An extreme citizen science approach to digital mapping in Ethiopia
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Key messages

- *Participatory mapping activities enable laypeople to be part of the mapmaking process, which has historically been the preserve of experts.*
- *Lack of education is not necessarily a barrier to participation. When they know the landscape well, non-literate participants can provide information that is rich, detailed, and valuable for decision making.*
- *Challenges include the cost and accessibility of equipment and data, and hostile legal environments that obstruct restitution of common resources.*

In this briefing we describe an approach to digital mapmaking that includes as collaborators people who have tended to be excluded from such projects. Our work contributes to the emerging field of *extreme citizen science*.[1] The features that distinguish this from the standard citizen science model are, first, that the ends to which data collection is directed are determined by or co-created with the community of users; and second, that rather than targeting people with high levels of digital literacy, the approach includes collaborators regardless of literacy (Vitos et al. 2013).

Historically, mapping has been predominantly a tool of colonial and state power, representing reality primarily in ways useful to administrators and extractive projects. However, laypeople have long made their own maps and used them in resistance to forces that ignored claims to customary territory. In one celebrated case, maps produced by Torres Straits Islanders were used as evidence in a 1992 Australian High Court case that challenged the doctrine of *terra nullius* which had been used to justify colonisation of Australia by British settlers. As Irene Watson has noted, this doctrine essentially meant, "There's no people here, it's ours" (Watson 2014: 509).

In the 21st century, as mobile technology has become more accessible, internet coverage has increased (ITU, 2021), and mapping or navigation apps (e.g. Google Maps) have proliferated, new opportunities for participatory mapping have opened up. Although some data collection apps have been designed to be used in resource-constrained environments (e.g. OpenDataKit[2]), substantial barriers remain regarding software design. Most mapping apps are designed for users with print and digital literacy – the often taken-for-granted skills required for interacting with phones and computers.

Our work took place in Ethiopia's Lower Omo region, where there is a long history of maps being used as tools of state power, and a more recent history of participatory mapping by indigenous people and their allies. Our aim was to explore the potential of a digital mapping process that responded to indigenous people's priorities, and in which locals could take a leading role regardless of their levels of literacy.

[1] See Moustard et al. (2021). Alternative formulations include "geographic citizen science design" methods (Skarlatidou & Haklay 2021)
[2] https://opendatakit.org/

Contested resources in the Lower Omo

The River Omo is the major geographical feature of southwest Ethiopia. In its lower reaches it is occupied by people speaking more than a dozen different languages, the majority of whom make a living from herding, farming, and fishing (Clack & Brittain 2018). The region is both literally and figuratively peripheral to the Ethiopian state, and only in the latter half of the 20th century was an enduring state presence established. In the 1960s and 70s, territory belonging to the Mursi and Bodi peoples was designated as national parks, without local consultation – Indeed, the architects of the parks went so far as to deny people ever lived there (Turton 2011). When the parks failed to generate the expected levels of tourist revenues, the logic of state projects shifted from "conservation" to "development", with the construction of a large hydroelectric dam and the establishment of commercial plantations. This form of state intervention was far more threatening to indigenous livelihoods than the national parks, since it involved annexation of agriculturally valuable riverside land and the razing of hunting and grazing territory to make way for sugarcane and other cash crops. In 2015, the Gibe III dam stopped the annual river flood on which many people downstream depended for their most reliable form of subsistence – flood recession farming (Pertaub et al. 2019).

While the threats that state projects pose to local livelihoods provide a clear incentive for people to reassert claims to land and water, the potential of digital tools to contribute to this enterprise is far from guaranteed. The limitations stem partly from infrastructure and economics, and partly from culture. Although a mobile education programme has operated in the Lower Omo since 2001, school provision and engagement are limited, and literacy levels are low. Few parts of the Lower Omo receive electricity from the national grid; townspeople rely primarily on diesel generators and less commonly on solar panels. And while the GPS satellite network is ubiquitous, and mobile network access and 3G signals have recently become widely available, access to hardware such as smartphones and tablets is limited, and the cost of devices and of data bundles is beyond the means of most local people. Deploying these tools therefore requires financial and logistical support. Equally important, but less tangibly, it requires creative engagement and collaboration across boundaries of culture, power and knowledge.

Citizen science in Nyangatom

From 2018 to 2020 two of us collaborated on a survey of wealth and poverty in the Lower Omo, and for this project we chose to work with communities with whom we had existing relationships. On the basis of our prior work and that of others who have used participatory mapping in the region (Hurd & Mursi Community 2008; Hodbod et al. 2019), we had a sense that people might wish to record sites related to herding, grazing, and other livelihood activities. However we deferred to the deep knowledge of the land possessed by locals, and introduced ourselves as facilitators rather than leaders of the enterprise. We began in August 2021 by discussing the potential benefits and risks of mapping activities with community members. Once these were clarified, six collaborators spread across three *kebeles* (the lowest unit of the formal system of governance in Ethiopia) in Nyangatom[3] came forward. All were men between the ages of 18 and 40. We did not so much select them as accommodate them based on the interest they showed in collaborating. It suited us, however, that they had varying levels of literacy (with school experience ranging from none to partial secondary education). Three of the six collaborators had seen maps before (e.g. a map of Ethiopia, in

[3] The Nyangatom are one of the several indigenous groups who inhabit the Lower Omo (for more information see Clack & Brittain 2018). The number of participants was limited by the number of phones we had available to distribute.

school); none, however, had previous experience of making maps. In terms of digital literacy, all collaborators owned basic mobile phones, with voice-call and text message functionality, and two owned or had in the past owned a smartphone.

From process to product

The digital platform that we used, *Sapelli*, attempts to lower access barriers through use of a pictorial interface.[4] Rather than being a ready-to-use app, Sapelli is a kind of container, customisable to enable users to be actively involved in designing both the appearance of the app and the purposes it serves, and therefore to take ownership of the mapping process (Rambaldi, 2005).

Following participatory software design methods, the first step in customising the Sapelli app was generating a taxonomy of local land use types that might be recorded in the landscape. This included key natural resources and places of local importance such as villages and shade trees, ponds, farming and herding sites, and places where wild foods and medicinal plants are gathered. The local instantiation of the Sapelli app was populated with icons representing these items, and we distributed smartphones, solar chargers/power banks and data bundles so that our collaborators could field test it. In the course of approximately a month of testing, they made substantial changes:

- They rejected the hand-drawn icons we had begun with, and substituted photographs.
- They added a new item of information that might be recorded for every feature in the landscape, namely whether it was of good or bad quality (represented by a thumbs-up or thumbs-down symbol).
- They requested captions in Nyangatom and Amharic alongside the pictorial icons (Figure 1).
- In addition to the "point" mapping technique (which attaches a GPS reading and timestamp to a land use type recorded *in situ*), they expanded the repertoire to include drawing boundaries (e.g. the outlines of grazing areas) and gauging the quality of grazing in different parts of the landscape – functionalities that can be used "off site," by drawing outlines on top of high-resolution satellite imagery base map, or exploring the region using multi-temporal satellite imagery if online (Figure 2). [5]

[4] The name of the app derives from the Sapelli tree of the Congo basin, where this technology was first deployed (Stevens et al. 2013)

[5] For more information on the process, see Moreu, Stevenson & Tekle (2022)

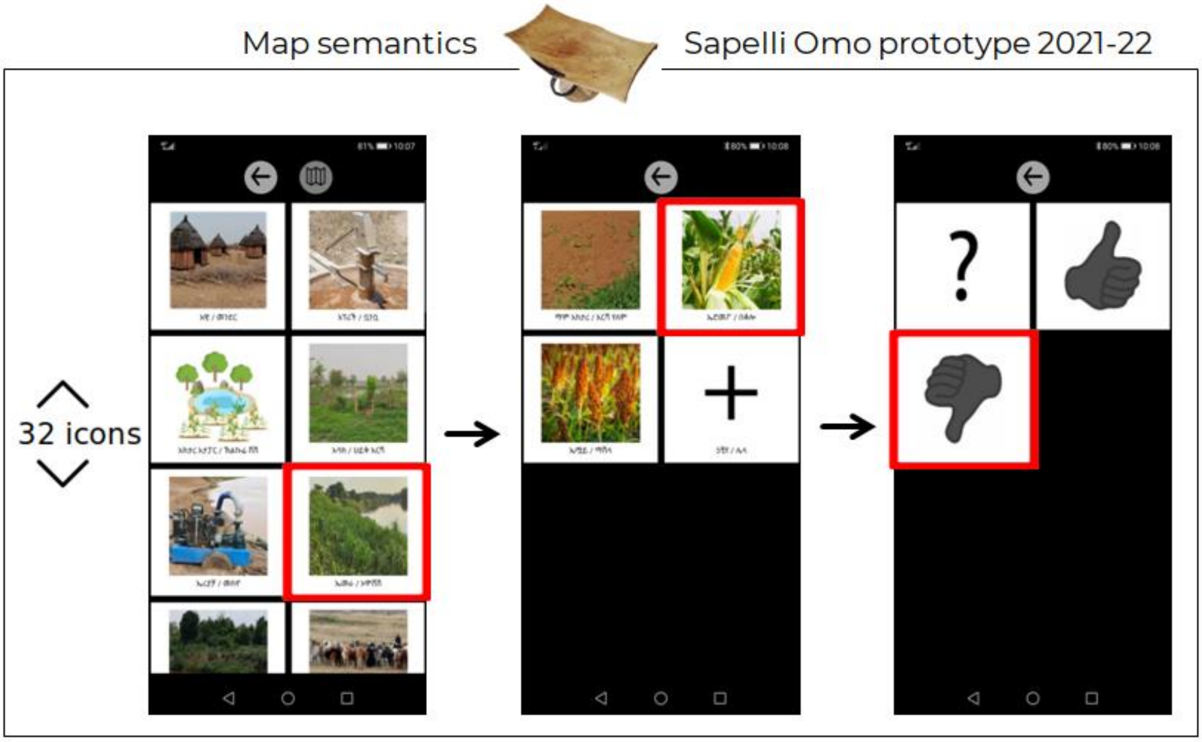

Figure 1: Screen grabs illustrating one possible route through the decision tree in the *Sapelli Omo* prototype app. The leftmost image shows some of the 32 land use icons. Highlighted is the icon representing *flood recession farming*. In the middle screen, the user is given an option of indicating which crop is being grown (here, *maize*). In the rightmost screen they indicate the quality of the crop (here, thumbs-down or *poor*).

Figure 2 Participants carried out mapping in two ways: using the GPS-based *in situ* technique (left) and the satellite imagery-based off-site mapping technique (right). In the image on the right people are sitting together looking at a satellite image of parts of the local landscape. This allows them not only to record location data, but to outline pieces of land used for different purposes.

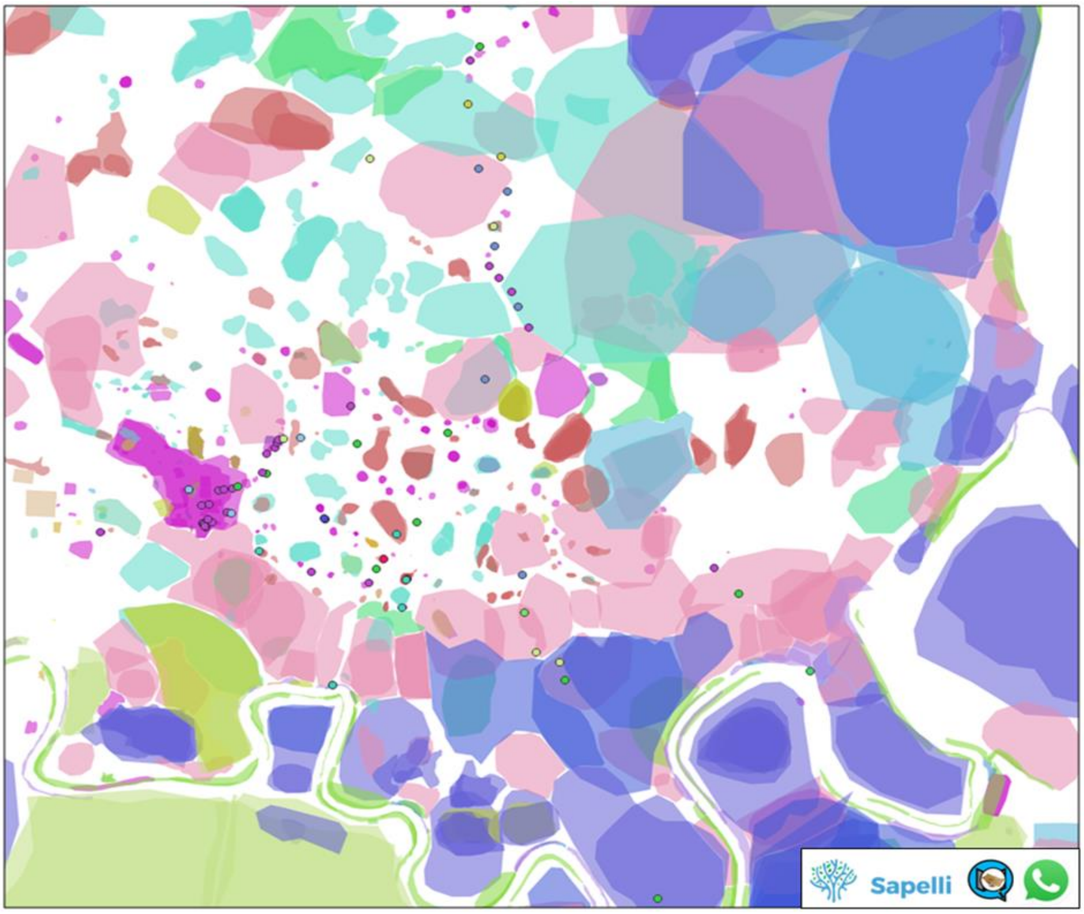

Figure 3 A portion of the map created by six collaborators in Nyangatom. The image illustrates the potential of participatory GIS to capture situated knowledge, and to represent it in digital map form. Coloured shapes represent features such as villages, farmland, and grazing areas. For purposes of (partial) confidentiality, colours are randomly selected, the basemap is disabled, and legend and scale bar are not provided.

A profusion of questions

The co-design and mapping process started in August 2021, and since mid-September 2021, we have provided only occasional support, either in-person or via phone calls. What kinds of data did this produce? How valid are the versions of reality that the resulting maps represent? To whom do the data belong? And what uses might they serve?

At present we can provide only provisional answers to these questions. Over the 12 months between August 2021 and August 2022, our collaborators recorded more than 1,700 map contributions, with the most commonly logged features being villages, ponds for recession farming or animal watering, and grazing areas. While some contributions to the map might be relatively easily checked against satellite imagery (e.g. the location of villages and ponds), others (e.g. the boundaries of grazing areas) are more difficult to verify. When we compare the data collected by our collaborators with other publicly available data, however, a number of differences emerge. Figure 4 illustrates the spatial and semantic differences between machine-generated maps, user-generated maps (OpenStreetMap), and land user-generated maps (the map generated by our collaborators).

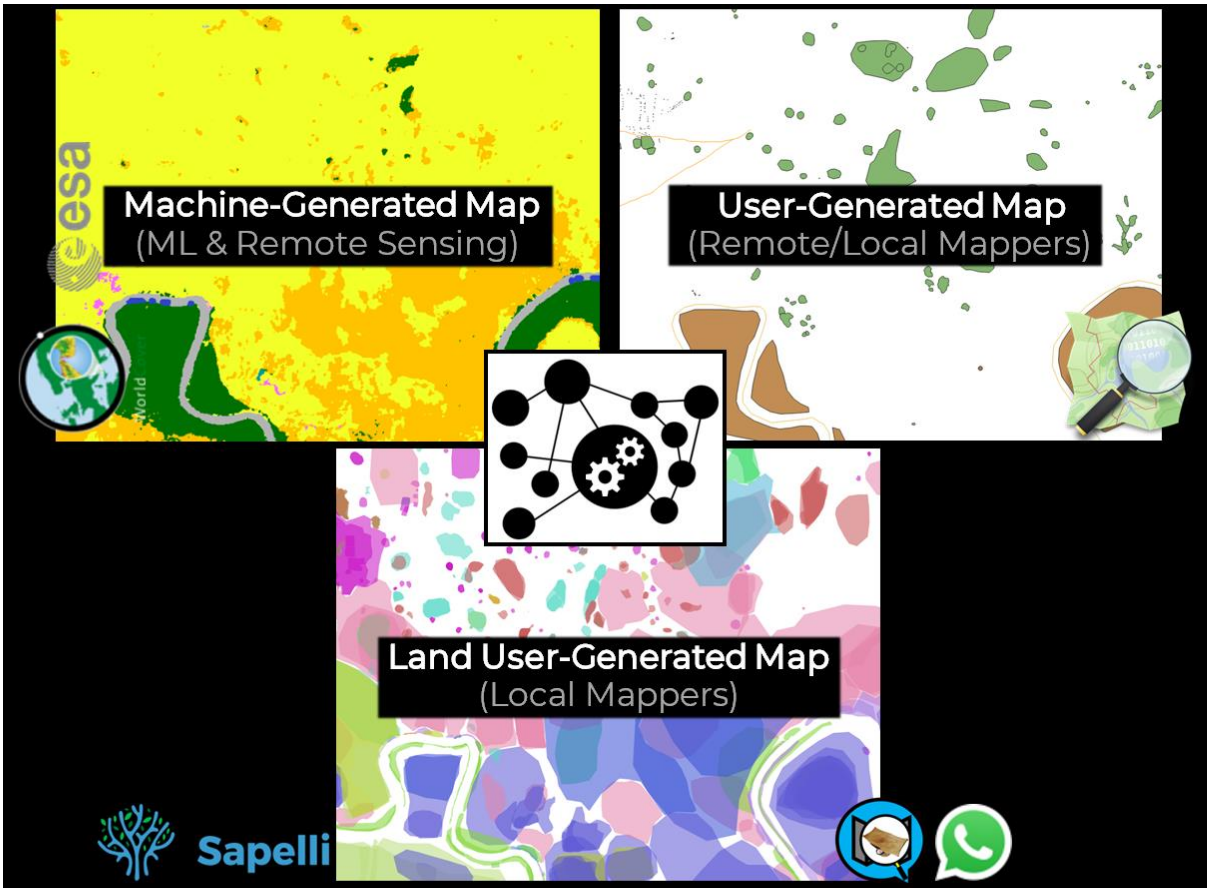

Figure 4 Data generated by collaborators in Nyangatom (bottom) compared with the European Space Agency WorldCover Map (top-left) and OpenStreetMap data data (top-right). The "land-user generated map" is produced by people who live in and know the landscape in question – either by taking GPS points *in situ* or by looking at looking at satellite images and identifying features they think they can see. The "user-generated" map, by contrast, is produced by people who may not know the landscape in question, and the "machine-generated" map is produced by Machine Learning and computer algorithms.

The greater detail and density of features in the land user-generated map are immediately apparent. Also notable is the fact that the land-user generated map, unlike the others, includes many overlapping boundaries. Do these represent rival claims to grazing areas? Or differing understandings of where the boundaries lie? How sharply or fuzzily delineated should we expect such boundaries to be?

Here we feel the appropriate response is to ask: Precision for whom? (McCall 2006). In a sense, the point of initiatives such as ours is to generate alternative renderings of the facts on the ground – to privilege the views of people whose realities are seldom represented on authoritative or machine-generated maps. Instead of "citizen science" or "participatory mapping" such activities might equally be called "counter-mapping" (Peluso 1995). The spatial and semantic challenges of crowdsourced data are substantial, and the question of how best to describe this enterprise is an ongoing topic of conversation for us and our collaborators.

Challenges and opportunities

The technical challenges to citizen science mapping that we have noted in this briefing are just one of many hurdles that lie in the way of equitable access to resources. In some ways the setting we worked in provided a favourable environment compared to other places where this approach might be adopted. Although literacy levels are low in Nyangatom, there is a significant minority who received formal schooling over the past half century, either from missionaries or in South Sudan. The most prolific contributors to our project were those who already had some literacy and experience using phones. We are still therefore some way from developing a means for people to engage in mapping on equal terms, regardless of literacy.

In terms of the longevity and widespread applicability of our socio-technical innovation, the main technical challenges are the cost of smartphones and data bundles. Off-site mapping can take place wherever people are, and can accommodate groups gathering around a shared device (as illustrated in Figure 2). The use of WhatsApp (as opposed to bespoke databases) for sharing and storing map contributions is a step towards addressing issues related to data ownership, project sustainability and scalability in resource-constrained environments – anyone can create a WhatsApp group for community mapping, and only members of the WhatsApp group have access to the data. But without external financial support, the costs of hardware and internet access are currently beyond the means of most of these people.

Finally, what uses might the maps serve? Specifically, what chance is there that data generated using approaches such as this might help people defend communal resources? Here, much depends on the legal environment. Defending land claims using citizen-generated data is feasible only where there is a judiciary or legislature willing to accept such evidence. The challenges are not just technical, and not just to do with data. It would be foolhardy to suggest that involvement in mapmaking is inherently empowering. Nonetheless these methods have a place in the toolkit of advocates and community organisers, alongside or in conjunction with other initiatives such as community conservation areas. And for researchers, there is promise in an approach to digital mapping that includes collaborators with low or no literacy, that allows for outsiders' misconceptions to be corrected early on, and that prioritises local representations of place.

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