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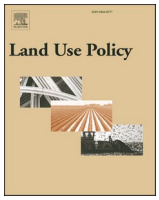

Lessons learned from participatory land use planning with high-resolution remote sensing images in Tanzania: Practitioners' and participants' perspectives

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ABSTRACT

Participatory mapping (PM) solutions have become common in many sectors of society to enhance engagement of the local communities in planning processes. Especially in data scarce regions, like Africa, PM that captures local knowledge in spatially explicit form is an important tool for integrating previously non-existent spatial knowledge in to collaborative planning. Despite the increasing usage of PM solutions, there still lies a gap in our knowledge of the influence and enabling factors of PM adoption in real-world decision-making processes. We studied practitioners' and participants' perceptions on benefits and limitations of PM that uses high-resolution remote sensing imagery to engage with participants in six use cases in Tanzania. We conducted interviews and one group discussion with practitioners, and feedback surveys among PM participants. According to the experiences of the practitioners and participants, PM methods based on high-resolution remote sensing images have increased practitioners' work quality and professional competence, and enhanced participants' active participation and spatial understanding for informed decision-making. Technical challenges and lack of skilled experts and institutional support were commonly identified limitations. Based on the users' perceptions we identified previously recognized enabling factors such as supportive policy environment but also context specific factors; removal of disincentives and wider awareness raising. Moreover, advocacy among policymakers on the benefits of participatory decision-making and geospatial technologies is needed to build their ownership of the new governance practices.

1. Introduction

Geospatial solutions have become common in many sectors of society in the global south (Amade et al., 2018; Sala and Dendena, 2015). These geospatial advancements have been spearheaded by increasingly wider access to spatial data, such as aerial and satellite images, low-cost location enabling technologies and software such as Global Positioning Systems (GPS), mobile phones, and open-source tools (Geospatial Media and Communications, 2019). Parallel with these data and technology developments, citizens have become active users of these data and platforms and also key producers of spatial information collected, for example on top of very high resolution remote sensing images in participatory mapping exercises (Fagerholm et al., 2019; Ramirez-Gomez et al., 2016; Scolozzi et al., 2015). Open Street Map (www.openstreetmap.org) is a good example of a global online map service, which runs on users' voluntary mapping data on top of high-resolution satellite imagery from Bing, ESRI, Mapbox and other data repositories.

Participatory mapping (PM) and participatory geographical information systems (PGIS) applications are nowadays increasingly used in different application domains due to accessible technologies for data collection, analysis, and collaborative planning (Brown and Kyttä, 2018; Cook et al., 2020). The variety of topics and methods of PM is evident also in the global south. A quick Google Scholar and Science Direct search reveals that PM applications in the global south within the last five years have addressed, for example, urban, rural, coastal and marine planning, solid waste management, flood risk reduction, HIV prevention, and children's lived spaces. These studies have utilized openly accessible Ushahidi and CyberTracker platforms on web or smartphone application, email or geotagged tweets (Mavakala et al., 2017; Padawangi et al., 2016; Paul et al., 2016), satellite images on printout or in GIS software projected on a wall (Alexander et al., 2018; Bustillos

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Ardaya et al., 2019; Green et al., 2016), and sketch mapping and web-based decision support systems (Basupi et al., 2017; Benninger and Savahl, 2016; Pedrollo et al., 2016; Zhang et al., 2019).

The recognition of the value of local experiential and place-based knowledge in providing more comprehensive understanding on the complex socio-ecological systems has motivated practitioners and decision makers to engage with stakeholders using PM applications (Reed, 2008; Turnhout et al., 2012). Methods that capture local spatial knowledge in georeferenced form using scale maps or high-resolution satellite images as the mapping background enable the level of spatial accuracy in map outputs required for spatial planning (Corbett, 2009). These georeferenced mapping methods have also the benefit that the participatory mapping outputs can easily be combined with other geospatial data. Thus, in georeferenced form and with higher spatial accuracy the local spatial knowledge can better accompany expert knowledge and bring new insights into decision-making processes. Especially, in data scarce regions of the world, participatory approaches have been shown to be important in informing resource management and planning decision-making at local level (Paudyal et al., 2015; Valencia-Sandoval et al., 2010). In addition to the instrumental value these participatory tools have, in the global south, they have often been aimed at enhancing stakeholders' decision-making capacity and local empowerment (Corbett, 2009; Fagerholm et al., 2019; McCall and Dunn, 2012; Ramirez-Gomez et al., 2016; Valencia-Sandoval et al., 2010). Therefore, PM approaches have high potential for the implementation of spatial planning policies and in improving planning processes, where stakeholders' participation is seen a key to more informed, inclusive and sustainable decision-making.

The performance of PM in terms of inclusiveness and supporting community members' self-determination in decision-making has been under scrutiny since the first PM applications in global north and south (see e.g. Abbot et al., 1998; Elwood, 2006; Reid and Sieber, 2019; Young and Gilmore, 2017). Despite the increasing usage of PM solutions, there still lies a gap in our knowledge of what kind of benefits participatory methods bring and how they influence real-world decision-making processes (Brown and Kyttä, 2018; Kahila-Tani et al., 2016; Meijer and Potjer, 2018; Pulles, 2017). In the global south, technology adoption and institutionalization are vivid with successful and less successful initiatives which call upon studies of their benefits and enabling factors as well as readiness of societal actors to adopt them (Ishengoma et al., 2019). Apart from increased accessibility, suitability of applications and favorable organizational politics have been identified to affect adoption and diffusion of GIS technologies in the global south (Mennecke and West, 2001).

Adoption of PM tools into planning and management practices rely much on the users' willingness and opportunities to master the methods and see their advantages over conventional ways of working. Thus, understanding from the user perspective how local knowledge flows in a fair way among the users and what aspects of PM may improve or hinder the planning process as a whole is crucial. User opinions have been elicited for example on feasibility, usefulness, adjustment needs and better design of PM applications (Aditya, 2010; Grant-Smith and Johnson, 2012; Hirata et al., 2018; Kahila-Tani et al., 2019; Ramirez-Gomez et al., 2017). Saija et al. (2017) present practitioners' reflections on planners' role in transformative planning processes in southern Italy, which highlight important lessons for participatory approaches to consider. Pietilä and Fagerholm (2018) studied practitioners' views on the potential uses of PGIS in national park planning and impediments for the methods adoption. Haworth et al. (2016) examined the user experience in contributing to participatory geographical information on bushfire occurrences and experienced benefits to community risk resilience. In these studies, the views of both the practitioners and participants of PM were envisioned to help develop the methods further and increase the effectiveness of participation and relevance of the process to the interests of both of these user groups. Moreover, the users may emphasize more profound benefits and application potential such as in the Haworth et al. (2016) study where increased social connectedness and engagement in risk reduction were considered by the users as more beneficial than simply the information sharing.

Tanzania is an example of a country undergoing a large-scale digital transformation of many sectoral planning and decision-making processes. In these processes, public participation has either been granted substantial role or PM has been introduced and piloted for added benefits: for example, urban flood mapping in Dar es Salaam city (ramani huria.org; https://resilienceacademy.ac.tz/), gendered data collection on women's problems (www.youthmappers.org), rural settlement mapping for health service provision and community development (crowd2map.org; www.hotosm.org/where-we-work/tanzania), land tenure formalization (www.dai.com/our-work/projects/tanzania-feed-future-tanzania-land-tenure-assistance-lta) and rural spatial planning (Eilola et al., 2019; Käyhkö et al., 2019; The National Land Use Planning Commission of Tanzania, 2018). In these pilots, several PM approaches have been developed to provide reliable and up-to-date spatial information for decision-making. Tanzania's National Five-Year Development Plans (2012–16; 2017–21, third one under preparation 2022-) and The Tanzania Development Vision 2025 (https://mof.go.tz/mofdocs/overarch/vision2025.htm) call for actions to improve ICT infrastructure, telecommunication networks, science and technology education as crucial enablers of socioeconomic transformation in the country. Especially spatial planning and natural resource management sector is exposed to this development, and participatory spatial planning is advocated in policies to better tackle unsustainable resource use, land tenure insecurity and land conflicts in the country (The National Land Use Planning Commission, 2013). Nonetheless, implementation of these participatory policies has been slow and constrained by limited political will and lack of financial and human resources (Hart et al., 2014; Walwa, 2017). Furthermore, numerous studies from Tanzania show that in effect higher-level authorities as well as international agencies and commercial actors often times retain or acquire much control on land use planning, land and natural resource management despite ostensibly participatory arrangements (see, e.g., Bluwstein et al., 2018; Huggins, 2018; Sungusia et al., 2020; Walwa, 2017). Thus, making it difficult to assess how PM fairs in the formal Tanzanian decision-making context.

To address this knowledge gap, we have studied practitioners' and local participants' experienced benefits and limitations related to PM methods that are based on high-resolution remote sensing images in six spatial planning and landscape research cases in Tanzania. Our research questions are 1) how do the informants perceive the benefits of using high-resolution remote sensing imagery in PM for land use planning and decision-making?, 2) what kinds of limitations the use of remote sensing imagery in PM has according to their views? and 3) what future potential such methods have for wider adoption into formal practices of local land use planning? We conclude our study with reflections on these participatory geospatial methods and the enabling factors for their adoption into spatial planning and natural resource management practice wider in the global south. These reflections help in identifying weaknesses in these methods and the operational environment as well as assist in further method development.

2. Material and methods

2.1. Participatory planning in Tanzania

Tanzania has several policies that enable decentralized land and natural resource management by local communities. The Village Land Act of 1999 and the Land Use Planning Act of 2007 sets village councils as the planning authority responsible for land use planning in the village land, while district planning authorities are to co-ordinate the planning in villages within their jurisdiction. As a result villagers establish a Village Land Use Plan (VLUP). Regarding forest land, communities and groups of individuals can establish community based forest management (CBFM) areas within villages (the Forest Act of 2002 and the Zanzibar

Forest Act of 1996). The planning processes leading to these participatory arrangements are instructed by guidelines, which emphasize active participation of local stakeholders in the decision-making. The guidelines also have provision on the use of geospatial data and tools. The VLUP guidelines mention the use of GIS software and satellite imagery (if available) by district planners in preparation of village maps and in delineating land parcels with villagers during land adjudication. The CBFM guidelines in Zanzibar recommend the use of remote sensing imagery in forest monitoring. In urban areas, city, town or municipal councils are the planning authority whereas the lowest administrative units, Street and Ward, have no predefined role in planning according to the Urban Planning Act of 2007.

Spatial planners, who graduate from Tanzanian universities and are responsible for facilitating and carrying out planning based on the guidelines, gain knowledge of geospatial tools in their degree but often face an operating environment on the job, especially in public sector, where such tools are not available to them. Research, capacity development and policy advocacy related to land use planning is conducted in the country by numerous actors including the National Land Use Planning Commission and non-governmental organizations (NGOs) working for example on community empowerment, land rights and nature conservation (e.g. Ujamaa Community Resource Team, LANDESA and Haki Ardhi). Increasingly private sector actors are engaging in land survey and planning activities capable of tendering for public spatial planning projects. The involvement of different actors in developing cost-effective and collaborative planning tools is needed while the country faces a challenge in planning as only about 13% of the rural Tanzanian villages have a land use plan (S. Nindi, National Land Use Planning Commission, personal communication, June 2017) and when urban planning is conducted it is often carried out in a non-participatory way (Huang et al., 2017).

2.2. The six participatory mapping cases

We selected 6 PM cases from Tanzania into this study. These cases have applied PM methods in village land use planning (cases 1a and b), local area planning (cases 2a and b), landscape research (cases 3–5) and urban flood risk assessment and planning (case 6) (Fig. 1 and Table A.1).

Fig. 1. PM method use in the studied cases. Case 1a) collective mapping of land use areas using marker pens; case 1a) collective planning and mapping of future land use allocation; case 2a) collective mapping of marine and coastal activities using marker pens and stickers; case 2b) representatives of expert organizations mapping marine and coastal threats using online mapping survey; case 3) mapping of individual's provisioning and cultural ecosystem services using wooden beads; case 4) group discussion on mapping results; case 6) mapping of community assets and flood risks using printouts of drone images and Open Data Kit. Copyright: Salla Eilola, Zakaria Khamis, Nora Fagerholm and Msilikale Msilanga.

A common method in all the cases was the use of georeferenced high-resolution remote sensing imagery (satellite, drone or aerial images) to facilitate stakeholder mapping and discussion exercises at local level (Fig. 1). The imagery were in true color and either printed (ranging in scale from 1:7000–1:12 000) or digital on screen and obtained via Google and Bing repositories (eg. Digital Globe data) or as digital aerial images provided by different projects to the facilitation teams. The mapping exercises have been either collective or individual and aimed at capturing local spatial knowledge and supporting spatial decision-making. The methods applied an approach, which facilitates stakeholder participation and visualization of local spatial knowledge through the use of different geospatial techniques and data, as exemplified in Fig. 2. First the mapping background image was produced by people with GIS expertise using commercial or open source software, then the image was used to facilitate PM and discussions of the mapped topics. The exercises were facilitated meaning that the facilitators assisted the participants to read the image and observed whether participants understood and were able to utilize the image during the exercise (see Table A.1 for further details). Depending on the objectives of the exercise and available spatial data, the mapped information was visualized, analyzed or combined with other data before returning it back to stakeholders for discussions. Finally, the mapping and discussion outputs were displayed and archived in appropriate forms for stakeholders to utilize them in the future.

The planning cases (1, 2 and 6) developed PM methods for capturing land and natural resource use information which was or will be used as a basis for formal spatial land use planning. In the landscape research cases (3,4 and 5), the local knowledge was collected primarily for research purposes to study local land use but returned back to the communities in the form of maps for group discussions. They were also linked with development of PM methods for CBFM in Zanzibar Islands. The flood risk assessment case (6) piloted PM that uses high-resolution drone imagery and scale maps in urban communities and built local capacity to run mapping campaigns and use the data in flood response planning. The authors were involved in planning and testing the methods in collaboration with Tanzanian planners and researchers in cases 1a, 2b, 3 and 4, and provided assistance in cases 2a and 5. In cases 1b and 6, the authors were not involved in any way.

To date the developed PM methods have been adopted into practice in the rural land use planning processes on mainland Tanzanian where as in Zanzibar archipelago and in the urban setting of Dar es Salaam city, the methods are yet to be embedded into the institutions' land use planning practice outside the pilot interventions. In the Southern Highlands region on mainland Tanzania, the method (in case 1) has been integrated in to the formal planning practice in five districts by planners and its use has been endorsed by the National Land Use Planning Commission, which has published a national guideline on its use (The National Land Use Planning Commission of Tanzania, 2018). Some individual practitioners who were interviewed in the study have adopted the methods into their own day-to-day practice and modified them to fit their operating environment.

2.3. Data collection and analysis

The collected user experience data consists of three different datasets. First dataset is interviews of the 12 practitioners, who had used PM methods in the studied cases (1–6). Second dataset, a group discussion, consists of documentation of the discussion event where 33 practitioners took part and third dataset includes feedback surveys of 351 participants in four of the study cases (1a, 2a, 3 and 4). The different informant groups in these three datasets differ in their familiarity with the studied geospatial PM methods. The interviewed practitioners had utilized the methods in practice as facilitators of PM while most practitioners in the group discussion had no such experience. The survey respondents were community members who experienced first time mapping exercises after which they were asked to share their opinions on them. The interview data is our main dataset rich in details of practitioners' perspectives.

We used purposive sampling of the practitioners, who we selected due to their hands on experience in using the PM methods in the case studies. We interviewed six government officers, two at national level and four at district level, three university lecturers, two from the University of Dar es Salaam and one from the State University of Zanzibar, and three practitioners from international development cooperation projects (in total 9 males, 3 females). Their educational backgrounds include urban and regional planning, sociology, geography and geo-information sciences. The interviews focused on practitioners' views on the usability and benefits of the applications to their work and to participatory planning as well as their reflection on the PM methods' wider adoption. The practitioners were also asked to describe how they had integrated the PM methods into their working practices (see the interview schedule in appendix B). The interviews were done face-to-face or on the phone between April and September 2018. The open-ended interview questions were asked in English and the interviewees were allowed to answer in their native Swahili language in case they wished to do so. The interviews were audio-recorded, with the consent of the practitioners, and then transcribed. The specific situation of expert interviews was considered before and during the interviews and in analysing the data (Alastalo and Åkerman, 2010). Accordingly, the interviewer had previous knowledge of the studied processes as well as existing documentation of them to familiarize before the interviews. The interviewer was able to construct probing questions for each practitioner and offer own interpretations of the process and its outcomes for the practitioners to reflect during the interview. In the analysis phase, the interviewer used the existing documentation to help data interpretation.

The group discussion was organized with 33 practitioners from 21 Tanzanian governmental, NGO and private sector organizations. The

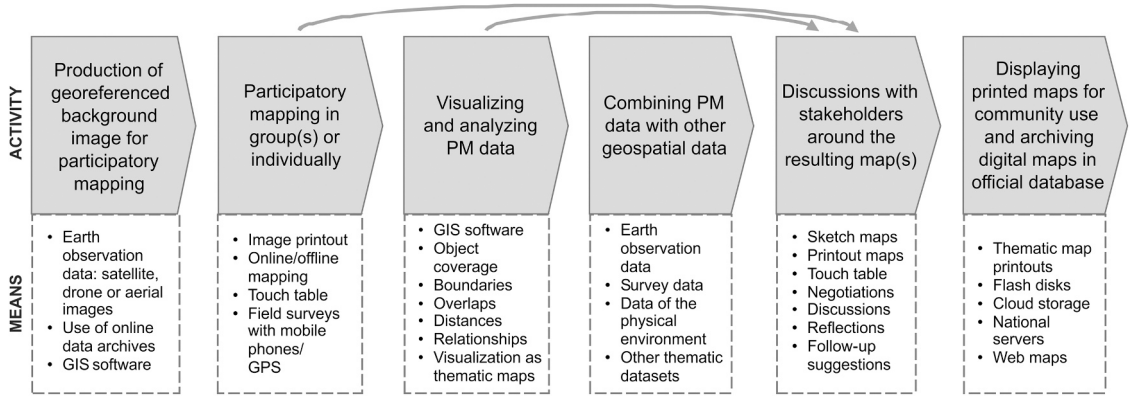

Fig. 2. General approach to participatory mapping that uses remote sensing imagery. The approach had been variedly applied in each of the six studied PM cases in Tanzania.

discussion was part of a national land use planning stakeholder meeting held in Dar es Salaam in June 2017 and organized by the National Land Use Planning Commission of Tanzania. It focused on the potential use of digital PM tools in planning and the authors facilitated the discussion. The discussion was documented by one of the researchers who took notes on the main points made by practitioners each speaking in their turn.

The datasets from the discussion and the interviews were analysed using conventional content analysis (Flowerdew and Martin, 2005) with NVivo 11 software. First, the interview dataset was coded into initial codes by open coding focusing on contents that were relevant to the three research questions. Then these codes were reviewed, modified and additional codes identified after which they were grouped into themes and subthemes rising from the data. The discussion dataset was smaller in size and covered only perceptions on the potential and limitations of digital PM tools and its content was compared with the themes identified in the interview dataset and any additional themes were identified. We state the data source of the perceptions, namely interviewed practitioners or group discussion, when we report them in the result section of this paper.

The participant feedback surveys were distributed on paper to participants after the mapping exercises or subsequent discussions of mapping results in four of the studied cases (1a, 2a, 3 and 4) (Table A1). The surveys were carried out by the authors or the Tanzanian researchers, who tested the PM methods. In the other two cases studied in this paper, no surveys had been carried out among participants. In total 351 participants (169 males, 182 females) answered the survey questions. The average age of the informants was 40.7 years (St.d. 14.7), while the youngest informant was 15 and the oldest 88 years old. The questions in the four surveys varied and only answers to those questions which were comparable were selected to form the dataset for this study. The comparable questions were in a form of three structured statements as follows: 1) Satellite image was easy to understand, 2) I personally learned something new during the discussion around the satellite image, and 3) Satellite image helped in the discussion. The wording in the structured interview responses varied between cases and were thus recategorized (scale yes-no-not applicable) and aggregated into one dataset. The dataset was analyzed using Excel to calculate descriptive statistics. The surveys included also open ended questions allowing informants to explain in words their answers to the structured statement questions. These descriptive answers were used in this paper to elaborate the participants' feedback.

3. Results

3.1. Experienced benefits of the participatory mapping methods

All interviewed practitioners state that the PM methods have had positive impact on their work; eased their work and increased its quality (Table 1). The use of georeferenced remote sensing image in mapping with communities has made their work less tedious and time consuming compared to previous method which relied on laborious and manual GPS tracking on the ground to capture georeferenced data of important localities, such as boundaries and sites of local services. Previously, collection of information had been done using GPS devices with few community representatives and or by drawing a sketch map with community representative on a blank piece of paper. At best, the collected GPS point data would capture only limited amount of locations and boundaries. In the interviews, most of the practitioners referred to these old methods, and compared them to the use of remote sensing imagery. They used terms "working in the darkness" and "being blind" to describe the way in which they felt they had being delineating land use areas or sites of importance in the past without the possibility of drawing a map with villagers on a remote sensing imagery. Due to the geospatial PM method the locations and area delineations reflect the reality of boundaries known by the local community members as they can map them in detail on the imagery. As one practitioner explained, the GIS experts no longer can or have to fabricate land use area boundaries on the map in places where no GPS points were taken to produce a digital land use map. Many of the interviewed practitioners have the perception that the method enables them to produce high quality spatial data. With high quality they refer to high mapping coverage (no data gaps and less uncertainties), depiction of local spatial knowledge into a map form and, thus, expected higher local relevance and content accuracy. One practitioner noted, however, that the high accuracy assumption has a downside in that one may trust the image and not do enough ground verification, which in case of old or wrong interpretation of images can cause inaccurate land allocations.

Table 1
Benefits and limitations of the PM methods as well as factors affecting their future adoption potential experienced by the method users.

Benefits identified by practitioners and participants	Limitations identified by practitioners and participants
• High spatial data quality as an output of the mapping process • More time-efficient mapping process as a whole • More active participation in the data collection and discussion exercises • Increased understanding of localities among practitioners and participants for informed decision-making • Increased professional confidence among practitioners and more trust on the process among participants	• Poor status of information and communication infrastructure especially in rural areas • Lack of experts with geospatial and information technology skills • Absence of institutional support for method adoption • Challenges among participants to read the remote sensing images • Lack of exposure to technologies among citizens
Future potential and factors affecting it identified by practitioners	
• Positive that methods can be adopted nationally due to increasing access to geospatial data and tools • Training and awareness raising needed among different actors • Practitioners need to be motivated to keep their know-how up-to-date • Disincentives to adopt PM methods need to be identified and removed from planning institutions • Higher level authorities need to be committed to promote the methods, create supportive policy environment and reduce dependence on outside assistance and resources for method development	

Several interviewed practitioners mention that using remote sensing imagery in mapping with communities has helped them to gain an overall view and more comprehensive understanding of the localities and particular features in them. On their own, the practitioners get an overall idea of the area by looking at the images. During PM, the images help them to comprehend the places mentioned by the community members and grasp less obvious landscape characteristics such as land use patterns or land use values in the village. This understanding then helps them also to advice the community in detail on land suitability and allocation, for which many of the practitioners say, they use the image. With the remote sensing image they can for example explain more understandably the consequences of land use allocation decisions, as this statement of one of the practitioners illustrates:

> *"[you the practitioner are] sitting with them, looking at the satellite image, and you say "you see the grazing land is just here and we cannot convert this [to forest land] because in the future where are you going to do your cropping". It is like you find at the end of the day they are happy and you are happy that you made them understand and there will be no blames that [you] were not fair."* (An expert from development cooperation project).

All in all, interviewed practitioners feel that their professional confidence is enhanced due to the use of remote sensing images. They mention for example that they are now able to produce more credible spatial data and land use plans and continue to improve their skills and knowledge of new technologies after learning to use this participatory mapping method in practice with community members.

All interviewed practitioners have observed impacts of using remote

sensing image on the participant engagement. The feedback from community participants in the surveys affirm similar observations. Practitioners have observed that the remote sensing image enables participation of people who previously had limitations to participate in planning activities, such as elderly and disabled. With the image there is less need to GPS track land uses in order to map them, which is an activity where physically challenged people cannot participate. The image enables these people to visually examine their village landscape and subsequently express their knowledge using the analogue or digital remote sensing image as a visual aid. Practitioners also mention having seen how the remote sensing image is engaging to participants. According to them it is fun, captures participants' attention and keeps them actively engaged during the mapping exercise. Interviewed practitioners have observed impact of use of remote sensing image on the quality of decision-making among participants in terms of better understanding of the planning issues and capture of wider participant views. Most practitioners (9) have noticed the increase of participants' spatial understanding such as on environmental condition, relative size of areas, and magnitude of resources. 84% of the participants who answered the survey (n = 351) stated that they learned something new about their environment during the exercises with images (Fig. 3). The practitioners have observed the remote sensing image to create a room for discussion and help participants to express themselves. 89% of the surveyed participants (n = 351) think images helped them in the discussion (Fig. 3). They give following explanations on how the image helps them to participate:

> *"Because the map was clear and I could see everything therefore it triggered my mind."* (Participant in case 3)

> *"Image makes me understand and argue my case."* (Participant in case 4)

> *"The map was used like a reference for discussion. Even tomorrow if someone asks I can show him areas where we get different environmental services."* (Participant in case 3)

> *"It shows what is where to get the big picture."* (Participant in case 4)

> *"It [the satellite image] helped when some people didn't know some area and some others did and they explained and we discussed well."* (Participant in case 1a)

Furthermore, practitioners also noted that the remote sensing image enables a common understanding to develop among participants on area boundaries and consequences of decisions, which did not happen during the use of previous methods. The ability to reach common understanding and have detailed discussions have helped practitioners to resolve land and boundary disputes, which many practitioners have experienced. Following is one example of these practitioners' accounts:

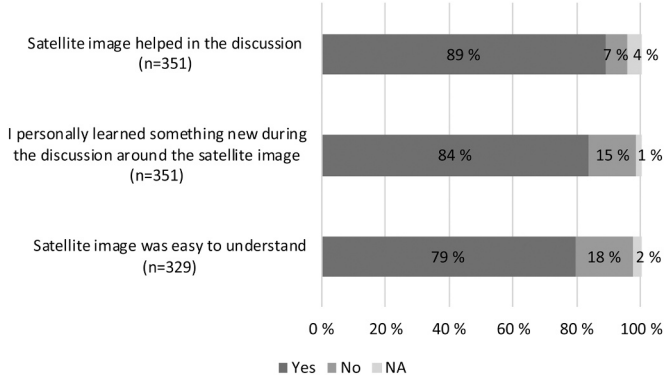

Fig. 3. Results of the four participant surveys (case studies 1a, 2a, 3 and 4).

> *"For our case satellite image has been used to solve the conflict [when] two villages were competing for the forest reserve. So what we did was to gather them and start discuss about the issue, they were discussing and finally we decided to show the images, satellite images to them, and the discussion proceeded but regarding to what they saw [on the image] so the discussion was then very simple because they finally said "oh if this is the forest we are competing, why can't we take just a part of it and you take the rest". Yes so that was simple because the other village was accepting because they saw it is just a small part."* (District planning officer).

One interviewed practitioner also pointed out that the use of remote sensing image in land use mapping exercises with community members has led to several situations where village representatives have ended up confronting village leadership over land deals, which have not gone through village assembly approval. The land deals have been revealed when the community members have discussed the location of available land areas seen on the image and the leadership had to confess that the land no longer belongs to the village government. Finally, several interviewed practitioners indicate increased process ownership of the community when using the method. They mention community feeling either ownership, comfortable or proud about the process or its output. As benefits to their own work, some of the practitioners also see that when the community members know how and why the land allocation decisions were made the way they were, the community has more trust in the process and its facilitators than before.

3.2. Limitations of the participatory mapping methods

All interviewed practitioners whose work is to obtain, process or manage the geospatial data and images mention that technical challenges obstruct the use of geospatial data and remote sensing images (Table 1). Commonly mentioned limitations are electricity outages, availability of reliable internet connection and powerful enough hardware, suitability of available imagery (up-to-date, cloud-free, high-resolution), and poor printing facilities. While digital mapping tools were mentioned beneficial due to zooming capability and non-reliance on printouts, the problem of poor ICT infrastructure in many districts is most pronounced when using digital solutions. In addition, lack of knowhow to use computers or digital tools among participants as well as practitioners hinder the mapping exercises. Practitioners who have used digital tools mention that participants might also not comprehend the remote sensing image on screen as easily as on printout and size of screens restrict the number of participants in discussions. One of them note that, a comprehensive view of the entire planning area does not form when exercises are done with digital map on screen. Practitioners of the group discussion on digital tools apart from stating technical challenges, also mention that most people in Tanzania are not aware of digital opportunities and applications. They also highlight that the policies on data security, quality and access to information are lagging behind or their implementation is stagnating in the country.

Practitioners across their different affiliations state institutional limitations for adopting or using the geospatial methods. They are concerned about the lack of skilled geospatial experts in the different organizations working on participatory planning in Tanzania. A few practitioners mention the lack of acceptance, willingness and support from their institutions for the adoption of these methods, while they as practitioners rely on resources allocated to them by their superiors. Practitioners also mention facing colleagues and superiors who have difficulties in accepting the accuracy reached using a remote sensing image as being enough for planning purposes. One of practitioners note the difficulty to validate participatory data, which may undermine its credibility in formal planning processes. This is related to the heads of institutions not being aware of how community-based experiential data differs from ground survey data collected by planners and experts and what is the value of local knowledge.

Practitioners and participants have noticed hindrances to the use of

the PM that are related to participants' preconceptions and capacities to work with remote sensing images (Table 1). The readability of remote sensing images is seen challenging to some participants. Several practitioners (6) mention that some participants are slow or find it difficult to understand the image and need more time and instructions by skilled facilitators who can ensure that all have equal opportunity to participate in the exercises. Similarly 18% of the informants of participant feedback surveys (n = 329) thought that the information in the images shown to them was not easy to understand (Fig. 3). The ability to understand the image depends on several factors such as thorough instructions to read the image, prior familiarity to the landscape and self-efficacy of the participant as well as the self-explanatory power of the image. These factors are exemplified by the following citations from the participants:

> *"From the beginning it [understanding information in the satellite image] was difficult but later I understood better after more introduction and orientation."* (Participant in case 3)

> *"For the first time it [understanding information in the satellite image] is difficult unless one is familiar with the area."* (Participant in case 3)

> *"First was difficulties before I had learned how to read the image, I was afraid that maybe I cannot."* (Participant in case 1a)

> *"In some areas there are manmade changes that had not existed when the satellite image was captured. When you compare the image and the condition of those areas now, it [understanding the image] is challenging."* (Participant in case 1a)

Five of the interviewed practitioners also note community members having suspicion or preconceptions against the use of remote sensing image in the exercises, which complicates PM. Since most participants are unfamiliar with remote sensing images and digital tools, they are fearful of how the methods can be used against them for example by appropriating their lands. Moreover, community members have been observed to utilize the remote sensing image to try to advance their unwarranted goals in the process, such as extending land claims to areas, which do not belong to them, making practitioners cautious of this risk. While people's awareness of the land and its resources increases due to the geospatial methods, these unwarranted land claims most likely increase as one practitioner speculates.

3.3. Future potential of the participatory mapping methods for wider adoption into practice

All interviewed practitioners are generally positive that the methods can be adopted nationally. The practitioners in the group discussion and some of the interviewed ones recognize that the accessibility of spatial data and tools is increasing with the advances in the geospatial field. One of the interviewed practitioners predicts that mobile mapping using handheld devices like smartphones will be common after 5–10 years since citizens are getting more used to and access to technology. In the group discussion, views are positive that costs of using technology will reduce when application providers become many and people see the business opportunities. Already now knowledge of the public on spatial data importance is increasing.

The upscaling requires supportive environment and that some obstacles are overcome (Table 1). Several (5) interviewed practitioners call for training and awareness raising for practitioners, planning students as well as communities and their leadership. They see that the more people hear about the methods and their benefits, the more likely they become a requirement for doing land use plans in the country. One interviewed practitioner gave a program where he works as an example of an institution where usage of remote sensing image with communities has been made a requirement in planning practice. Practitioners in the group discussion, however, reminded that the use of PM methods which utilize geospatial technologies should not be made a national level requirement since they need skills and technologies which are not readily available all over Tanzania. Nonetheless, on individual level, when practitioners have experienced the benefits of participatory geospatial methods it becomes hard for them to work without them. The interviewed practitioners call for motivation among experts to constantly up-date their knowledge on technological advances in order to apply the methods. Some of the practitioners are already members in social media networks where practitioners share knowhow and advise each other. The interviewed practitioners recognize also that among practitioners there is resistance against the methods, which manifests in, e.g., claims that it is not feasible or requires training. One practitioner speculates this to stem from the fact that it reduces time in the field from which practitioners earn extra income as field allowances. Another practitioner sees resistance to stem from people being scared of changes and wanting to maintain their status, which could diminish when more people learn the new technology and they themselves lose their expertise role.

Some of the interviewed practitioners and practitioners in the group discussion emphasise the need of national level planning authorities to genuinely promote use of the PM methods and create supportive policy environment for them. In general, spatial planning in Tanzania is undermined by lack of resources due to low prioritization of land management and planning issues in budgeting. One interviewed practitioner doubted the dedication of district planners and decision makers in using the methods since the use is knowledge intensive and entail many working steps:

> "*I'm also thinking about the district setting. Because this VLUP [Village Land Use Plan] sometimes is not a priority to them, you know. So when [it is done] with donors maybe it is ok, there is resources. But when they have to do it on their own, I'm not sure if they are able to use the satellite image. I know the cost of printing is not that high. But could be issues with, like, they need to have a strong internet to access [the image]. They need to have a computer and software to work with the satellite image. And they have to be able to send it somewhere for printing and then bring it back [to get the printout]. Buying these other things, joining* etc. *It can be challenging if some districts are not dedicated to it.*" (An expert from development cooperation project)

Another interviewed practitioner reminded about the dependence on outside assistance and resources while Tanzanian commitment to adopt and develop the methods and carry out necessary training is not warranted. The practitioner also noted the need to test the methods in different cultural, livelihood and environmental contexts in the country so as to inform further development of the methods.

4. Discussion

In this paper we have studied user perspectives on PM through six spatial planning and landscape research cases in Tanzania. As the results of the study show, PM methods that utilize high-resolution remote sensing imagery with stakeholders bring many benefits to motivate practitioners to adopt them even under prevailing constraints. The studied PM methods have eased practitioners' work, increased professional confidence and quality of the outputs. The methods have also made mapping an attractive and beneficial exercise for participants to engage in spatial decision-making. Having the remote sensing image allows the landscape to be observed and discussed in one spot with large amount of participants. This assists people with less knowledge of the entire village area to learn through the aerial perspective and from the more knowledgeable participants giving everyone better opportunity to understand the issues discussed and contribute to the discussion. Our findings on the value and possibilities of the use of geospatial PM methods concur with those of Aditya (2010), Brown (2012), Hirata et al. (2018) and Pietilä and Fagerholm (2018). In our Tanzania case, the studied PM methods which have been used in formal planning practice are also cost-effective compared to previous time-consuming and less-participatory GPS tracking based mapping methods, thus, making

them feasible for wider adoption.

Based on the studied user's perspectives, the main limitations for the implementation of geospatial PM methods are poor ICT infrastructure, geospatial skills, exposure to technologies and institutional support. These are mainly remedied through decisions on higher level such as infrastructure and human capital investments. ICT infrastructure and open source data such as satellite imagery are, however, increasingly available in countries of the global south (Avgerou et al., 2016; Geospatial Media and Communications, 2019). The practitioners can also affect the situation by embracing new technologies when opportunities arise and by developing their geospatial skills on their own initiative. While the PM exercises were observed to accommodate participation of people who previously have not been involved in planning processes, the inclusivity of the methods is dependent on proper facilitation by the practitioners since the high-resolution remote sensing imagery does not open up to all participants. In suburban Indonesian community, where both digital and analog tools were tested, printed high-resolution aerial imagery was identified as the most appropriate mapping tool for group discussions and building common understanding (Aditya, 2010). In the Indonesian study, the printed imagery was observed to be easy to learn, engaging, as well as error tolerant for participants to use in mapping. Participant evaluation of the usability of printed high-resolution satellite imagery and the need of thorough instructions and orientation by facilitators in rural Tanzania are reported also in Eilola et al. (2019).

Even though, the interviewed practitioners saw that the participatory geospatial methods increased local ownership of the process and its outputs in the studied cases, there are several aspects of the planning processes and the geospatial methods that limit local ownership. The formal decision-making process conditions in Tanzania do not offer support for the ownership to develop in communities and among citizens. The planning processes are often carried out in short time, the phenomena to be mapped are not locally identified and the processes are usually funded by outside actors with their own planning objectives (Eilola et al., 2019; Hart et al., 2014; Huang et al., 2017). The influence of external funders and prioritizations are generally recognized as diminishing local ownership of seemingly participatory processes (Kahila-Tani et al., 2019; Sullivan-Wiley et al., 2019). The lack of control over the process and technologies was observed to perpetuate mistrust towards the authorities among communities in the Tanzanian case and, thus, undermines the benefits of the method. This mistrust is potentially also exploited by interest groups to spread false information against formal planning and land tenure transparency.

Furthermore, the technical tools themselves, if inaccessible to local stakeholders, undermine the ability of communities to decide on what is mapped, how data is interpreted, used and shared (Elwood, 2011; Ghose, 2001; Huggins, 2018). The methods in the study cases of this paper are such that no local community or stakeholder group can access or utilize them without the assistance of GIS experts and acquiring relatively expensive equipment. Despite this, the sense of ownership of the planning process and its outputs has increased relative to previous less participatory planning methods according to the practitioners. An example from Zimbabwe offers an approach, which developed capacity of local non-governmental organization to plan and carry out mapping activities, analyse and visualize the data as a form of empowerment (Eitzel et al., 2018). This might not be a feasible approach as it was an outside intervention (it required several years commitment by foreign educational professionals), but serves to remind us that, when capacity development efforts are at place, geospatial technologies and data allow self-directed application by communities to initiate projects and address issues through community-led planning.

The practitioners are positive that the methods will be widely adopted in Tanzania but consider it to require training and wide spread awareness raising on their benefits and commitment to participatory governance in general. The endorsement of one of the studied methods (case 1) by the National Land Use Planning Commission and subsequent policy guideline on its use serves as an encouraging sign on institutional support and efforts in training for the adoption of these methods. In the following, we will discuss further the methods' adoption potential and enabling factors for adoption. The availability of means and competencies needed to utilize geospatial technologies is a concern to practitioners in general (Pietilä and Fagerholm, 2018). Since PM methods are plentiful it is possible to select, adapt and further develop the methods to suit the prevailing conditions and available means of the planning context. However, means and skilled personnel should be emphasized in Tanzania if collaborative spatial planning is prioritized by high-level authorities and policymakers. As our study shows, there are disincentives (reduced field days and threat to established expertise) in the Tanzanian planning practice, that play against adoption of technologies and that should be looked more into in order to address them. The increase of spatial data quality offered by geospatial technologies could be an incentive for adoption. Furthermore, development of automated spatial and qualitative analysis tools for georeferenced PM data will enable practitioners with less sophisticated skills to use the data in planning decision-making processes. Automated analysis methods would reduce the time and skills needed to process the data into interpretational form. Spatial decision support systems (SDSS) that are interactive and model impacts of land use options based on spatial and non-spatial information would also be valuable for practitioners and communities and increase the usability of the PM data (Pelzer et al., 2016; Rodela et al., 2017). With the increasing availability of spatial data the SDSS, especially when open source itself, will become even more relevant and topical in planning processes in the global south.

Our user perception study supports the idea that PM methods which utilize high-resolution remote sensing imagery are adoptable in practice among planning institutions and individual practitioners in the global south. In Tanzania, the participatory planning and management practice is not dictated by rigid policy guidelines, and therefore practitioners are allowed to experiment and adopt new methods which they see useful. When we reflect on the enabling factors for geospatial technology adoption in global south identified by Mennecke and West (2001), a following situation unfolds. The availability and suitability of the technologies as well as flexibility of adaptation to local circumstances are present but there is a lack of awareness on geospatial opportunities, and efforts in GIS education and on-the-job training are needed. Furthermore, the organizational political environment (Kyem, 2012; Mennecke and West, 2001) is often not favorable for PM and geospatial technology adoption and implementation. The studied cases show some examples of the organizational political system not being ready: adherence to work place hierarchy, limited political willingness, lack of personnel training opportunities, restrained financial conditions and counter effective remuneration system. Kyem (2012) notes that changes in these social structures that generate behaviors conducive to technological innovation happen gradually.

The production and use of more reliable geospatial information create a situation where land resources, land use and tenure arrangements become visible to actors involved in the decision-making process and beyond. This enables disclosure of land misappropriation, assists dispute resolution and more transparent land administration, which are desirable outcomes in regard to inclusive land access in a country where participatory land management remains often a mirage. However, the situation may also invite some actors to take the opportunity to extend their control over land resources, hinder the technology adoption and risks the data and technology being used against community interests as witnessed by some of the interviewed practitioners and in another study from Northern Tanzania by Huggins (2018). It is evident, that land allocation decision-making is intertwined with the political and economic power imbalances in the society that cannot be addressed with participatory methods alone. To mitigate the adverse effects and power imbalances the use of these geospatial methods need to be accompanied with a more democratic development in the decision-making system of a country. Tanzania, however, is currently ranked among the ten countries most at risk of autocratization in the world (V-Dem Institute, 2019).

Adoption of the participatory methods evolves with the politics and we should be cautious of the negative effects the tools may create (Pánek, 2013). The political will or lack of it influences the land planning and management practice but at the same time as our study demonstrates individual practitioners find ways to navigate in their environment to adopt methods that are beneficial for their work, increase its meaningfulness and their professional pride.

Instead of advocating for one particular type of geospatial method over another, many practice based studies emphasize the need to be flexible in the choice of methods and find methods that suit the context, stakeholder groups' capacities, objectives and stage of planning process (Aditya, 2010; Grant-Smith and Johnson, 2012; Haworth et al., 2016; Kahila-Tani et al., 2019; Sullivan-Wiley et al., 2019). In order to fulfill the various requirements and objectives of planning practice, the studies emphasize mixing of methods. Such as mixing simple and advanced geospatial technologies depending on the technological readiness of the participants and planning institution, choosing collaborative and individual mapping exercises to accommodate the needs of marginalized community members and the knowledge needs of the planning phase as well as supplementing the mapping exercises with non-spatial participatory tools to gain knowledge of for example rational behind land use decisions, limitations in land access, and gender roles in land use. In the light of our user perspective study, this requires that practitioners have sufficient knowledge of the various methods in order to choose between them and sufficient time for on-the-job reflection to assist in the choice and adaptation of PM methods in practice.

The participatory geospatial methods studied in the Tanzanian cases have been used in three different landscape and sociocultural contexts; highland farming communities, resource poor island communities, and diverse urban communities. Tanzania alone is a diverse country and the views of interviewed practitioners do not reflect the various sociocultural contexts in the country, where benefits and limitations of using the methods could be somewhat different. Moreover, the methods have not been institutionalized in all the studied cases, which limits the study of enabling factors for institutionalizing geospatial technologies. The observations, opinions and terminology of the interviewed practitioners are influenced also by their educational and professional backgrounds, the objective of the exercises they have been part of and their roles as GIS expert, field officer, trainer or researcher in the processes. Among the 12 interviewed practitioners we aimed to have a diverse set of professionals in order to gain understanding from different perspectives and we received insights also from the 33 practitioners who participated in the group discussion.

5. Conclusions

As far as our results indicate, Tanzania should be able to adopt PM methods that use high-resolution remote sensing imagery more widely in spatial planning and natural resource management processes. The need for their use is identified by the practitioners on the ground to enable higher spatial quality and more active community participation in decision-making. Poor ICT infrastructure, lack of geospatial skills among planning practitioners and exposure to technologies among citizens limit the methods' use currently. With the advances in geospatial technologies and infrastructure development these limitations are diminishing. Nevertheless, geospatial training and efforts to ensure that the participatory practices build local ownership of the mapping outputs and the planning process as a whole are needed. Similarly, wider adoption of PM methods in Tanzania requires institutional support for practitioners on the ground and commitment to participatory governance in general. The commitment to participatory governance influences also the level of inclusivity among community members and local process ownership granted to communities during PM exercises. Our study shows that the adoption of PM methods may be at odds with the organizational political system and political willingness while the methods themselves are suitable, accessible and beneficial to their users. The possible disincentives in the institutional practices or policies should be identified and removed, and PM developers should be aware of the incentive mechanisms of the planning and management organizations in order to tap onto them in method adoption.

The usability of the PM methods and data in planning processes can be increased by developing tools for data analyses and visualization that require less time and skills from the practitioners. Transdisciplinary teams of researchers and practitioners with understanding on implications of the given policy environment and organizational political culture will be best suited to develop methods adoptable to the prevailing organizational culture. Moreover, during method development interventions advocacy on the benefits of participatory decision-making and geospatial technologies is needed in order to inform policymakers and build their ownership of the new governance practices. This will increase the likelihood of institutional support and favorable future policy amendments such as the publication of a new planning guideline that incorporates one of the developed PM methods studied in this paper.

CRediT authorship contribution statement

Salla Eilola: Conceptualization, Investigation, Formal analysis, Writing - original draft, Writing - review & editing. **Niina Käyhkö**: Conceptualization, Writing - review & editing, Supervision, Funding acquisition. **Nora Fagerholm**: Conceptualization, Writing - review & editing, Supervision.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2021.105649.

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