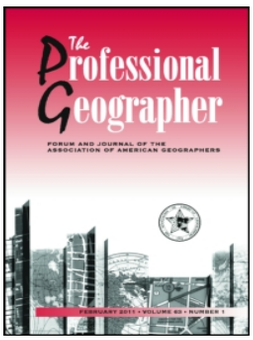

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Mapping Meaning: Critical Cartographies for Participatory Water Management in Taita Hills, Kenya

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Participation of local people is often neglected in natural resource management, which leads to failure to understand the social aspects and historical construction of environmental problems. Participatory mapping can enhance the communication of local spatial knowledge for management processes and challenge the official maps and other spatial representations produced by state authorities and scientists. In this study, we analyze what kind of social meanings can be revealed through a multimethod participatory mapping process focusing on water resources in Taita Hills, Kenya. The participatory mapping clearly complicates the simplified image of the physical science mappings, typically depicting natural water supply, by addressing the impacts of contamination, inadequate infrastructure, poverty, distance to the sources, and restrictions in their uses on people's access to water. Moreover, this shared exercise is able to trigger discussion on issues that cannot always be localized but still contribute to place making. Local historical accounts reveal the social and political drivers of the current water-related problems, making explicit the political ecology dynamics in the area. **Key Words: environmental histories, participatory mapping, spatial meaning, Taita Hills, water resource management.**

自然资源的管理经常忽略在地人的参与，并导致无法理解环境问题的社会面向及历史建构。参与式製图能够为管理过程增进在地空间知识的沟通，并挑战国家机构和科学家所绘製的官方地图及其他空间再现。我们于本研究中聚焦肯亚台达山丘中的水资源管理，分析透过多重方法参与式製图过程，能够揭露何种社会意涵。参与式製图透过指出污染、基础建设不足、贫穷、获得资源的距离，以及使用他人的水资源管道的限制之影响，明确地复杂化描绘出自然资源供给的一般物理科学製图。再者，此一共享的活动，能够引发对无法总是在地化、但却仍对地方打造有所影响的议题进行讨论。地方历史的说明，揭露了当前与水资源有关的问题的社会及政治驱力，明确呈现出该地的政治生态动态。 **关键词: 环境历史，参与式製图，空间意涵，台达山丘，水资源管理。**

La participación de la gente de la localidad a menudo no es atendida en el manejo de los recursos naturales, lo cual lleva al fracaso de entender los aspectos sociales y la construcción histórica de los problemas ambientales. El mapeo participativo puede robustecer la comunicación de conocimiento local para los procesos del manejo y reta los mapas oficiales y otras representaciones espaciales producidas por autoridades estatales y científicos. En este estudio analizamos los tipos de significados sociales que pueden revelarse a través un proceso de mapeo participativo de método múltiple enfocado en los recursos hídricos de Taita Hills, Kenia. El mapeo participativo claramente complica la imagen simplificada de los mapeos de ciencia física, que típicamente representa el suministro de agua, abocando los impactos por contaminación, infraestructura inadecuada, distancia a las fuentes y restricciones en sus usos de los accesos de la gente al agua. Aún más, este ejercicio compartido sirve también para instigar la discusión sobre asuntos que no siempre pueden localizarse, pero que aún así contribuyen a la construcción de lugar. Los registros históricos locales revelan los controles sociales y políticos de los problemas actuales relacionados con agua, haciendo explícita la dinámica de la ecología política en el área. **Palabras clave: historias ambientales, mapeo participativo, significado espacial, Taita Hills, manejo de los recursos hídricos.**

Local people's participation is important in water resource management for the identification of local water-related problems, their causes, and strategies to solve them (Global Water Partnership 2000; Dungumaro and Madulu 2003; Rault and Jeffrey 2008; Upadhyay and Rai 2013). It is common, however, that the local administration lacks capacity and skills to facilitate community participation and to utilize local knowledge that entails the societal and cultural meanings of resources and environmental changes (Batchelor 1999; Wester, Merrey, and de Lange 2003; Jansky, Sklarew, and Uitto 2005). The state water management institutions also typically address problems on large spatial scales from a national level to a district level with the main focus on material resources and economic aspects. This could lead to misunderstanding the nature and impacts of the local problems and their interaction with global phenomena (Berkes 2006; Musacchio 2009).

Participatory mapping can facilitate communication of local spatial perceptions and knowledge for natural

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resource management (International Fund for Agricultural Development 2009). It is a useful tool, for example, for mapping local ecosystem services (e.g., Fagerholm et al. 2012; Brown and Fagerholm 2015; Darvill and Lindo 2015), social values attached to landscape (e.g., Fagerholm and Käyhkö 2009), place attachment (e.g., Brown and Raymond 2007), and narratives (e.g., Elwood and Mitchell 2012). It is a relevant method not only for locating resources and problems or for complementing quantitative geographies but also for identifying the social meaning and historical political development of spatial attributes (Sletto 2009a, 2009b, 2014). It can also serve as *counter-mapping* (Peluso 1995) that challenges the formal authoritative maps as official representations of places (Smith 2003; Wood 2010). This study contributes to the scholarly debate by relating spaces and histories into participatory maps, adding complexity to the space representation provided by official technical maps, and aiming to empower local people in environmental resource management.

We explore the issue through an empirical case study based in Taita Hills, Kenya, where mapping has so far largely centered around the authority of state agencies and foreign and Kenyan scientists (Pellikka et al. 2009; Maeda et al. 2011; Boitt, Mundia, and Pellikka 2014; Piiroinen et al. 2015) who mainly employ ground surveying and remote sensing techniques in data collection. Our study is a follow-up of a long-term research cooperation in Taita mostly focused on forests, climate, and water-related changes. In contrast to other projects bringing mainly foreign researchers to analyze environmental issues through standardized data and modeling in cooperation with local administrators, this research is qualitative and, although led by outsider scholars, also involves Kenyan researchers, local grassroots activists, and community members. We wanted to bring in the local perspective on water-related problems; therefore, we proposed a mapping project to the community-based organizations operating in the area. Our aim was not simply to produce a bidimensional spatial representation of natural resources of Taita but to involve a people-based reflection of the environmental challenges occurring locally. Our research was guided by the following questions: What kind of meanings can be revealed through a participatory mapping process that do not emerge in expert cartography? How could these different meanings be operationalized in environmental management planning? Can the representation of these meanings enhance spatial responsibility? We examined maps through a critical semiological analysis that can reveal higher level sociocultural meanings of the map signs (Rose 2012). Our study confirms that a participatory mapping process is able to identify several problems and social meanings related to water resources that complicate the fixed place image given by conventional maps. Incorporation of historical socioecological perspectives into mapping can assist discussion on issues that contribute to the production of sense of place and make explicit the political ecology of water.

Taita Hills on Maps: A Critical Cartographic Approach

In environmental management processes, thematic and topographic maps produced by state agencies or scientific experts are commonly used to analyze the spatial distribution of resources. Those maps bear an ostensible authority brought by their cartographic appearance and the status of their producers (Wood 2010). Critical cartographers have questioned such authority and, instead of regarding maps as static representations of the constellations of physical elements in space, they focus on studying their social construction (Harley 1989), underlying political agendas (Wood and Fels 1986, 2008; Wood 1992, 2010), and processual remaking (Kitchin and Dodge 2007; Kitchin, Gleeson, and Dodge 2013). In this section, we provide a brief critical examination of the cartographic presentations of the Taita Hills and their meanings.

During our field trips to Taita in 2013 and 2014, the most commonly used map by the state officers and also by us, the researchers, to guide our journey, was a topographic map prepared by the Survey of Kenya together with Japan International Cooperation Agency, published on the scale of 1:50,000 in 1991. Although the appearance of the map aims to be neutral and objective, it is slanted by the conventions of spatial accuracy of scientific cartography, manifested by the spatial reference system metadata given on the map sheet. The claim of spatial accuracy itself is a symbol for authority and Western utilitarian philosophy (Harley 1989). In addition, the content of the map is unavoidably selective and even "tells lies" through its geometric and content generalizations that are necessary to clearly show those parts of reality that the mapmaker considered relevant (Monmonier 1996).

If we understand the topographic map as a semiotic rather than a factual system, however, we realize that it contains a level of myth created by mapmakers that serves their intentions (Wood and Fels 1986). These intentions might be seemingly neutral, like in the case of this map depicting the relief of the hills, but these intentions also often serve the interests of power and colonial and capitalist perspectives of the state or corporate actors (Scott 1998; Biggs 1999; Craib 2000; Sletto 2009a; Wood 2010). Thus, the semiotic system of a map is also a system of values (Wood and Fels 1986). In this sense, maps are "propositions" rather than "representations" of the reality (Wood and Fels 2008; Wood 2010). This is what makes the maps always political.

The political dimension is clearly present on the topographic map in the boundaries of different administrative regions, which indicate the state authority. The scale of the map (1 cm on the map equals a 500-m distance in reality) also serves administrative purposes and leaves out a lot of details that appear in the scale of everyday human life. For example, there are several streams and springs that are too small to be depicted on this scale but are essential water sources for people living in the area. There are also some

important nonphysical boundaries that are not assigned signs on the map. For example, the boundaries of the private land also often constitute the social boundaries that determine people's access to resources. What is not represented on the maps, though, can be ignored by policymakers (Monmonier 1996).

There are also several other maps made by the government agencies and scientific researchers that depict the physical and biogeography of Taita. Common to all of the maps is that they make propositions assuming linkages between locations and the conceptual content of the map signs (Wood 2010). The maps of Taita assume linkages, for example, between the suitability of land for growing mango trees, maize, cassava, and sweet potatoes and the altitude described as "lower midland" (Jaetzold and Schmidt 1983; Boitt, Mundia, and Pellikka 2014) and between the distribution of the remaining indigenous forest patches and hill peaks (Pellikka et al. 2009; Maeda et al. 2011). Indirectly, these maps also associate higher precipitation and wetter climate with higher altitudes. Such propositions can be transformed into simple "facts" when the maps are used for management purposes, which is problematic, because they do not tell anything about the social meaning of these facts. Therefore, the alternative local understanding also needs to be spatially presented.

The preceding structural criticism does not aim to understate the importance of the scientific cartography but rather to suggest that it cannot be the sole source of spatial information for environmental management, especially when the aim is to empower local people to manage their own resources. Other veins of critical cartography have provided an important legitimatization for the alternative cartographies—for example, through participatory mapping—by questioning the ontological security of maps. The ontogenetic perspective, introduced by Kitchin and Dodge (2007), understands maps as "mappings; spatial practices enacted to solve relational problems," which "are brought into being and made to do work in the world . . . through practices" (Kitchin, Gleeson, and Dodge 2013, 2), thus broadening the range of spatial actions that can be included in cartography.

Multimethod Participatory Mapping

The participatory mapping process of our study was part of qualitative research on socioecological perspectives of water management in the Taita Hills (Hohenthal et al. 2015) that employed sketch mapping, timeline exercises, focus group discussions, semistructured interviews, and walking as methods to collect local spatial and historical knowledge. Sketch maps are typically used in critical and qualitative participatory geographic information systems (PGIS) to map local people's spatial narratives (Boschmann and Cubbon 2014). As a temporal counterpart to sketch maps, community timelines can be used to capture the place-specific oral histories of communities that often diverge from or remain undocumented in the official histories that tend to consider large-scale "expert-driven metanarratives" (Riley and Harvey 2007, 349). Focus group discussions and semistructured interviews are established qualitative research methods (Crang and Cook 2007) that were used to supplement spatial and historical information. Walking is also a widely used but rarely properly recognized research method that increases understanding of the study area and might assist in identifying further questions for the data analysis (Pierce and Lawhon 2015).

Due to the lack of spatial accuracy and cartographic basis, the value of sketch maps is sometimes dismissed by natural scientists and management officials (Cadag and Gaillard 2012). Therefore, our project also included the production of digital georeferenced maps with geographic information systems (GIS) that serve as a communication interface to support decision making based on spatial attributes (Aditya 2010). PGIS can be understood as a knowledge coproduction tool that combines the cartographic conventions of spatial accuracy with the native spatial knowledge (Sletto 2015).

Case Study Setting and Methods

The mapping project focused on two water catchments in the Taita Hills: Wundanyi catchment located in the highlands (downstream outlet at 1,258 m above sea level) and Mwatate catchment that extends from the southern border of the Wundanyi catchment to the Teita Sisal Estate dam in the foothills (831 m above sea level; Figure 1). The majority of the inhabitants in both catchments are subsistence farmers (Kenya National Bureau of Statistics and Society for International Development East Africa 2013), whose livelihoods are highly dependent on water availability. Small-scale cattle keeping is also common and water is needed to water the animals. In the lowlands, the Teita Sisal Estate, which is largely outside the Mwatate catchment, is one of the largest in the world (over 12,000 ha) and is a significant water user that also competes with local people for land. Water management planning through mapping is thus urgently needed to agree about equal distribution and sustainable use of the scarce resources among the multiple actors.

The mapping was organized and facilitated in 2013 by a mixed team of foreign and Kenyan researchers. The contents of the mappings were produced by local people and the research team was responsible only for the technical realization of the georeferenced maps. Sketch mapping, timeline exercises, and focus group discussions were made in two workshops, one in Wundanyi and one in Mwatate catchment, where the research team invited members from different community groups that are involved in natural resource management (i.e., forest groups, water projects, fish pond owners, water resource users associations [WRUAs], and farmer groups). In both workshops, the participants were divided into four working groups of four to ten people according to their living location. Each group drew a sketch map depicting

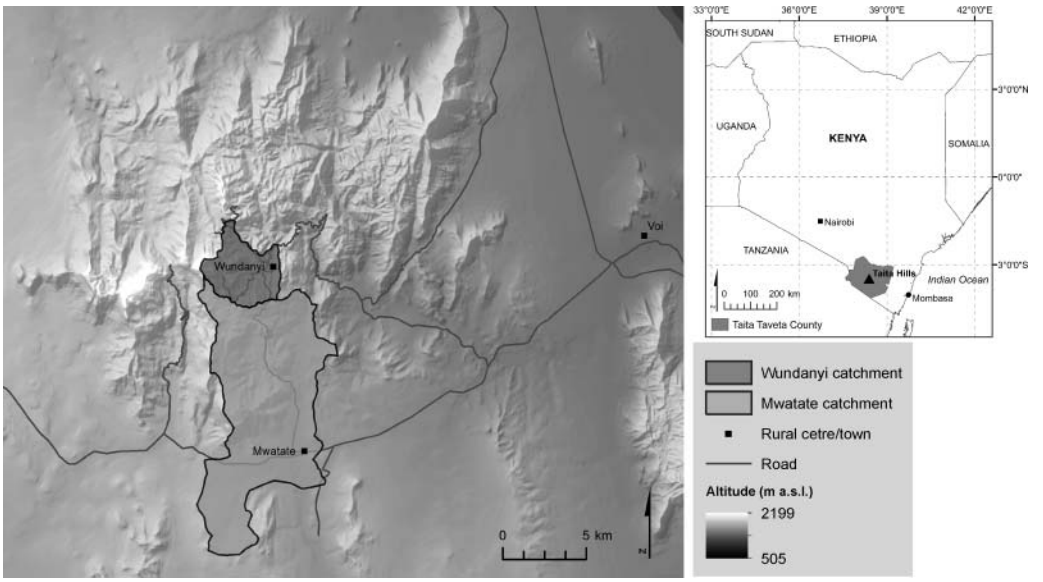


Figure 1 *Wundanyi and Mwatate water catchments in the Taita Hills, Kenya, depicted on a topographic model generated from topographic maps of the Survey of Kenya. m.a.s.l. = meters above sea level.*

the waterscape (streams, springs, water infrastructure) of their respective area. The main goal of the workshops was to identify problems related to water or water provisioning ecosystems, which the participants wrote on paper notes and attached to the maps. After the exercises, the groups presented the contents of their maps and timelines to the other workshop participants in interactive sessions. That was followed by a collective discussion on the catchment's water and land use issues led by a representative from a community-based organization. The research team intervened in the discussion only to make some specifying questions and to keep the discussion within the agreed time frame.

After the workshops, the research team took walks with knowledgeable community members, visiting the most important places that the workshop participants had indicated in their mappings. The team also collected geographical coordinates of those places using a handheld Global Positioning System (GPS). They also interviewed local water users and authorities about water resources and environmental management practices. Later, the researchers prepared preliminary workshop reports and distributed them to the workshop participants as a firsthand feedback of the research. The participants had a chance to comment and make corrections to the reports and thus contribute to the contents of the final project report.

After the first field period, the research team georeferenced the spatial data using the collected coordinates and produced drafts of digital catchment maps with Quantum GIS 1.6.0 software (Quantum GIS Development Team 2010). The land cover data from an earlier study (Clark and Pellikka 2009) were used as a background map. River channels and fish ponds were digitized based on the combination of GPS points and interpretation of the aerial photography taken in January 2012.

Finally, the researchers compiled all of the results and georeferenced maps into a research project report, the contents of which were validated in two concluding workshops organized in Mwatate and Wundanyi in 2014. Workshop participants were the same community groups who had participated in the previous workshops, state officers, chiefs, elders, and representatives from the nongovernmental organizations. Potential actions to improve the management of water-related resources were also discussed in these workshops. Later, the research team distributed the revised final reports to the community groups and relevant institutions.

Ethical Considerations

Participatory mapping processes are affected by power dynamics between the participants and the external facilitators and within the community itself. Besides affecting people's capability and willingness to participate (Sultana 2009), these dynamics determine whose meanings the sketch maps and other outputs represent (Chambers 2006). It must be noted that "local people" or "communities" are not homogenous entities but consist of individuals who have differing experiences and knowledges affected by their gender, age, personal and ethnic background, and social status. Thus, we considered the contradictory perceptions among the community, as they might become critical in participatory mapping processes (McCall and Dunn 2012). The majority of the local participants were at working age, but some elderly people also participated in the household interviews. Both men and women were present in the workshops and some of the women were very active, although, in general, the men had

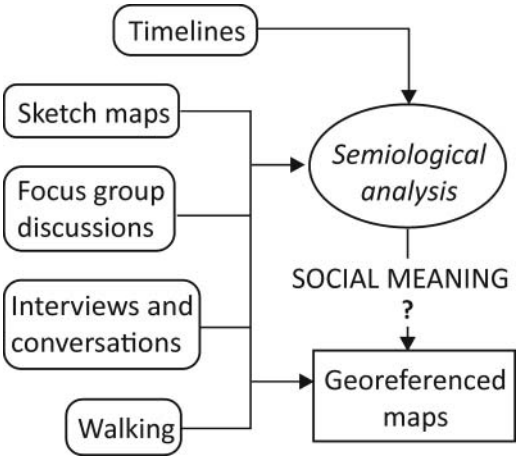


Figure 2 *Flowchart illustrating the research methods.*

"louder voices," especially when it came to the public presentation of the group maps and timelines. In the interviews, not all women were fully enabled to express their opinions, leaving this option to households' men. Taita culture has traditionally been dominated by patriarchal norms (Fleuret 1988; Bravman 1998), and although women's position has improved, it was obvious that some discrimination against them still exists.

We also had to carefully consider how the sketch maps and social meanings could be conveyed to the digital formats to be shared with local authorities in a beneficial way and not detrimental to the participants. There are some things that should remain hidden (Madhok and Rai 2012). Thus, the identities of the participants were protected and it ensured that problems could not be linked with individual households. It was also agreed that the ownership and user rights of all of the raw material as well as the digital maps and reports would remain within the community.

Semiological Analysis

We applied a semiological approach to the analysis of the sketch maps (Figure 2). We started the analysis by identifying the signs. For these, we considered the general configuration, orientation and symbolization of the maps, the water-related problems, and the mapping process itself. Then we moved on to analyze the meanings of these signs through the mapmakers' descriptions of their maps, problems, and timelines, as well as other related conversations and interviews. The analysis of meanings focused on a connotive level; that is, studying the higher level social, cultural, and political meanings of the signs. Literature was used to validate and complement historical points and to support the analysis.

Results

Each sketch map had a unique composition regarding the choice of landscape features, symbols, scale, and orientation. Some maps followed the north–south orientation and were accompanied by legends (Figure 3), which shows that their makers had some knowledge of scientific cartography that they had possibly learned at school or in previous

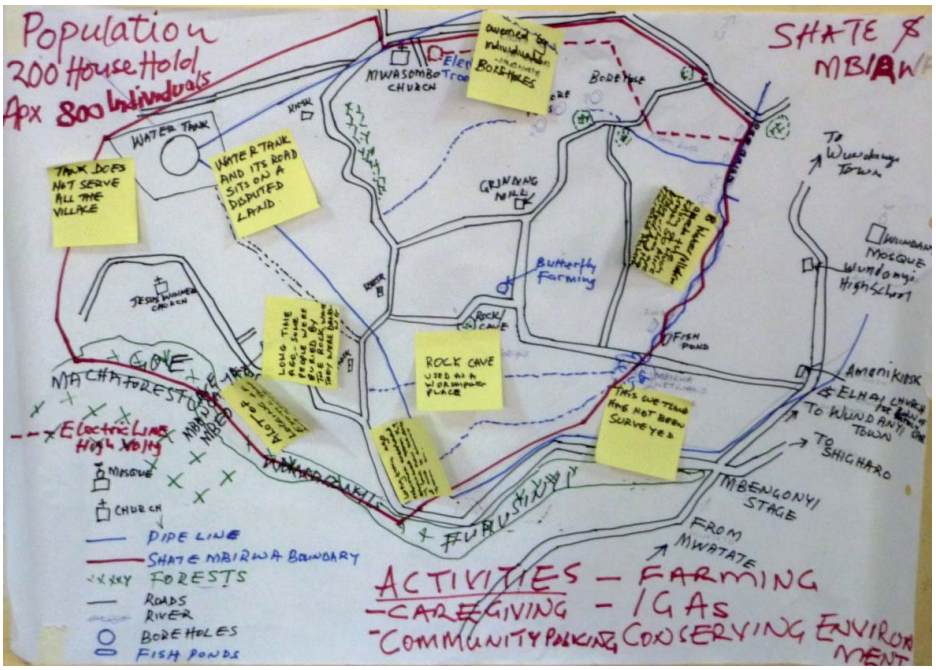


Figure 3 *Sketch map drawn by Shate/Mbirwa working group in Wundanyi workshop. The map covers the southeastern corner of Wundanyi water catchment in Figure 5. (Color figure available online.)*

Figure 4 *Sketch map drawn by Kidaya/Ngerenyi working group in Mwatate workshop. The map covers the northwestern corner of Mwatate water catchment in Figure 6. (Color figure available online.)*

mapping exercises or adopted from formal maps. Other groups oriented their maps either facing downhill or uphill regardless of the compass points (Figure 4). In a mountainous landscape, such mental orientation becomes natural and reveals better the participants' own embodied experiences and the sense of place than the north–south direction, which is irrelevant in practice most of the time.

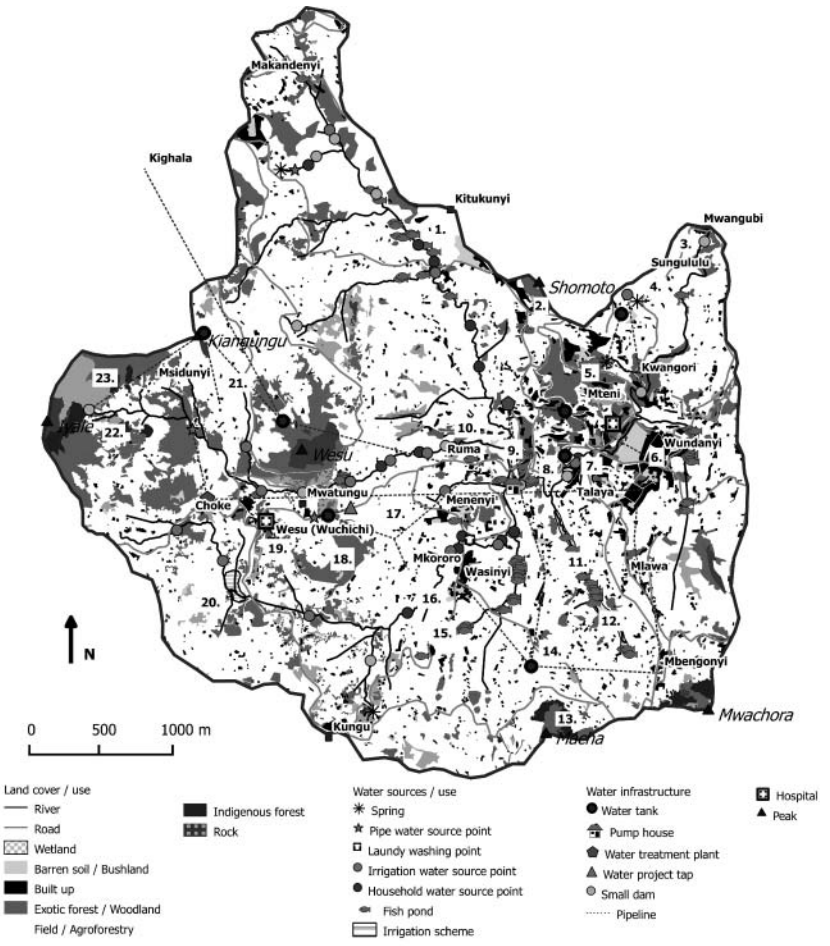
The selection of the attributes that the working groups included in their maps was partly guided by the list of examples, which we provided to narrow down the scope of the exercise. Irrespective of these guidelines, some groups tended to give more value to the pipelines and tanks of the government's water supply system, whereas some highlighted natural water sources such as rivers and springs or small water infrastructures. This selection was most likely guided by people's experiences in the use of these sources or involvement in their maintenance.

The contents of the timelines were also selective and varied between the working groups. All of them, however, to some extent reflected the phenomena that had affected the whole nation, such as the arrival of the Christian missionaries in the late nineteenth and early twentieth centuries, the period of colonial occupation from 1895 to 1963, world wars in 1914 to 1918 and 1939 to 1945, and demarcation of land since the 1960s. Some of the listed events, however, were considered differently in the two catchments. For example, in the upland areas of Wundanyi, the world wars were not mentioned at all, whereas in Mwatate, they were present in people's accounts, obviously because some of the battlefields were located nearby.

Georeferenced Catchment Maps

Certain aspects of people's sense of place were inevitably lost in the georeferencing process, such as their mental orientation in the landscape when it differed from the north–south orientation used in the GIS. In addition, some attributes that were not directly related to water resources but rather served as the landmarks of the local spatial reference system (e.g., schools and churches) were not included in the final georeferenced maps.

The presentation of the water-related problems on the georeferenced maps was sometimes difficult, because not all of the problems were attached to certain point locations but referred to larger areas. For example, certain dry springs were easy to locate, whereas decreasing rainfall that emerged as a topic in group discussions and interviews was not confined to one location and was thus more difficult to spatialize. In addition, social problems, like poverty, which creates a pressure for taking more land for food production, concern wide areas, although it was in some cases located to certain villages on sketch maps perhaps due to a mapper's personal experience. This problem of spatial presentation, together with the fact that several problems had unique characteristics and were accompanied by lengthy explanations by the workshop participants, made it seem inappropriate to reduce the problems into map symbols. Therefore, the water-related problems were grouped according to their approximate location and assigned serial numbers plotted on the georeferenced maps (Figures 5 and 6).



Problems:

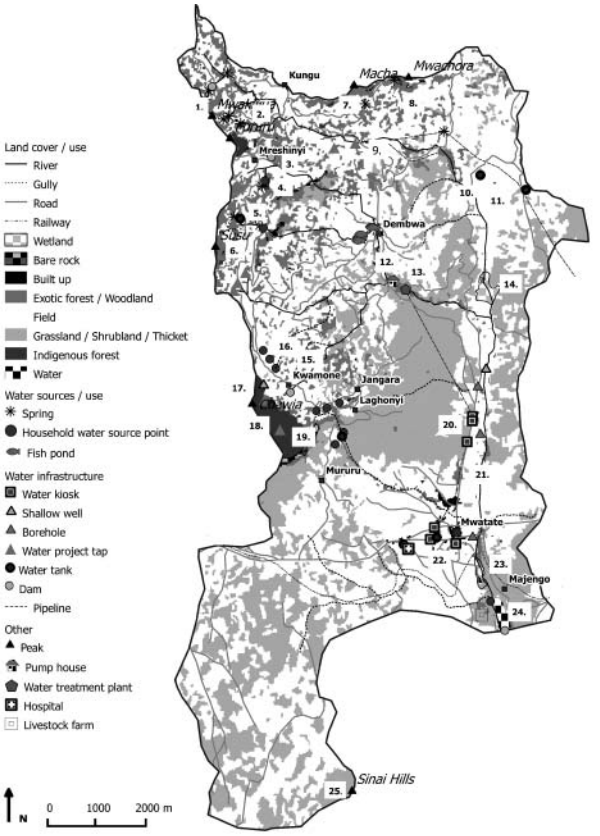
1. Kitukunyi village: lack of water and firewood; soil erosion contributes to siltation of water bodies
2. Shomoto Hill: exotic trees planted for pole production use a lot of water; falling rocks and land slides during heavy rains
3. Mwangubi village: sand harvesting causes river siltation
4. Sungululu: water levels have gone down; lack of knowledge of resource conservation and protective farming methods
5. Shambadii forest (indigenous and exotic): County council has plans to clear the forest, which would have detrimental impacts on Kidakiwi spring that is a source of water for the surrounding community, including Wundanyi village
6. Wundanyi village: waste water flows to the river
7. Wundanyi prison: sometimes waste water leaks into the river
8. Coffee factory: large-scale production ended in 2000, now only small-scale activities; potential source of chemical contamination
9. Pump house and water treatment plant for TAVEVO water supply system: changes in river water level cause problems for pumping; old machinery; no measurement of bacteria, lack of qualified staff
10. Ruma village: lack of water
11. Mbirwa river: water flow has diminished; agrochemicals (from farming for Vegpro) have contaminated water, which has killed frogs and thus the number of malaria spreading mosquitoes has increased; fish ponds potential source of river water contamination
12. Mbirwa wetland: borders not surveyed, which raises disputes over land ownership and hampers conservation efforts
13. Macha forest (indigenous and exotic): logging for firewood and pole production; stone digging causes erosion
14. TAVEVO water supply system tank: on a disputed land; works with gravity, so does not not supply water to the higher areas
15. Wasinyi: Kiziki forest is destroyed, which is leading to drying up of rivers and lack of water
16. Kighononyi river: washing and bathing deteriorate water quality
17. Toro water project: lack of infrastructure; eucalyptus forest above the water source uses a lot of water
18. Mbili forest (indigenous and exotic trees): eucalyptus trees use a lot of water, which decreases river flow nearby
19. Wesu hospital: potential waste water leakage into the river
20. Wesu irrigation scheme: agrochemical contamination
21. Iyale/Msidunyi water project: lack of funding and infrastructure; problems with maintenance; vandalism
22. Msidunyi/Wesu river source: lack of water due to deforestation and farming
23. Iyale Hill: water-exigent eucalyptus trees

Figure 5 *Wundanyi catchment map with water-related problems.*

Social Meanings of the Maps

On a connotive level, the signs on the community maps reflect the meanings linked to values and practices related to forest resources, land privatization, economic factors, and organization of water supply. In some cases, it was possible to draw a link between a historical driver and a current water-related problem (Table 1). This is important for understanding the roots of the problems and for incorporating the historical perspective into the mapping process.

Taita people generally associate indigenous forests with water resources and consider deforestation and the plantation of water-exigent exotic trees to be the main factors causing a decrease in water levels. The immediate accusation focuses typically on



Problems:

1. Mwakivua forest (exotic trees): illegal firewood harvesting and logging; springs are drying up; exotic trees invading indigenous Fururu forest nearby; reforestation campaign led by the Kenya Defence Force failed
2. Mwanginyi dam: no water in the reservoir; soil erosion; logging
3. Mbundukinyi forest and Agricultural Training Centre (ATC) dam: massive government induced deforestation by ATC board; soil erosion and siltation; the dam has not benefited the community, but proposals for wider access to its water are made
4. Ndiwenyi forest and wetland: siltation has destroyed Ngulu dam within it; deforestation; wetland encroachment and introduction of exotic trees; lost cultural site; a drying spring
5. Ikungunyi water project: problems with management; conflicts between users
6. Susu forest (indigenous and exotic trees): grazing; timber production; intentional burning
7. Macha forest (indigenous and exotic trees): illegal logging
8. Mbengonyi forest: enchroachment; *fighi* destroyed; high demand for firewood and building materials
9. Josa-Modambogho water project: water sources encroached; in upstream areas water used for irrigation; problems in management
10. Mwalukumbi: Low river water level; humans and animals use the same water source; Plan Int. river rehabilitation project failed
11. Kilulunyi forest: *fighi* that has suffered from encroachment
12. Mwamkute river: water used extensively for irrigation; water source and river bank encroachment
13. Mwatate water supply (ran by the County Council): not enough infrastructure; problems in management
14. Ngulu wetland: encroachment, agrochemical contamination; graphite mining upstream used to cause siltation in the 1950s
15. Mkolonge water project (funded by DANIDA): incompleted; stream dried up due to lack of catchment protection; problems in management
16. Kwashuma stream (and streams nearby): dried up due to harmful farming methods; pollution from fertilizers
17. Mwaroko shallow well (in Chawia forest, constructed by UNDP in 2001): clean water, but a broken pump
18. Chawia forest: inadequate guarding; eucalyptus invasion and cattle disturbance; a natural pond and several springs within and on the edges of the forest have become seasonal
19. Iyombonyi-Sinai water project (infrastructure constructed by Plan Int.): no water at intake in Chawia forest during dry spell
20. Water kiosks (Mwatate-Wundanyi road): sometimes salty water
21. Upper Mwatate river valley: no water in the river during the dry season; sand harvesting and intensive farming on the river banks cause erosion; deforestation
22. Mwatate: harmful farming methods; conflicts over water use; lack of rain water harvesting and storage equipment
23. Lower Mwatate river valley: siltation; occasional flooding; livestock and elephants destroying the crops; sand harvesting contributes to gully formation
24. Sisal estate dam: heavy siltation of the reservoir due to farming in the upper parts of the catchment; lack of public support
25. Sinai Hills: bush fires and smoke indicating charcoal burning

Figure 6 *Mwatate catchment map with water-related problems.*

the current timber and pole production from eucalyptus trees (Figure 5, Problems 2, 13). The historical accounts, however, show that the roots of the indigenous forest destruction date back to the early twentieth century when the Christian proselytism started to reduce people's respect for traditionally protected sacred forests, *fighis* (Figure 6, Problems 4, 8, 11), and when the British settlers introduced the exotic trees to dry up wetlands and to produce fuel wood for the newly built railway (cf. Ofcansky 1984). After independence, the land reform that followed the Land Adjudication Act of 1968 also contributed to the decrease in indigenous forest cover. The reform aimed at enhancing agricultural production in Kenya through consolidating and privatizing the communal lands and promoting

Table 1 *Main historical events that have contributed to the emergence of the current water-related problems in the Taita Hills*

Time	Event	Impact	Problem no. on a map
–1900–	Onset of Christian proselytism	Loss of respect for traditionally protected sacred forests	Figure 6: 4, 8, 11
1910–	Construction of the Voi-Taveta railway line during World War I	Forest destruction, introduction of exotic trees	Figure 5: 2, 17, 18, 23 Figure 6: 1, 4, 18
1920–	Arrival of British settlers	New farming methods (agrochemicals, cash crops) Land grabs, Deforestation, Introduction of exotic trees	Figure 5: 8 Figure 5: 2, 17, 18, 23 Figure 6: 1, 4, 18
	Missionaries construct a dam to Ngerenyi (later owned by the Agricultural Training Centre)		Figure 6: 3
1930–	Establishment of the Teita Sisal Estate	Land grabs,increased water use	Figure 6: 24
1940–	Onset of mining and horticulture Construction of dams	Deforestation, siltation Water disputes	
1950–	Mining Construction of Wundanyi water supply system (Wesu) Drought and hunger "*Nyangira*"	Deforestation, siltation	Figure 6: 14
1960–	Introduction of modern irrigation techniques	Increased water use	Figure 5: 20 Figure 6: 9, 12
	Land Adjudication Act 1968	Decreasing size of land holdings, land disputes, forest and wetland encroachment	Figure 5: 12 Figure 6: 4, 6, 8, 9, 11, 12, 14, 18
1970–	Rain seasons start to become more irregular	Traditional agricultural knowledge no longer applicable	
1980–	Arrival of Danish International Development Agency and Plan International Construction of the Wundanyi pump house 1989	Increased water infrastructure	 Figure 5: 9
1990–	Increased sand harvesting	Erosion, siltation	Figure 5: 1, 3 Figure 6: 23
	El Niño rains 1997	Flooding	
2000–	Water Act 2002	Decentralization of water governance, increased bureaucracy	
	Arrival of Tavevo Water and Sewerage Company 2007	Takes over the management of state water supply from the ministry	
	Introduction of fish farming Constituency Development Fund funding for water projects	Potential water contamination Water projects	Figure 5: 11
	Inflation	Decreased purchasing power	Figure 5: 17, 21 Figure 6: 17, 22
	Vegpro company started cooperation with farmers in 2008	Increased use of agrochemicals	Figure 5: 11
2010–	Establishment of water resource users associations	Delegation of water management responsibilities to local level	
	Environmental groups	Reforestation initiatives	

Note: Where possible, the events are linked to the specific problem numbers on the catchment maps in Figures 5 and 6.

cash crop production (Orvis 1997). During this process in Taita, some forested areas were given to people for farming and grazing. Privatization also led to the decreasing size of the inherited land holdings, causing pressure to search for farmland in the remaining forests and wetlands (Figure 5, Problem 12; Figure 6, Problems 4, 6, 8, 9, 11, 12, 14, 18, 21).

As a solution to the problem of diminishing indigenous forest cover, most people (apart from a representative of the Kenya Forest Service, who promoted eucalyptus planting for timber production) suggested the gradual replacement of the exotic trees with the indigenous species to revive the hydrological cycle. Such projects should be run by the local communities rather than be imposed on them (Figure 6, Problem 1).

The land privatization also contributed to the decreasing water quality. Although the natural water sources, such as streams and springs, were not privatized, the land titles were issued up to their banks; consequently, the lack of land forces many farmers to encroach on them, which causes siltation and chemical contamination of water (Figure 5, Problems 8, 11; Figure 6, Problems 12, 21).

There are also several dams in the Taita Hills. Many of them were constructed during the colonial period on the land grabbed from the local community. Typically, they remained in private usage after independence, sometimes causing conflicts between water users. For example, during our study, the largest dam in the uphill area was owned by the Agricultural Training Centre and since 2014 by Taita Taveta University College, instead of being used for the benefit of the surrounding community (Figure 6, Problem 3). In the lowlands, the water in the Teita Sisal Estate reservoir is generally accessible to local people, but it is of poor quality (Figure 6, Problem 24). Moreover, there are land conflicts, especially in the border areas, between the Sisal Estate owners and local people who think that the estate occupies their ancestral lands.

People suggested that the problems related to the lack of land and private ownership should be discussed concretely with community maps. The laws that aim at water protection, such as the prohibition of cultivation on the river banks, should also be enforced on private lands. Fencing of the water sources, wetlands, and remaining forest patches was also suggested to protect them from the encroachment.

People also indicated that local water projects (Figure 5, Problems 17, 21; Figure 6, Problems 5, 9) and the major commercial water service provider, Tavevo Water and Sewerage Company (Figure 5, Problems 9, 14), have problems with infrastructure and maintenance. These problems stem at least partly from the current neoliberal water governance system based on the Water Act 2002 (Government of Kenya 2002), which forces water providers to search for their own funding, which is often difficult, especially for the community-based water projects, due to heavy bureaucracy. The high inflation rates of the 2000s and 2010s have also raised the costs of infrastructure maintenance. The private land owners also need to be compensated for building the infrastructure on their lands. Poverty also causes incapability to pay for services. Therefore, for example, in Wundanyi catchment, despite being the core area of the water supply infrastructure development in Taita, there are still many people who do not have proper access to piped water.

The decentralized neoliberal organization of water management also gives important social meanings to the community map itself as a sign. The maps make local people look like legitimate sources of knowledge in the eyes of management officials and decision makers (McCall and Dunn 2012). Participatory mapping is in line with Kenyan water sector policies that formally support the use of participatory methods to enhance local communities' involvement in resource management and monitoring (Water Resource Management Authority [WRMA] 2009, 2012). Some local WRUAs in Taita, together with the regional WRMA, have already started using participatory mapping to develop subcatchment management plans. Local people expressed, however, that there is a need to clarify the WRUAs' role in water management and their relation to WRMA. WRMA should not operate on the local level (e.g., to grant water use permits) without consulting the WRUAs. WRUAs should also be empowered so that they can start acting as community planning agencies and mobilize themselves to initiate participatory mapping projects. The multimethod participatory mapping process indeed has the potential to combine locals' historical and spatial knowledge and challenge the official understanding of the resource use dynamics. This requires that the focus of mapping is not on the end product that reflects a specific moment and becomes fast obsolescent, particularly when it comes to defining anthropic features. Instead, more attention should be paid to the mapping as an ongoing process. It is equally important that in future projects, the power is transferred to local people (especially WRUAs) so that they are able make decisions at all stages, from problem analysis and monitoring to policymaking, thus bringing the maps into being.

Discussion and Conclusions

The results of the participatory mapping process suggest that land use and land cover changes, especially the plantation of water-exigent eucalyptuses, have reduced natural water resources in the Taita Hills. The historical roots of this dynamic and its impact on local people could not be understood just by mapping the forest and water resources using scientific cartographic methods that normally create static images of the reality and do not cover social meanings. The participatory mapping also revealed issues related to water justice that resource-based mapping could not confirm. Not everybody has equal access to clean or protected water sources in Taita due to the widespread contamination of sources, inadequate coverage of the water infrastructure, poverty, physical distance to sources, and restrictions on their use. The participatory mapping thus complicates the simplified image provided by the physical science mappings that, for example, consider the uphill area of the hills relatively wet based on precipitation statistics (e.g., Jaetzold and Schmidt 1983; Boitt, Mundia, and Pellikka 2014). This is in line with the conception that natural water supply is not the same as people's access to water, which depends on time taken to fetch water and capacity to pay for it (Sullivan, Meigh, and Giacomello 2003), its usability determined by the quality of water (Falkenmark 2005), and people's restricted rights to use certain sources that are based on the (political) recognition of water as a commodity rather than a commons (Bakker 2007).

The mapping process triggered discussion on the historical issues that cannot always be localized but contribute to place making. The historical perspective is able to provide a deeper insight into the political ecology of water in Taita. Particularly, an understanding of the complex historical nation- and global-scale cultural, social, and political development of the current water-related problems and hydrosocial meanings is important for revoking the Malthusian narratives that blame local land use practices and overpopulation for the lack and deterioration of land and water resources (Bassett and Crummey 2003)—an image typically derived from the population density figures and sometimes even adopted by the community members themselves. Recognition of the political responsibility for the state regulations to which local people have to adapt helps to empower them, when they are no longer seen as guilty for making bad choices in terms of land use and family planning but instead as knowledgeable citizens who are able to govern their common resources.

Overall, the mapping project was a modest step on a path toward community empowerment in water resource management in Taita, but opening up a deliberative space (Fischer 2006) and identification of the problems is a start. Our aim is not to offer ready-made solutions that need political decision making but to propose a methodological mix to local communities that renders them competent agents in environmental planning. Instead, stronger modes of activism would require political action, internal leadership, and wider representation of local actors. Operationalization of the mapped meanings in the management processes and sharing of responsibilities for taking actions could be assisted by taking into account the concrete suggestions people made for reviving the water resources and communality. It is also crucial that the local community can participate in the reporting of the use of the produced maps and other documents so that their agency is also recognized at the higher levels of management. The mapping exercise should be replicated on a regular basis to capture changes, not just in the material environmental resources but also in the sociocultural meanings attached to them. Together with timelines stretching over suitable time frames, the participatory mappings can support the plurality of ideas being expressed in Taita and in other local contexts. ■

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