Participatory digital map-making in arid areas of Kenya and Tanzania

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by TOM ROWLEY

Background and context

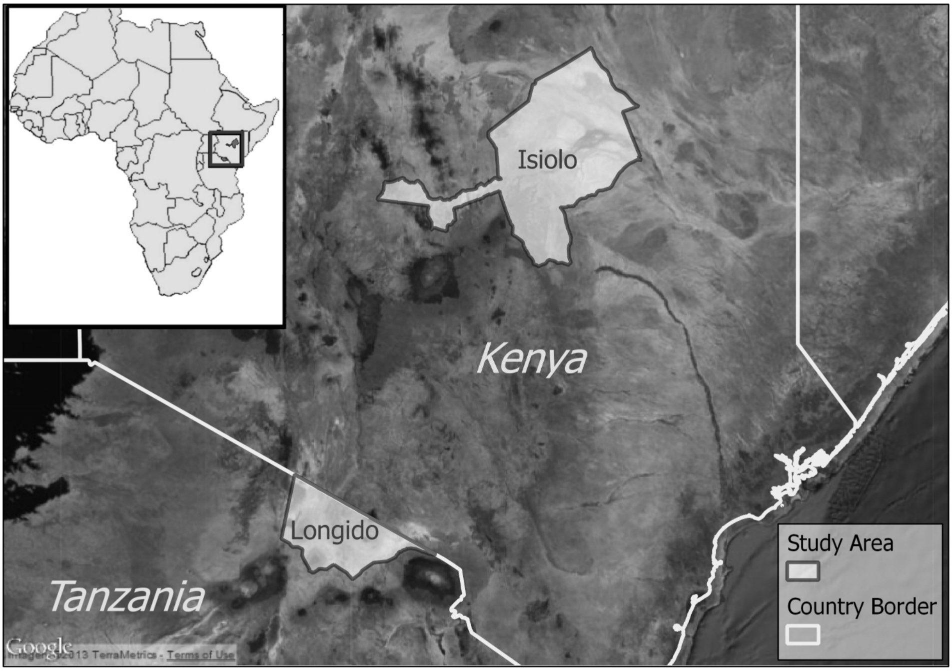
Pastoralists have long used their extensive and detailed knowledge of arid and semi-arid environments to maximise livestock productivity and minimise asset loss (Krätli and Schareika, 2010). Scattered and variable rainfall, characteristic of arid and semi-arid lands (ASALs), means that pasture, particularly grasses, are available in different places at different times. Because the nutritional quality of plants changes during their growing cycle, the availability of nutritious pastures in the ASALs is also variable and constantly changing because of the uneven rainfall. Different soil types with different fertility characteristics, different plants species with different nutritional qualities, and different topographical features, such as gullies and depressions where water may concentrate, add further complexity. The nutritional profile of ASAL rangelands – particularly in the rainy season – is highly variable and ever changing.

Yet this is not a constraint for pastoralists. Indeed, it is a resource. Pastoralists positively exploit the ever-changing concentration of nutrients in ASAL rangelands, particularly during the rainy season, by moving their animals to those areas where the pastures are at their 'nutritional height'. They provide a higher nutritional diet to their animals than if they remained in one area. Livestock mobility is the principal strategy used by pastoralists to maximise livestock productivity under conditions of environmental variability.

Livestock mobility and secure access to a wide range of pastures are, however, increasingly threatened by a range of other competing activities including the spread of arable farming, conservation enclosures, new settlements, population growth, mining and trophy hunting. This steady encroachment and alienation of pastoral resources over much of East Africa has seriously undermined pastoralism as a livelihood and economic system, contributing to increasing poverty, land degradation and conflict in many pastoral areas.

Poor understanding by policy makers and planners of pastoral production strate-

Figure 1: Mapping study areas



Satellite imagery showing the Kenyan–Tanzanian border and first-level administrative boundaries – Longido District and Isiolo County are highlighted.

gies and how pastoralism (compared to other land uses) contributes to local livelihoods and the wider economy partly explains the failure of policy and planning to enhance pastoral mobility and protect the rangelands. The inability of pastoralists to articulate the deep knowledge they have of their environment and how they carefully manage natural resources to generate wealth and prosperity in a sustainable manner compounds the problem.

The mapping processes discussed here help to close this communication gap by enabling pastoralists to demonstrate – in a 'language' understood by policy makers and planners – their extensive understanding of ecological processes and their impacts on livestock and people, and thus the logic behind their livelihood strategies. With this improved understanding, there is the potential for governments to recognise and support pastoralism as a viable and productive livelihood and economic system. This paper describes the use of Google Earth (GE) images to support the mapping of natural resources by local people in Longido District in northern Tanzania and Isiolo County in northern Kenya. This project is being carried out by IIED in partnership with the Ministry of State for Development of Northern Kenya and Other Arid Lands, the Tanzania Natural Resource Forum, local government authorities and other local actors, with the support of the GeoData Institute of Southampton University in the UK. The work is being implemented within the context of two broader projects (see Figure 1) seeking to strengthen local government planning in support of adaptive and climate-resilient drylands development.[1]

[1] The projects were: Mainstreaming climate change adaptation in drylands development planning in Tanzania (2010-12). Funded by DFID, CORDAID and GORTA; Supporting local climate resilience through innovative district funding and social protection mechanisms in the drylands of Kenya (2012-13). Funded by DFID and CORDAID. See: www.iied.org/drylands-pastoralism

Photo: Alais Morindat

A group of men explore the distribution of key resources for livestock rearing in Longido. The perception map is made on the ground using marks in the dust and stones.

The need for accurate mapping

Pastoralist's tenure of land and resources in ASALs depends on being able to define them accurately. Traditional livestock routes, water resources and pastures are not officially described or recognised in maps or spatial planning. These resources are vulnerable to loss or fragmentation because of competing activities.

Participatory mapping has long been used to consult the knowledge and perceptions of community groups (see e.g. Rambaldi *et al.*, 2006). But it often produces perception maps,[2] where map scaling and styles are inconsistently improvised during the consultation process. For this reason, transferring results to other contexts outside the workshop setting is difficult, as the scale and style are incompatible. Perception maps often require explanation before they can be understood by those who did not produce them. Any comparison with other maps is inherently qualitative and vague as no distances or positions can be objectively measured without accurate scaling.

Specifically, one key limitation of participatory mapping is transferring perception maps (often drawn on the ground or paper and not necessarily to scale) into formal decision-making processes where accurate maps are required, for example to pass a byelaw. Paper maps may be very powerful in their immediate setting – but it is very hard to use such maps in other contexts. Different contributors may use different icons to describe the same type of feature and no objective verification of map features on the ground can be performed without the scaling and accuracy provided by the grid systems used in formal maps.

Digital maps have a built-in coordinate system, referencing locations which corre-

[2] A map drawn from people's perceptions, without coordinate data and therefore not necessarily to scale.

Photo: Tom Rowley

Using paper flipcharts to create a perception map in Kinna ward, Isiolo.

spond to a global reference grid, so they can be linked to maps used in other formal systems. This provides a means to define the absolute positions and importance of key natural resources which can more precisely inform management decisions. A coordinate system also provides a geographically precise basis from which to discuss natural resource management. This makes the outputs of participation in mapping more universally useable and user-friendly. Making local knowledge more useable can result in better management outcomes, for example land-use byelaws that refer unambiguously to specific locations that were pinpointed by the resource users themselves.

The need to make maps at an appropriate scale and focus

Pastoralists use resources which are spread over vast areas that vary in productivity and value within and between years. Depending on the type of pastoral system, and the prevailing conditions with respect to pastures, security or market opportunities, pastoralists may travel considerable distances with their livestock to access pasture and water. Pastoralism therefore requires mapping on a range of different scales ranging from a settlement-level scale for the planning of domestic water to a wider ecosystem scale for the planning of livestock mobility corridors between wet and dry seasons. Conventional planning in the ASALs, particularly at local government level, usually occurs within specific administrative and/or political jurisdictions such as a village or a district and usually does not extend to capture the full spatial extent of pastoral livelihood strategies and movements that may cross numerous political and ecological boundaries.

Unlike farming, the transient use of resources by pastoralists, which often leave no physical mark on the environment (e.g. the seasonal use of different pastoral

Photo: Alais Ndangoya

Participants geo-referencing key natural resources in Longido.

areas), makes it hard for outsiders to identify specific pastoral land-use strategies. It involves no habitat conversion, no hard boundaries or any privatisation of the land. It is far easier, and possibly politically expedient, to identify and therefore map private land holdings within well-defined political boundaries than it is to recognise the more diffuse and ever-changing usage of the Commons. To identify pastoralist resources, maps must be made at the ecosystem scale, at which this system operates. This could also help support the management of mobile grazing wildlife populations, which could make it easier to obtain political support for such planning tools.

Project workshops

During the project, several large workshops were held to discuss natural resources and land management with a range of stakeholders in both Isiolo and Longido. The workshops both introduced the project and identified important issues and features to include in the resource maps.

Following a quick exploration of the satellite imagery to orientate participants and pinpoint the location of the workshop, participants led the collection of digital data from the satellite images from Google Earth (see Figure 2, step 2). Google Earth was projected onto a large wall with the original paper perception maps hung next to them. Participants could navigate the imagery and indicate key resources, or their indicators, with a long stick. For each feature a digital marker – an icon, a line or a polygon – was used to show the correct position and extent. Placing these digital markers allowed us to transfer points of interest from the paper maps into a geographic information system (GIS), producing coordinates that pinpoint the locations in a way that can be independently and objectively verified (see photos and Figures 3 and 4). This process of geo-referencing local knowledge to a coordinate

Figure 2: The mapping cycle

Step 1. Participants begin with exercises listing the kinds of resources to map out and why. The chosen types of features are mapped out on sketch maps.

This produces perception maps showing the relative positions of natural resources using pen on paper or marks and objects on the ground.

Step 2. Google Earth is projected onto a wall next to the perception maps from step 1. Participants locate key resources or their indicators from the satellite imagery and place an icon to show their precise location.

This produces the coordinates that pinpoint the locations of natural resources in a manner that can be independently and objectively verified.

Step 3. Participants add attributes to the different types of natural resources that have been mapped out so that they can be more fully described.

This allows fuller descriptions and analysis of natural resources and management issues. Spatial and attribute data can be added by several groups and pooled on one map, allowing more cross checking, detail and area coverage.

Step 4. Spatial data from Google Earth is merged with the attribute data recorded in Excel. GIS maps of the study area are produced with the attributes embedded and participants' choices of basemap, icons and colour schemes.

This transformation allows all the data collected to be shown on a single, easy to interpret platform that allows processing, printing, sharing and analysis.

Step 5. Feedback of the map to groups who provided data, local government and other interest groups. Data is returned for participants to evaluate and validate the maps and to reach consensus between the various groups.

This allows the maps to be returned for validation, cross-checking and styling according to the wishes of those who provided the data, building trust as well as more refined, readable and validated maps.

Step 6. Cycles of learning and feeding back results (repeat steps 1–6) are used to refine the maps, broaden participation and reach consensus, to a point of diminishing returns where no more is added and participants are satisfied that the maps are complete.

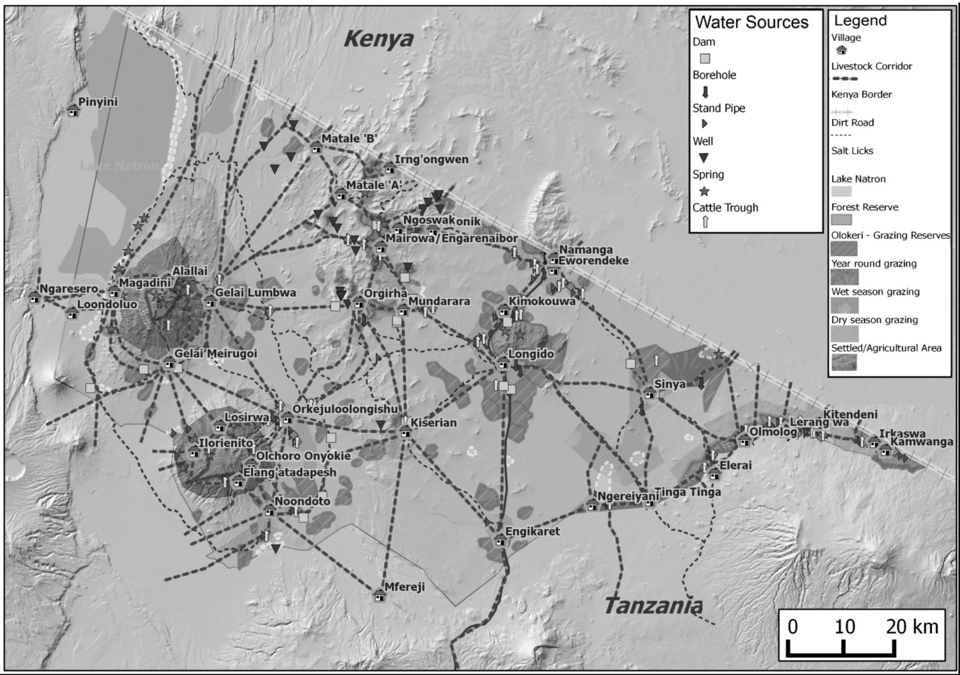
Repeated cycles of learning can build richer maps, trust, and be used to refine the mapping process, evolve priorities for the usage of the maps and discuss underlying natural resource management issues.

Step 7. GPS marks for contentious features, those undiscernable from, or newer than, the satellite imagery and those which demonstrate the accuracy of the map must be collected on the ground.

This provides specific troubleshooting for hard to find points of interest along with a more general validation of the maps accuracy by checking and marking the locations of key features on the ground.

NB, this is an idealised sequence. In reality it is useful to remain flexible. For example, collecting GPS marks for key features before a feedback session, and using feedback workshops to gather and standardise attribute data were found to be helpful.

Figure 3: Overview of Longido District, showing pastoralist dynamics, natural resources and infrastructure.



system is what allows the resource maps to be produced to scale.

Qualitative and quantitative data describing the attributes of these key resources was also collected, for example the capacity of water sources and the plant species characterising different grazing areas (see Figure 2, step 3). This was compiled in an Excel spreadsheet using an ID numbering system that corresponded to the features mapped out in Google Earth. The two data sources were later merged into file formats for use in a GIS, with the attributes of natural resources embedded into the spatial data describing their locations. We chose to use Quantum GIS (QGIS) for this post-processing, as it is a free, open source platform that is far easier to share and handover than a commercial package requiring thousands of dollars per year to use.

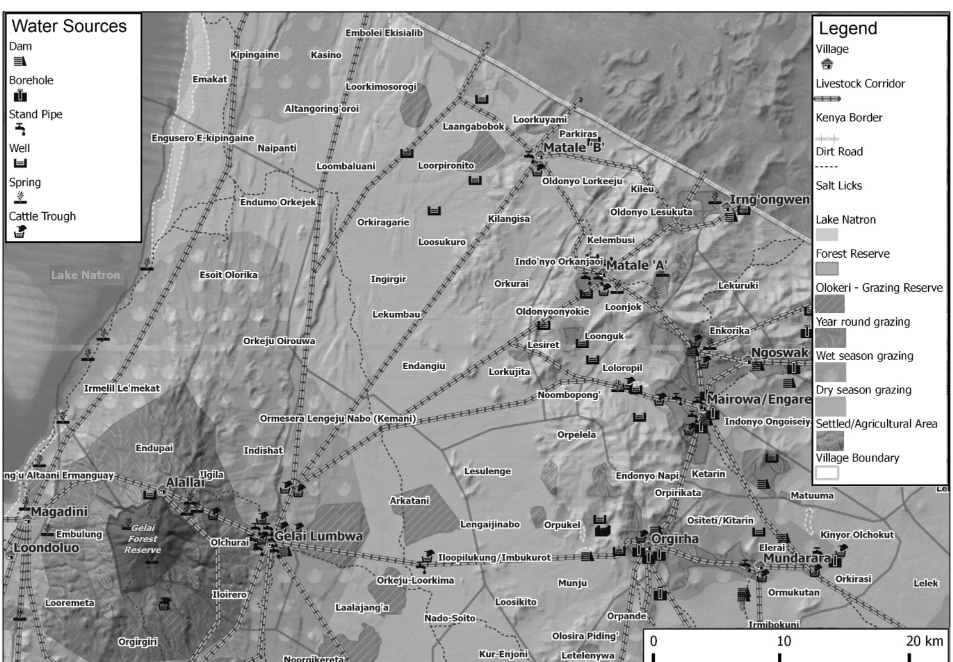
Data showing the different seasons in which pastures are grazed and the major livestock routes connecting them was also collected to allow the maps to reflect the patterns of access to these resources. These dynamics are important as they reflect the mobility that generates resilience in mobile resource tracking across ASAL regions.

Cycles of learning about the study area from community groups, digitally capturing local knowledge and feeding back the results were used to more exhaustively explore the potential of the satellite images, GIS and local knowledge (see Figure 2, steps 4–6). The workshops included regular feedback sessions to return the data to those who provided it and to thoroughly cross check the results as they were pooled together from different groups. Regular cycles of contact and learning also helped to build trust and encouraged the sharing of information on sacred sites and previously unknown gemstones, for example. These feedback sessions were also used to develop better methods, discuss the implications and usage of the map, and to evaluate the project.

Photo: Tom Rowley

Participants geo-referencing key natural resources in Isiolo.

Figure 4: Longido map sub-section, showing Engarenaibor ward with water point icons and the names of grazing areas.



Digital markers taken with handheld GPS on the ground were used to verify the map accuracy and pinpoint hard-to-find locations, for example those under clouds on the satellite imagery (see Figure 2, step 7). This verifies the location of any outstanding contentious features and more generally the precision of the map and the knowledge used to make it. It is worth noting that this is a fairly idealised cycle and that in reality it is useful to remain flexible, for example, collecting GPS marks for key features prior to feedback sessions and using feedback sessions to gather and standardise attribute data.

Geo-referencing for objectively verifiable maps

Physical maps have been extensively used to support community group consultation and development planning (see e.g. *PLA* 54 Rambaldi *et al.*, 2006). However, perception maps that are not to scale tend to have limited power when transferred out of the context in which they were created. Making maps that describe the dynamics of nomadic lifestyles, and which remain applicable in other contexts, is difficult. Google Earth provides an important 'bridge' that can allow local people to make maps in an objectively verifiable coordinate system. This helps to overcome the difficulties of using the results of participatory information-sharing by making the outputs more useable and transferrable. It is also worth mentioning that bringing local knowledge to bear on digital mapping in fact also brings significant advantages in the cost, speed and relevance of digital data collection.

Using imagery to build richer maps and record attributes

Exploring local knowledge on land and natural resources in a workshop setting can be more stimulating, non linear and productive with satellite imagery and a terrain model available for the participants to explore (Figures 3 and 4). Using GE projected onto a large wall allows more stimulating and interactive approaches that lead to richer maps with more features and detail. In Longido ward, Longido district, 36 water points became 142 water points during the digitisation process. This explosion of observations and available detail requires some careful facilitation. For example, this apparent abundance of water is misleading as further questioning revealed that at any given time a large proportion of them (28.5% of all Longido's water points at the last workshop) were not working. This was due to a range of factors, for example the reliance on rainwater recharge, broken pumps or disturbance by road building or elephants. Watching the features build up on the satellite imagery as they are pointed out gives some instant feedback which provides some immediate cross-checking of inputs within the group and the means to explore issues as they emerge.

Box 1: Using mobile phones for participatory data collection

In one ward, a notable improvement to participation and the quality of data collection was employed by participants. Several features important to livelihoods were newer than the satellite imagery and could not be located. Participants found they could map these precisely by quickly visiting them by motorbike and obtaining coordinates with GPRS-enabled mobile phones they were carrying.[3] These were then entered into the computer so the features could be displayed in their correct locations. This was exciting in terms of the level of uptake and commitment to the mapping process it indicated, the precision it allowed and the manner in which it demonstrated the strength of local knowledge. When the coordinates were entered manually, the points of interest did not jump far from their previously estimated positions. The steady uptake of this kind of technology and the possibilities it offers could have exciting implications for ownership, monitoring changes and building more robust, ground-truthed maps.

[3] General packet radio service (GPRS) technology is integrated into certain mobile phones. GPRS is a cellular networking service that supports WAP, SMS text messaging, and other data communications.

The digital platform being used to capture data also allowed observations on the attributes of features being mapping to be recorded and embedded. As people put features onto the map they also described the characteristics of these features. For example, a water point would be mentioned along with its capacity, the water quality, extraction method, access conditions and whether or not it currently functioned. Similarly, different types of grazing area were described according to the seasons they are used in, their physical features, and the species of plant that are usually present. In Isiolo, different soil types were used to differentiate pasture types, for example chalk (*boji*) and black cotton (*malbe*) that were clearly distinct in the satellite imagery. An inventory of plant species totalling over 200 was given to further describe different grazing areas along with data on wildlife concentrations. These descriptions and data can be captured during the mapping process adding considerable richness to the map and allowing deeper analyses of the systems they describe.

As the map develops in front of the group, it tends to bring about a sense of ownership and pride in the map that is produced. This was often seen to encourage further participation.

Strengthening community voice at local, national and international scale

Making more accurate maps for stronger advocacy

Accurate digital maps can be independently verified and therefore gain more traction. This can allow them to act as a more effective 'loudhailer' – amplifying the impact of community voices at all levels. Using arguments referenced to a coordinate system can bring evidence-based local knowledge to bear on planning and decision-making in a way which is much more difficult to discredit and ignore.

Pooling local knowledge onto a single platform

Capturing information onto a digital platform allows several groups to contribute independently to the same map. This allows cumulative improvements to be made to the level of detail and cross-checking in the map, and to the extent of its coverage. The digital platform allows different groups to add information concerning the areas they are interested in and easily make sense of one another's contributions. This is not always the case for paper maps where more explanation is usually required. Some paper maps produced in a specific context can be difficult to understand and virtually impossible to use when taken out of context.

Mapping based on GE images still requires the facilitator to be proactively inclusive and take account of who has taken part in the process and seek out those have not yet been able to contribute. However, the images and data are readily understood and this makes it much easier to include the views of different groups as they take their turn to add their observations.

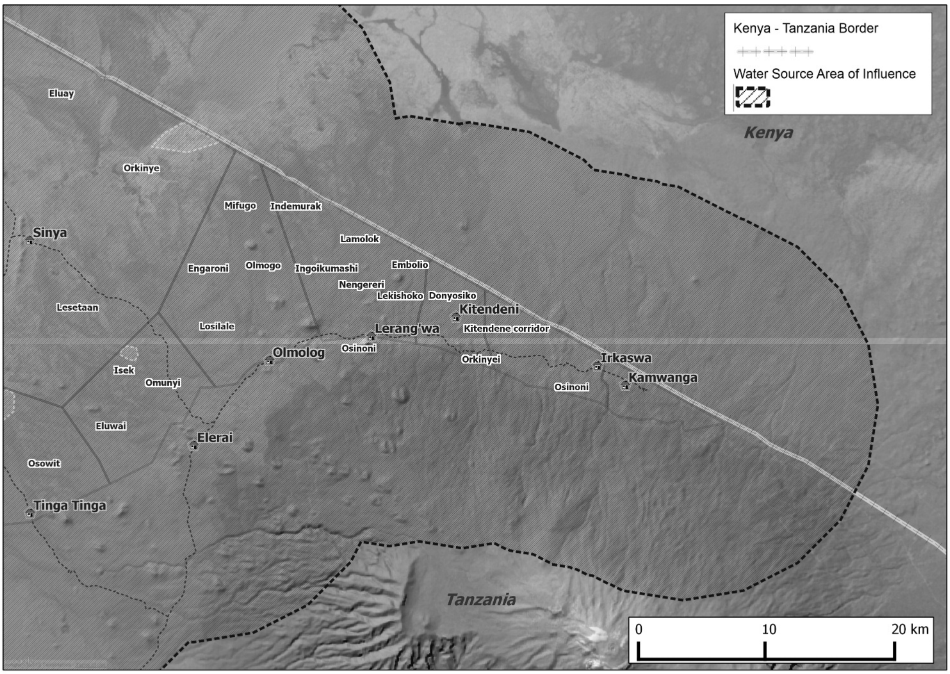
Making maps with flexible scale

Pooling local knowledge also allows an appropriate scale for examining natural resources to be evolved as the patterns of usage emerge. As well as building a grand overview, digital mapping allows zooming into specific areas and selective presentation of data so that participants can work on small subsections of an area, or on specific issues. Currently our maps are constrained by political boundaries but we can clearly see cross-border issues emerging. For example, the water made available at the foot of Kilimanjaro clearly has a sphere of influence covering a large portion of Amboseli and many major cattle routes connect these areas across the Kenya–Tanzania border (Figure 5).

Demonstrating the power of local knowledge

As mentioned previously, the robustness of community perceptions can be demonstrated using digital maps. This can be achieved by directly measuring the accuracy of perceptions against the imagery, by

Figure 5: Fifteen-kilometre buffer zones around cattle troughs in Longido, showing their influence on pastures in Kenya.



ground-truthing with handheld GPS and also by simply comparing the paper maps from early in the mapping process with the digital maps they later produced (Figure 6). This, along with the detailed attributes describing features of the map, can be used to evidence how highly developed and necessary this knowledge is for survival. Maps made in this way are very swiftly and accurately produced in a manner that is compatible with other spatial planning. This allows comparison of different planning efforts, the overlaying of different maps and potentially, where appropriate, the formation of arguments that reconcile mainstream planning with customary land-use reasoning and priorities (Figure 6).

Critical reflection

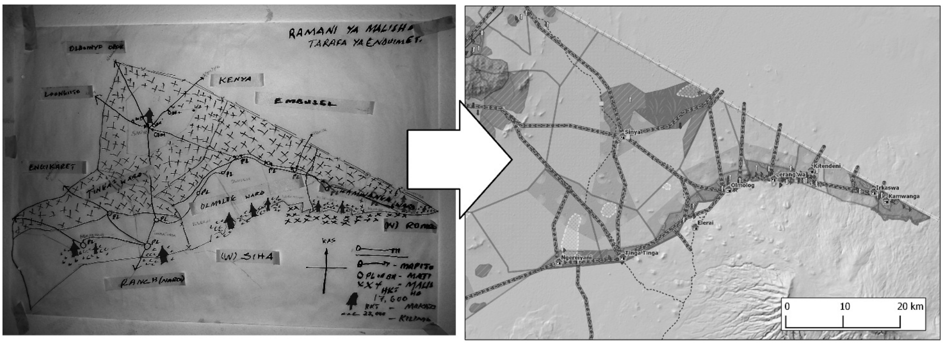
Handing over of maps and mapping tools

It is critical to return the maps to those who participated in building them. However, the introduction of technology such as laptops and GIS makes this harder to achieve. Some local actors were able to take data sets for Google Earth and portable document files (pdf) maps onto their laptops. Local governments also have capacity to take custody of, and in some cases use, the digital data. Leaving maps at the village level currently relies on the ability to print paper maps. In Longido, 33 A3 sheets were printed, cropped and stuck together to achieve this. In Isiolo, six A0 sheets were used. A greater reliance on technology means that the facilitator's paradox of being in control of something that needs handing over is intensified by this increased reliance on technology.

Technology and developing mapping styles

It may seem unexpected that people with little or no experience of digital technologies can make use of GE images but uptake and use was very quick. This is particularly due to the ability to explore a 3D terrain model which provides a side-on view showing elevation of familiar features, helping

Figure 6: Comparison of perception maps and geo-referenced digital maps shows the accuracy of local knowledge in terms of distance and direction.



participants to orientate themselves.[4] We found that all groups would respond very quickly to a warm-up exercise finding and marking their current location in the workshop. Once this 'we are here' point had been zeroed in on, participants rapidly oriented themselves and began to take control of the interactive exploration of the study area. Most groups started by adding major landmarks before fleshing out the details in between. Some groups used mountains, some rivers and some roads as reference points for doing this. Other groups added all levels of detail, methodically moving away from the starting point, the location of the workshop. Allowing participants to drive exploration of the areas was very important but slightly different mapping styles emerged as a result.

Some groups were also vocal on how they wanted the maps to look. Fortunately, we came across no conflicting opinions and were able to use the styles of the groups that were vocal on this issue e.g. blue for livestock routes, red for arable farming areas and so on.

The management of the process by which the images are projected and manipulated is crucial to the success of the mapping exercises and a great deal depends on the quality of the facilitation. As with all participatory methods, the tools are not as important as the approach and principles being followed in the facilitation. Digital mapping is just a recent addition to the processes which contain something of a paradox for the facilitator who has control of a process that they in turn want to hand over to other people.

Making use of maps

Mapping itself does not infer or affect pastoral community group resilience. Rather it is a tool for communicating the local knowledge that, when given room to be applied, can engender resilience in pastoralist communities. It is hoped that the benefits of mapping local knowledge can be brought to bear on the activities of other rangeland users who would otherwise displace and disregard the dynamics of pastoral land use. However, the production of a map is several steps away from its use by politicians to mediate competitions over land and resource access. Validation of maps by community groups and local government, empowering local government and customary institutions to make use of them to form appropriate planning and public good-type investments, seeking legal advice and legal action over gazettements to protect key areas, and generating will at the

[4] See also Piccolella *et al.* (this issue) for a discussion on how the third (vertical) dimension stimulates memory. 'A two-dimensional map looks the same from any direction. With a three-dimensional model, what you see varies according to your position.'

national level not to override local governance are required for mapping to have impacts on livelihoods on the ground.

Gender

The pastoralist societies we worked with were quite male dominated, especially in relation to issues of long-distance herding and territory. In all but the locations and attributes of domestic water sources, men's contributions were overriding. However, we observed that in workshops that were facilitated or attended by powerful women, all the women present contributed more. Collecting separate data for men and women's groups and using a digital platform to later overlay them would be interesting. This conforms to findings in other forms of mapping where men and women often produce quite different maps when working separately. However, maps based on Google Earth images can easily be used to re-combine different maps, and the maps of one group can easily be shown to the other on the same background.

Valuable lessons

Cross-checking throughout

As the data was built up on the projector screen it allowed participants to see the map emerging from their individual contributions. This allowed instantaneous cross-checking throughout the collection of data. It was also helpful to use the measuring tool, a flexible scale bar that can measure distances from the image in kilometres, particularly when zooming in and out, to keep participants orientated and allow better cross-checking within each group. Measuring distances, for example to triangulate the location of a new point in relation to other known points or to measure the breadth of a grazing area helped generate accurate data. Also, participants often became interested in checking the accuracy of their knowledge against the ruler tool and seemed to enjoy verifying their knowledge of distance and direction using the satellite imagery.

Cycles of learning

As well as feeding back results within workshops, returning the data once it had been processed in a GIS allowed participants to improve the maps considerably. Presenting the data over a different base-map and with clear icons helped participants to reinterpret their maps and provide amendments and additions. Some groups preferred a base-map made from the original satellite image but in black and white to allow the data in colour to stand out. Others preferred solely using elevation data with a shading effect to highlight the topographical relief of familiar features. Cycles of consulting local knowledge and then processing and presenting the data built trust as well as richer maps. Having gone through three cycles of collecting mapping data and feeding back the results in Longido, a piece of paper describing a sacred site and two important gemstone seams was given to the facilitators. This highlights the importance of returning data to the groups that provided it and cross-checking the digitisation process both within and between groups.

The emergence of power issues – Longido

We found during the cyclic learning and feedback sessions that community groups had limited knowledge of certain types of features that were only partially or inconsistently added to the maps. When trying to prompt participants to offer better data for these areas of interest it became clear that we had stumbled across an area where local knowledge was inadequate. The types of features that could not be reliably mapped from local knowledge were all land-use gazettements designed to support foreign interest in the study area, specifically activities focused on wildlife and rare mineral resources.

There were four distinct categories of land-use planning in which local people and institutions had limited knowledge and involvement: tourism, hunting, conservation enclosures and mining for gems and other rare earth minerals. Planning around these types of features occurs at the national level and is often at odds with planning at the district level. This could be due to the more international stakeholders invested in these types of land use, their interactions with national-level actors, and a difference in focus between government planning levels concerned with national versus local-level economic performance. Promotion of tourism and mineral exploration can support formal commercial economic processes at the national level, though this is at the expense of performance in the local economy. This is exemplified by the risk that, in this context, creating mining towns, lodges, farms, hunting blocks and reserves that limit or disrupt mobility (though beneficial to high-end, national/international-level economic processes) will seriously undermine resilience in the local economy, causing hardship, conflict and land degradation.

This highlights a paradoxical tension between bottom-up and top-down planning which results in incoherent, duplicated and often inappropriate spatial planning. Local government in the ASALs who are more directly accountable to local people aim to support stable and productive livestock-keeping as the dominant economy and welfare support to their most numerous and most vulnerable constituents (United Republic of Tanzania, 2009). This requires protecting the integrity of the Commons and empowering customary institutions to continue to practice sustainable, dynamic natural resource management on a large scale. However, overriding planning at the national level tends to cater for those invested in the fragmentation (e.g. conservation enclosures, villagisation[5], or privatisation) and liquidation (hunting, mining, full-scale habitat conversion) of natural resources (Figure 7). While this paradoxical promotion of welfare at the district level and commerce at the national level remains politically and logistically expedient in terms of spatial planning, local governments and customary institutions will remain subjected to gazettements under their feet resulting from decisions made over their heads, and which they have little information on.

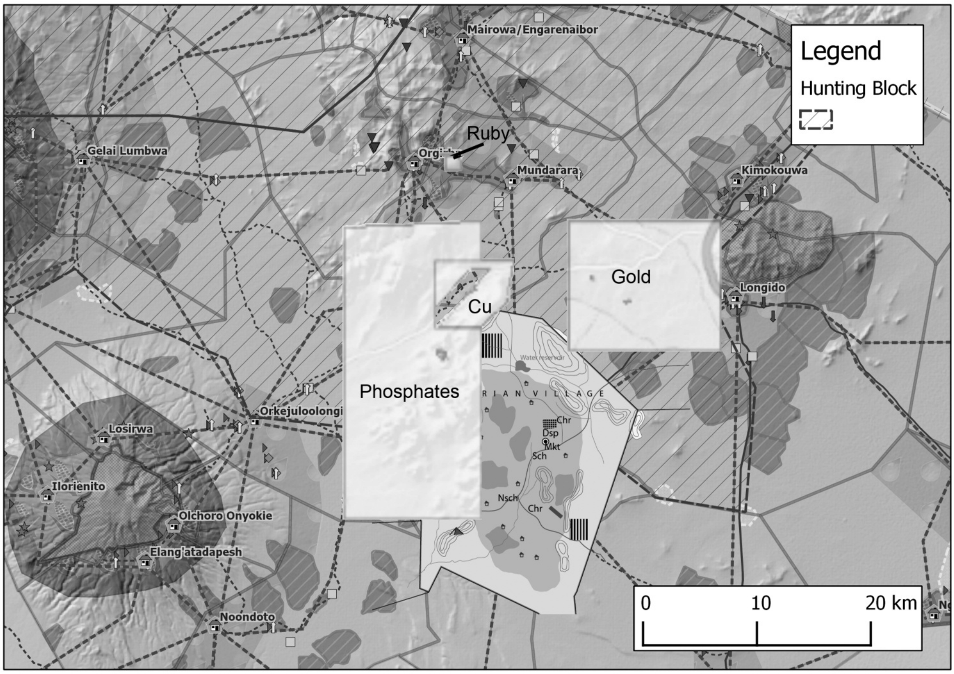
Commerce and welfare need not be diametrically opposed as there are many parallels between livestock-raising and rangelands wildlife management. Assets in both sectors are characterised by the breeding and predation of large, grazing herbivores and that need to migrate in order to optimise their access to water and nutriment. Some of the disparity in local- to national-level government agendas could be reconciled somewhat by acceptance of the common dynamics of pastoralism and the ecology that supports wildlife conservation and tourism, both major drivers of foreign investment in the study areas. Wildlife-focused activities could also in the long term be supported by appropriately defined, ecosystem-scale rangelands management designed to preserve dynamic stability in large, resilient and flexible ecosystems. However, this will only be possible if stakeholders in tourism can be persuaded that preservation of ecosystem integrity and complexity rather than the isolation and monopolisation of small, valuable areas is the way forward in the long term.

Conclusions

Mapping using digital technology in conjunction with local knowledge is still relatively new in East Africa. But it is showing early promise – not only from a technical perspective (e.g. accurate, efficient, cheap and transferrable) – but also as a tool to empower communities and bridge communication gaps between citizens and their government. Participation in mapping the land generates some ownership of the maps and the land management issues they describe, mobilising community group engagement in these issues. The process

[5] Villagisation is the (usually compulsory) resettlement of people into designated villages by government or military authorities.

Figure 7: Pastoralist dynamics with a sample of hunting, mining and villagisation gazettements overlaid.



also can encourage government agencies to visit and engage with their constituents who can now use maps to provide more communicable and coherent ways of articulating their land-management knowledge and priorities. Maps in a digital platform can also be directly compared, allowing planning and management issues to be clearly crystallised, and perhaps more easily resolved.

At the time of writing, work is on-going in Longido and Isiolo, where the maps described in this paper will be used to support decision-making on public good-type investments to build local adaptive capacity to climate variability and change. Plans are being finalised to extend and upscale the work to neighbouring counties and districts in Kenya and Tanzania respectively. As the size of the area mapped increases towards the landscape scale, a more comprehensive overview of pastoral dynamics, cross-border effects and natural resources distributions can be provided, resulting in an increasingly powerful tool. Monitoring systems for updating the maps and handing over of ownership are being put in place with some capacity-building required to support this. Legal advice is also being sought on how to use maps to pass byelaws protecting key resources and preserve the mobility required to access them.

We plan to make the maps available online as well as disseminating printed 'atlas' type maps where electricity and computing do not allow the data to be shared directly. To achieve better hand-over, uptake of ownership and ongoing monitoring of changes we must further explore how to make the maps into interactive tools to support adaptive management and decision-making by using techniques such as crowdsourcing data to develop a community of users and contributors around the data, adding and using updates in real time.

Some challenges stem from the need to hand over digital technology, though uptake is advancing rapidly e.g. the spread of GPRS-enabled mobile phones (Box 1). Another challenge will be harmonising spatial planning activities between different stakeholder groups and local- and national-level government planning departments. The communications gap between pastoralists and other stakeholder groups and managers can be bridged using maps to convey the copious and pertinent data contained in local knowledge in a precisely verifiable and more widely applicable form. However, the capacity and will of government to accommodate pastoralist knowledge and reasoning in the mediation of land management issues will determine the success of landscape-scale rangelands management in the long term.

CONTACT DETAILS

Tom Rowley
Box 11598
Arusha
Tanzania
Phone: +255 764 930 588
Email: tjtr22@gmail.com

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