indicating on-going change processes.

Results and discussion

Comparing three Adivasi communities using the social-ecological web

In this section, we highlight some of the most pronounced observations and findings of our social-ecological study. The social-ecological webs (Figures 2–4) reveal that the three Adivasi communities are structured differently and face dissimilar changes. The components of the social-ecological system (dots in Figures 2–4) differ in their importance for the Kuruma, Kurichya and Paniya communities. Also, the number of interrelations (lines in Figures 2–4) between the components differs in each community. Taking the number of interrelations as an indicator of the magnitude of change, the Kuruma community (41 interrelations; Figure 2) is undergoing most change, followed by the Paniya (39; Figure 4) and lastly

the Kurichya community (16; Figure 3), which is experiencing the least change.

Unlike the Kuruma and Kurichya, the livelihood strategies of the Paniya are strongly influenced by other web components such as deforestation, paddy cultivation and environmental changes (Figure 4). This leads to the conclusion that their livelihood strategies are currently changing most compared to the other two communities. Based on our interpretation of the data, the forest has a stronger meaning for the Paniya than for the Kuruma and Kurichya. In the past, the Paniya lived in the forest⁹; as such deforestation has a huge impact on their relationship with nature and community life. In particular, members of the Paniya community referred to the negative effects of deforestation on the environment and on the use of natural resources and paddy cultivation. In line with Mohindra *et al.*²³, we found that alcohol consumption is also a severe problem in the Paniya community. This

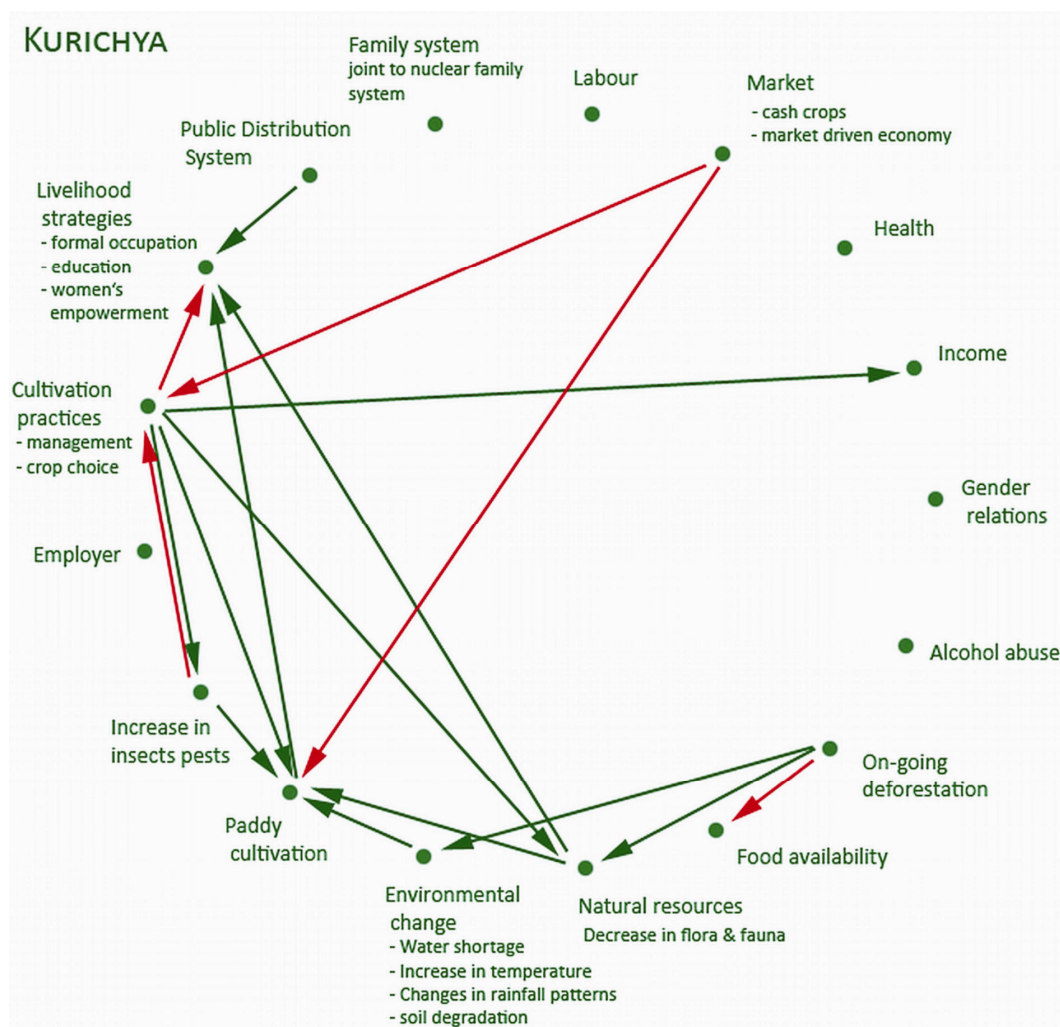


Figure 3. Social-ecological web of a Kurichya community. Dots, lines and arrows same as in Figure 2.

became clear during the interviews, which revealed the highly disruptive effect of alcohol consumption on family structure and the gendered division of roles and responsibilities.

Among the Kurichya and Kuruma, most of the landholders are agriculturalists, and agricultural practices such as paddy cultivation are at the centre of community life. But a closer look at the social-ecological web for the Kuruma community reveals that almost all components are interrelated (Figure 2). Hence, it seems that the whole community structure is currently in a phase of reorganization. Unlike the landless Paniya, who also find themselves in a stage of reorganization, the landowning Kuruma have the power to partially control the changes taking place in their community. As landowners, they are in the position to take agricultural decisions in response to market demand. For example, they increased vegetable cultivation some years ago as the market price of rice was no longer profitable²⁴. Furthermore, the Kuruma do not depend on agricultural labour; therefore, they have the

option to shape their livelihood strategies, for example, by seeking higher education and formal employment. However, this changes agrarian relations within the community due to reduced time available for agricultural work.

In contrast, social organization in the Kurichya community, for example, family structure and gender relations, appears to be largely unaffected by the changes so far (Figure 3). Indeed, compared with the other two, the Kurichya community retains a more traditional social organization. Among modern socio-economic institutions, only the market has some impact, on their agriculture; Kurichya farmers now cultivate modern rice varieties on a small portion of their land for sale.

Despite these differences, there are also similarities among the three communities. All the respondents stated that on-going deforestation is the main driver of environmental degradation, e.g. changing rainfall patterns, which in turn has negative effects on agriculture, especially paddy cultivation. Furthermore, logging negatively affects

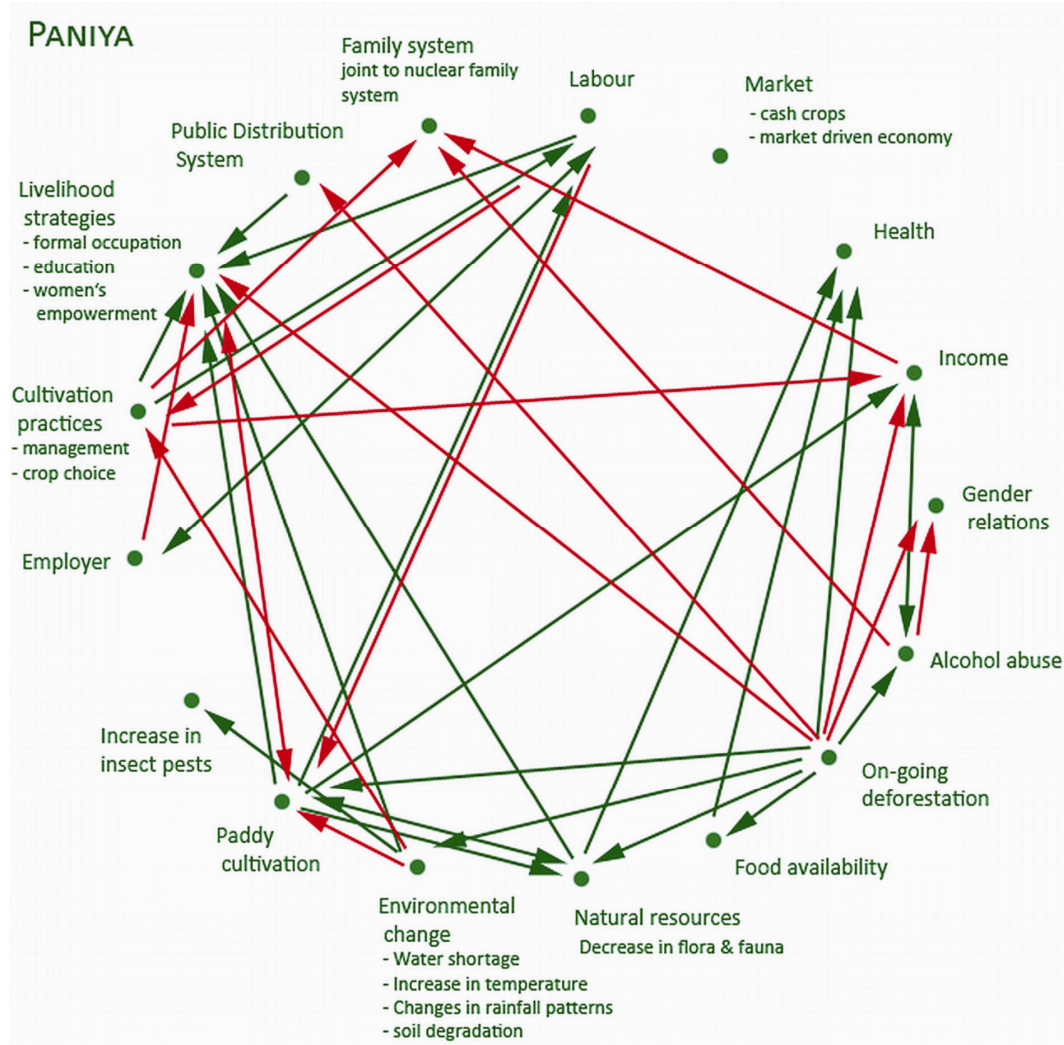


Figure 4. Social-ecological web of a Paniya community. Dots, lines and arrows same as in Figure 2.

the nutrition patterns of the all three communities. In the past, the forest was used as a resource for extraction of edible plants and hunting game²⁵. Today, this is hardly possible anymore due to habitat loss as well as a hunting ban decreed by the Central Government under the provisions of the Indian Wildlife Protection Act²⁶. The availability and/or quality of natural resources (e.g. edible plants, fish) are important for the livelihood strategies of the three Adivasi communities due to the increasing cost of food purchased for consumption. Kurichya and Kuruma respondents considered intensified cultivation practices to be the cause of the declining quality and quantity of natural resources available.

The social-ecological web method – a useful tool?

The social-ecological web is a graphical depiction of the current state of a particular social-ecological system; in this case each of the three webs depicts an indigenous

farming system in Wayanad. It is a useful tool that helps simplify, portray and categorize the complexity and structure of an agricultural system, which leads to a better understanding of the system. It identifies important system components and those components most responsible for changes in the system. As such, the social-ecological web is a useful tool for a comparative analysis, as in our case, where it highlighted the differences among three Adivasi communities.

One limitation is that the web does not quantify the relative importance of the different components in the social-ecological system. Based on the available data, this quantification was not possible. One option to improve the social-ecological web could be to ask the participants to rank the components according to their importance, similar to Net-Map exercises^{27,28}. Further enhancement of the social-ecological web method could be achieved by a participatory development of the webs. For example, farmers could draw interrelations between components suggested by the researchers. Moreover,

participants could add components they think the researchers missed out. Using a participatory approach would also allow the formulation of social–ecological webs for the past and the future, which would highlight change processes even better. To complement this study, it would be interesting to use the same method with non-indigenous farmers in order to highlight the differences between different social classes and ethnic backgrounds, which are so important in such a culturally diverse country as India.

Although the idea of the social–ecological web was taken from food webs and thus ecology, it became obvious during the critical reflection that this social–ecological web is similar to the methods used in social science, e.g. Net-Maps or social network analysis^{28,29}. This leads to the conclusion that ecology and social science actually use similar methods. Therefore, the social–ecological web is a kind of hybrid between methods from social and ecological science and thus an interdisciplinary tool that is easy to understand and to use for both disciplines. It also fulfils the requirements of a bridging concept, by integrating knowledge from different disciplines and helping overcome terminological differences.

The two objectives of this study were to learn about (i) the ecological knowledge and agricultural practices of the communities, and (ii) the social–ecological transformation processes taking place. It turns out to be difficult to tackle both issues at once. The social–ecological web method is an effective way to depict relationships between social and ecological components within an agrarian system and to analyse indicators of changes in agricultural practices. For detailed analysis of the ecological knowledge of members of the community, the social–ecological web is of limited use. The linkages between different ecological components, such as pest species, paddy cultivation or deforestation, as explained by farmers, offer some insight into their ecological knowledge. Nevertheless, interviews and ethno-ecological exercises might be a more appropriate methodological tool to elucidate farmers' ecological knowledge³⁰.

Challenges of integrating different disciplines and stakeholders

After having explained and discussed the use of the social–ecological web for this interdisciplinary study, we now focus on the challenges of integrating more than one discipline. We consider that communication between the two disciplinary teams, including the RAs, was the key to overcoming disciplinary boundaries, by establishing feedback loops within the research process from the very beginning of the study. This is in line with transdisciplinary reflections on the research process that emphasize reflexivity and the importance of feedback loops¹⁶. Discussions among the researchers led to a common understanding of the research questions and to their necessary

reformulation, from the initial academic jargon into a simplified language. Nevertheless, for data collection we used only qualitative methods from social science; methods used in ecology are quite different so that it is difficult to combine the two. To analyse the data we developed the social–ecological web, a tool which turned out to be a hybrid between social network analysis and ecological food webs. This social–ecological web allows for the visual portrayal of the complexity of a social–ecological system and enables researchers from different disciplines to better understand the changes occurring in agrarian communities.

Furthermore, the experience of carrying out this social–ecological study provided insights into how stakeholders can be integrated into the research process. The tandem approach, whereby each team was composed of a German and an Indian researcher, allowed for an informal access to the Adivasi communities; performing as an intercultural team helped to overcome language barriers and cultural biases. In addition, the dual role of our Indian tandem partners being both staff members of the M.S. Swaminathan Research Foundation (MSSRF) and BioDIVA's project partners led to a greater acceptance of the social–ecological study due to MSSRF's high reputation among the Adivasi farmers and within Wayanad as a whole.

Conclusion

In this article, we have described how ecologists and rural sociologists integrated their research interests into an interdisciplinary social–ecological study. The overall objective of this baseline study was to better understand changes occurring in the social–ecological system in Wayanad. Central to this study was joint data collection and the development of an interdisciplinary concept, the social–ecological web, designed as a bridging concept to facilitate the integration of knowledge from social and natural sciences. The social–ecological web is a useful tool to illustrate and compare the complexities of three different agrarian systems. The comparative approach reveals the differences among the Kuruma, Kurichya and Paniya groups, in terms of the structural changes that are occurring in the communities, the interrelations among system components, and the overall number of interrelations, which together describe the degree of change in the three social–ecological systems. The results of the comparative study among the three Adivasi groups show that the social–ecological system is modified by different components in each case. For example, deforestation negatively affects livelihood strategies of the Paniya. For the Kuruma and the Kurichya, market mechanisms influence the traditional agricultural system, e.g. the choice over crops and cultivation practices. Common to all groups is deforestation as the major driver for environmental

change, the loss of natural resources and consumption habits. Overall, we can conclude that changes in the agrarian system strongly shape social transformation processes in all three communities.

As a problem-oriented hybrid between social and ecological network analysis, the social–ecological web is a useful tool that facilitates interdisciplinary dialogue by visualizing the dominant themes identified through data analysis. It could be further developed in a transdisciplinary manner by involving stakeholders.

1. Muenster, D., Farmers' suicides and the state in India: conceptual and ethnographic notes from Wayanad, Kerala. *Contrib. Indian Sociol.*, 2012, **46**, 181–208.
2. Pohl, C. and Hirsch Hadorn, G., Core terms in transdisciplinary research, 2008; http://www.transdisciplinarity.ch/d/Transdisciplinarity/documents/HB_Core_terms.pdf
3. Cronin, K., Transdisciplinary research (TDR) and sustainability, 2008; http://www.learningforsustainability.org/pubs/Transdisciplinary_Research_and_Sustainability.pdf
4. Pretty, J. *et al.*, The intersections of biological diversity and cultural diversity: towards integration. *Conserv. Soc.*, 2009, **7**, 100–112.
5. Brosius, J. P. and Hitchner, S. L., Cultural diversity and conservation. *Int. Soc. Sci. J.*, 2010, **61**, 141–168.
6. UNESCO World Heritage Centre 1992–2013, Western Ghats, 2012; <http://whc.unesco.org/en/list/1342>
7. Rath, G. C., *Tribal Development in India. The Contemporary Debate*, Sage Publications, New Delhi, 2006.
8. Chathukulam, J. and John, M. S., Issues in tribal development: the recent experiences of Kerala. In *Tribal Development in India. The Contemporary Debate* (ed. Rath, G. C.), Sage Publications, New Delhi, 2006, pp. 182–202.
9. Nair, G., *Wynad: Its People and Traditions*, Higginbotham & Co, Madras, 1911.
10. Indian Institute of Management, Wayanad initiative: a situational study and feasibility report for a comprehensive development of Adivasi communities in Wayanad, 2006; <http://www.scribd.com/doc/4074255/Wayanad-Initiative>
11. Kumar, B. M., Land use in Kerala: changing scenarios and shifting paradigms. *J. Trop. Agric.*, 2005, **42**, 1–12.
12. Guillerme, S. *et al.*, Impacts of public policies and farmer preferences on agroforestry practices in Kerala, India. *Environ. Manage.*, 2011, **48**, 351–364.
13. Lerche, J., Agrarian crisis and agrarian questions in India. *J. Agrarian Change*, 2011, **11**, 104–118.
14. Kurup, K., Wayanad through the ages: a study in socio-economic transition. University of Calicut, 2010.
15. Kulirani, B. F., The shrinking livelihood strategies of the Paniyar, 2011; <http://www.sasnet.lu.se/conferences/livelihood-strategies-among-forest-related-tribal-groups-south-india>
16. Novy, A., Beinstein, B. and Voßemer, C., Methodologie transdisziplinärer Entwicklungsforschung. In *Aktion & Reflexion Texte zur Transdisziplinären Entwicklungsforschung und Bildung*, Paolo Freire Zentrum, Wein, 2008, **2**, pp. 1–42.
17. Newing, H., Eagle, C. M., Puri, R. K. and Watson, C. W., *Conducting Research in Conservation: Social Science Methods and Practice*, Routledge, London, New York, 2011.
18. Jackson, J., Feminism spoken here: epistemologies for interdisciplinary development research. *Dev. Change*, 2006, **3**, 525–547.
19. Padmanabhan, M., Women and men as conservers, users and managers of agrobiodiversity: A feminist social–ecological approach. *J. Socio-Econ.*, 2011, **40**, 968–976.
20. Bergmann, M., John, T., Knoblauch, T., Krohn, W., Phl, C. and Schramm, E. (eds), *Methoden transdisziplinärer Forschung. Ein Überblick mit Anwendungsbeispielen*, Campus Verlag, Frankfurt am Main, 2010.
21. Deppisch, S. and Hasibovic, S., Social–ecological resilience thinking as a bridging concept in transdisciplinary research on climate-change adaptation. *Nat. Hazards*, 2013, **67**, 117–127.
22. Sunderland, K. D., Powell, W. and Symondson, W. O. C., Populations and communities. In *Insects as Natural Enemies* (ed. Jervis, M. A.), Springer, Dordrecht, The Netherlands, 2007, pp. 299–434.
23. Mohindra, K. S., Narayana, D., Harikrishnadas, C. K., Anushreedha, S. S. and Haddad, S., Paniya voices: a participatory poverty and health assessment among a marginalized South Indian tribal population. *BMC Public Health*, 2010, **10**, 149.
24. Kerala State Land Use Board, Status Report on Paddy Cultivation in Wayanad District, 2006.
25. Münster, U. and Vishnudas, S., In the jungle of law. Adivasi rights and implementation of Forest Rights Act in Kerala. *Econ. Polit. Wkly*, 2012, **XLVII**, 38–45.
26. Government of India, Wildlife Protection Act of 1972, 2012; <http://www.envfor.nic.in/rules-regulations/wildlife>
27. Schiffer, E. and Hauck, J., Net-Map: collecting social network data and facilitating network learning through participatory influence network mapping. *Field Methods*, 2010, **22**, 231–249.
28. Schiffer, E., Net-Map toolbox. Influence mapping of social networks, 2007; <http://netmap.wordpress.com/about/>
29. Scott, J., *Social Network Analysis. A Handbook*, Sage Publications, London, 2000, 2nd edn.
30. Martin, G. J., *Ethnobotany*, Earthscan, London, 2004.

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