Interpretation-based land cover mapping

Possibilities and challenges for rural land management

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Dissertation for the degree of philosophiae doctor (PhD)
at the University of Bergen

2016

Dissertation date: 19. February 2016

Year: 2016

Title: Interpretation-based land cover mapping:

Possibilities and challenges for rural land management

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Acknowledgements

I want to express great gratitude to my supervisors: Many thanks to Anders Lundberg for encouraging me to start this PhD work and supporting me in the challenging development of the project, and to Kerstin Potthoff for her genuine interest and strong support until the completion of this work. When I almost gave up on the project, the knowledge of her commitment and support encouraged me to carry on. I also want to thank Håvard Juliussen for his supervision, even though it was only for a brief period before his stay at the Department of Geography came to an end.

I greatly appreciate the cooperation of the Norwegian Forest and Landscape Institute, and I owe them many thanks for their invaluable interest, support and sharing of data. Without them, this research would not have been possible. A great many thanks as well to the informants in the municipalities where I conducted my fieldwork.

I also want to thank Knut Hidle, Tor Halvdan Aase and Eivind Dahl for their valuable comments on my manuscripts, and Kjell-Eivind Frøysa for the helpful methodological inputs.

Many thanks also to my three sons, Ivar, Rasmus and Olav. You have given me essential breaks from PhD work and invaluable perspectives on the important things in life.

Last but not least, thanks to Eivind for your love, encouragement and reliable and solid support.

Abstract

Interpretation-based land cover mapping: Possibilities and challenges for rural land management.

Land cover/use maps are often seen as a prerequisite for spatial decision-making processes. Those who have the power to settle land cover categories have an implicit power to imprint certain management regimes on the land. Although aspects of power are well known in cartography and geographic information science (GI science), an increased focus on participatory practices and legitimacy in spatial decision-making processes makes it relevant to draw attention to the power of knowledge inherent in the process of land cover/use map production.

This thesis builds on theory that establishes maps as knowledge-producing practices. Within such a framework, the focus is on how maps are made and remade in various ways (technically, socially and politically) as solutions to spatial problems by people within particular contexts and cultures. Elements from planning theory are used to underline the importance of maps and geographic information systems (GIS) as an essential foundation for spatial decision-making processes, public participation and legitimacy in land management and planning. Quantitative and qualitative methods are used to explore how technical, social and individual aspects influence and direct the knowledge-producing practice of map production, and how this influence creates implications for participatory practices in spatial decision-making processes.

The investigation was conducted with a Norwegian land cover dataset named AR5. AR5 forms an important basis for planning and farmland management in Norway. It consists of a discrete polygon coverage presented as an area class map. The dataset is subject to both a periodic and a continuous updating regime carried out by the national mapping agency and local municipalities, respectively. The study was mainly carried out in different municipalities of the county of Hordaland in

the western part of Norway, but for comparison, a study area from the county of Vestfold in the eastern part of the country was included.

The thesis consists of three papers:

Paper 1 is based on a quantitative GIS change analysis of the AR5 dataset. It explores and discusses technological and human factors that create challenges and opportunities for comparability and change detection. Results show that periodic updating provides unique possibilities for performing change analysis through GIS technology, but boundary uncertainty and closely related area classes challenge the interpretation and can lead to differences in mapping practice.

Paper 2, based on an ethnographic observation of a land cover mapping process, explores the social construction of a land cover map and discusses its implications for the use of GIS as a land management tool. Results show that interpreters from different social contexts classify land areas differently even if the same area class definitions are used. Different interests and needs contribute to this divergence of area classes and result in different mapping regimes. Dissimilarities are most evident when categories are ambiguous and transitions between categories are gradual.

Paper 3 is based on a quantitative GIS analysis that compares land cover map products covering the same area produced by five different skilled interpreters. It explores the variation in land cover classification due to individual interpreter assessment. The investigation shows that even if only one mapping regime is involved in a mapping process, the still needed individual assessments can challenge the comparability and consistency of the map product.

The results of the papers underline the need to create consciousness about the different interests in the map-producing process, the multiple purposes of a map product and the importance of who has the power to define land cover/use. Mapping reflects the values and judgements of individuals who construct the maps. It also creates knowledge about the land through selective stories. Mapping can therefore always be considered as being political, and access to spatial knowledge production creates power when mapping is used for land management and planning. The main argument of this thesis is that access to spatial knowledge production is required for increased participatory practices in land management and planning. According to a communication theory of power, dialogue and debate among the public are considered necessary to create conditions for legitimate spatial knowledge production representing the values and interests of citizens, thereby ensuring access to spatial knowledge production.

Increased public access to spatial knowledge production can be criticised as challenging the map product's consistency and verifiability. However, if increased public participation is achieved at a fundamental level in land cover/use map production, then increased participation can be achieved without challenging the consistency and verifiability of the map product. This increased participation in spatial knowledge production should concern the legitimacy of map standards, category definitions and the aim of the map product rather than the agreement over local land covers and borderlines.

List of publications

Straume, K. (2013). Monitoring Norwegian farmland loss through periodically updated land cover map data. *Norsk Geografisk Tidsskrift - Norwegian Journal of Geography, 67*(1), 36–48. doi:10.1080/00291951.2012.759616.

Straume, K. (2014). The social construction of a land cover map and its implications for geographical information systems (GIS) as a management tool. *Land Use Policy, 39*, 44–53. http://dx.doi.org/10.1016/j.landusepol.2014.03.007

Straume, K. (2014) Variation in land cover classification due to individual interpreter assessment: A case study of farmland mapping in Norway. Manuscript submitted for publication.

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PAPER 3. Variation in land cover classification due to individual interpreter assessment: A case study of farmland mapping in Norway. Manuscript submitted for publication.

1. Introduction

Maps provide a powerful and visual way to classify, represent and communicate complex information about land cover and land use. In recent decades, a growing amount of land cover/use information has become available as a result of new and effective mapping techniques. Such techniques are based on remote sensing technology, different degrees of automated computer interpretation and geographic information systems (GIS). These mapping techniques produce information that has become a precondition for policy making and land resource management (Dalal-Clayton & Dent, 2001).

Maps emerge through social and technical practices; therefore, it has been argued that they have no secure ontological status (Kitchin & Dodge, 2007). Maps are created and constructed by individuals and reflect the social context of these individuals. Maps produce and communicate knowledge about the world, and they have often been characterised as the product of a privileged and formalised knowledge. In this perspective, maps are both the products and producers of power (Harley, 1989; Kitchin & Dodge, 2007). Their power derives from the fact that maps are a practical form of information processing and a compelling form of rhetorical communication (Dodge, Perkins, & Kitchin, 2009). Classifying land will stimulate certain management regimes, and interpreters with the power to settle land cover classes will therefore have the power to impose a certain management regime (Robbins, 2001).

The communicative turn in planning has drawn attention to the claim that access to and control over map production play an important role in participatory practices in land management and planning (Corbett, Chapin, Gibson, & Rambaldi, 2009; Elwood, 2009; Healey, 1992; Innes, 1995). Indigenous mapping and public participation GIS (PPGIS) are examples of methodologies for the production of map data from a participatory perspective. In such a perspective, maps are not treated as objective preconditions for spatial decision-making processes but as context-dependent knowledge.

Aspects of power are well known in the field of cartography and GI science (see, e.g., Harris & Weiner, 1998; Hoeschele, 2000; Pavlovskaya, 2009). Nevertheless, the use of map data as a premise in spatial decision making, the increasing focus on participatory practices, and legitimacy in spatial decision-making processes underline the importance of drawing attention to the power of knowledge inherent in the process of map production. Attention should be given to the implications of using such map information in participatory decision-making processes. This can be achieved by understanding land cover/use maps as a set of context-dependent practices, which means considering the technical, social and individual aspects in the map production process and their influence on the map product. Adopting such an understanding of maps and map production opens up informed discussions of the possible impacts of map products on spatial decision-making processes.

1.1 Objective

This thesis aims to explore how technical, social and individual aspects influence and direct the knowledge-producing practice of map production, and how this influence creates implications for participatory practices in spatial decision-making processes such as in rural land management.

1.2 Research questions

The main research question of this study is: What challenges and possibilities do the production and application of interpretation-based land cover maps generate for spatial decision-making processes? This question is further specified trough the following three questions:

1. In what ways do technology, social context and individual assessment inform the processes of land cover/use mapping?

2. What are the implications of these ways of informing for use of the map product in spatial decision-making processes?

3. How can the map production process create possibilities and constraints for participation in spatial decision-making processes?

1.3 Structure of the thesis

The following section presents a theoretical framework 1) to frame maps as a knowledge-producing practice (dependent on the assessment of individual mappers, their social context and the available technology), 2) to elaborate on the power inherent in map production and 3) to explain the role that maps and map production play in participation in management and planning. Quantitative and qualitative methods were used in this thesis. The methods section presents the main methods (GIS analysis, observation and interviews) and discusses the advantages and disadvantages of combining different methods in the framework of this thesis. The results section presents results from the three papers (see page 6), focusing on how they answer the first and second research questions. The first part of the results section focuses on how technology, social context and individual assessment inform the processes of land cover/use mapping, while the second part focuses on implications for management and planning situations. The third research question regarding implications for decision-making processes is covered in the discussion section, which builds on the findings that answer research questions 1 and 2.

2. Theoretical framework

This section first conceptualises cartography and GIS, and then presents the philosophical aspects of cartography and maps to establish an understanding of maps as knowledge-producing practices. Finally, this section places maps and GIS within in a land management context using elements from planning theory. This provides a foundation for discussing of the implications of the production and application of interpretation-based land cover maps on spatial decision-making processes.

2.1 Conceptualising cartography and GIS

The modern discipline of cartography concerns the design, compilation and publication of maps. Computers are increasingly used to manage the acquisition, manipulation and display of geographic information on screen and have become the dominant technology of contemporary mapping (Dodge, Kitchin, & Perkins, 2011a; Goodchild, 2009). A GIS is a computer application concerned with the manipulation of geographic information, including the representation, analysis and visualisation of all information about the distribution of features and phenomena on the surface of the earth (Goodchild, 2009). There is clearly an overlap between the definitions of cartography and GIS, and the distinction between them is blurred (Goodchild, 2009). Cartography may be seen as necessary but not sufficient for GIS, where maps are only one form of expression of geographic information (Goodchild, 2000; Muehrcke, 2011). GIS technology goes beyond automated mapping, especially regarding how data are structured in databases (see Chrisman, 1997). Goodchild (2000) argued that in this new era of GIS, cartography is marginalised but needed more than ever because GIS technology empowers more and more people to make maps and creates an increasing need for good cartographic practice.

2.2 From objective truth to emergent practices

Since the Middle Ages, maps have been seen as objective, neutral products of science, where the surface of the earth is represented as faithfully as possible, with a direct association between the real-world phenomena and their cartographic representations on the map (Kitchin, Perkins, & Dodge, 2009). In this dominant perspective, the correctness of the representations is derived from the act of observation rather than from the social and cultural context in which the representations are embedded (Edney, 1993). The development within cartography is a story of progress based on the development of technologies and ever more precise maps. Numerous small technological advances have built up the discipline; therefore, the technological foundation of cartography is seen as crucial to understanding the contemporary nature of maps (Dodge et al., 2011a; Kitchin et al., 2009).

A general understanding of maps as objective knowledge is still found when maps are used and GIS are constructed for decision support in spatial management and planning contexts (Perkins, 2009). However, significant work has been done within the philosophical domain of cartography, discussing the ontological and epistemological aspects of maps and, more recently, the use and construction of GIS. Even though one can identify a development of philosophies in cartography from the late part of the 20th century and onwards, different philosophies continue to coexist and cross-fertilise one another (Perkins, 2009, p. 397). Mapping is regarded as both epistemological and deeply ontological because it is a way of thinking about the world (a framework of knowledge) and a set of assertions about the world itself (Kitchin et al., 2009).

Towards the end of the 20th century, cartography science was greatly influenced by Arthur Robson and his focus on effective maps that best portrayed information to the map reader (Robinson & Petchenik, 2011). This paradigm of cartography as a graphic communication science (communication approach) was adopted by the discipline of cartography in the 1970s. A central idea was that all maps have a predefined purpose. The goal was to convey or communicate the content selected to meet this purpose (MacEachren, 1995). The goal of cartographic communication was to produce a single best map that presented information clearly based on cognitive and psychological understandings of map use. The keywords of this single best map were clarity, accuracy and certainty, and a call for map design based on cognitive and perceptual research was created (Orford, 2005, p. 196; Robinson & Petchenik, 2011). The cultural and postmodern turn in geography has drawn attention to power relations inherent in this communication approach. The basic production rules for making the best map (with a focus on accuracy, clarity and certainty) are seen in cultural and postmodern geography as blurring aspects of the actual map-making activity, showing certain things and not including others.

Crampton (2001, p. 235) identified two developments that derive from the understanding that maps are 'unproblematic communication devices'. The first is the explorative practice of 'geographical visualisation' (representational approach); the second is the study of maps as power-knowledge practices, initiated by Harley (1989) (see further down). The representational approach was introduced in the early 1990s and proposed a more critical form of cartography. The rationale behind geographical visualisation is to 'see the unseen' in large and complex datasets. This is done by drawing pictures of the data using available computer technology (Orford, 2005). In this context, maps are recognised as knowledge-producing items that do not solely communicate information. The goal shifts from the search for an optimal map to the search for methods for spatial data abstractions that can help identify spatial patterns and lead to insight (MacEeachren & Ganter, 1990). The study of power-knowledge practices begun by Harley (1989, 1990) focused on understanding maps as socially constructed texts; therefore, it became important to be aware of the social context in which the mapping is performed. Harley (1989) encouraged what he termed an epistemological shift in how the nature of cartography should be understood, rooted in social theory rather than in scientific positivism.

According to Harley (1989, p. 14), 'the map is never the reality, it helps to create a different reality.' Harley argued that the map is not neutral but presents a subjective version of reality. Mapping is thus understood as an act of knowledge production rather than just knowledge revelation (Kitchin & Dodge, 2007). In this perspective, maps are seen as products of privileged and formalised knowledge facilitating governance by the powerful (Dodge, Kitchin, & Perkins, 2011b). Maps are therefore both products and producers of power (Harley, 1989). Harley used what he defined as a deconstructionist tactic and tried to decouple the link between reality and representation, which he claimed has dominated cartographic thinking. The deconstructionist perspective leads the user to read between the lines of the map, thus discovering the silences and contradictions in it.

Despite this shift towards social construction, there is still a 'landscape truth' embedded in the map, which can be revealed if one considers the ideology inherent in the representation (Crampton, 2002). Thus, the representational way of thinking about maps did not change until a post-representational perspective was introduced at the turn of the new millennium (Kitchin et al., 2011). Then, the focus shifted from what maps represent and mean to how maps work and what their effects are on the world. Corner (2011) argued for an understanding of maps as processes, in which mapping is seen as multiple processes of actions that affect the world. The power of maps lies not only in their capturing and presentation of data but also in their use and suggestion of new possibilities.

Kitchin and Dodge (2007) built on this post-representational turn and moved even further away from the representational approach by denying maps any ontological certainty as representations of reality. Like Corner (2011), they argued that cartography should be conceived as a processual science and that maps should be understood as a set of practices. Maps are theorised not as mirrors of nature (objective truth or socially constructed representations) but as emergent and oncogenic (constantly in a state of becoming) (Kitchin & Dodge, 2007). Maps can therefore be understood as relational and context dependent; they are never fully formed, and their work is never complete. This understanding of maps provides a way to critically consider the practices of cartography and not just the end product (the map). The important question is not what a map is (a spatial representation or performance) or what a map does (communicates spatial information), but how the map emerges (emergent cartography). The study of mapping practices is the study of how maps are made and remade in diverse ways (technically, socially and politically) as solutions to spatial problems by people within particular contexts and cultures. This focus theoretically bridges two sides of cartography: the map as applied knowledge (asking technical questions) and the map as power knowledge (asking ideological questions). Different methodologies can be applied to examine these practices as long as they are sensitive to the contextual nature of the studied practices (Kitchin & Dodge, 2007).

Similar developments to those within cartography can be found in the field of GIS. GIS began as a technological method to handle geographical data in Canada in the 1960s (Goodchild, 2009). In the 1990s, the positivistic claims dominating the discourse were criticised, and the neutrality of GIS products became part of the discussion (Kitchin & Dodge, 2007). GIS was criticised for encouraging rational planning in spatial decision-making processes rather than opening the decision process to participatory practices (Nyerges, 2009). PPGIS emerged as a reaction to critiques that GIS is unable to include the knowledge needs and priorities of a diverse range of social groups, and that GIS favours quantitative information produced by a limited group of skilled GIS persons (Elwood, 2009). PPGIS research has proposed that the definition, validation and use of spatial knowledge play a significant role in determining participation and power (Elwood, 2009). In recent GIS research, the notion of truth (focusing on accuracy and error) has been replaced by the concept of uncertainty and the relation between truth and power.

2.3 Maps, GIS and participation in spatial planning and management

Since the 15th century, cartography and planning have had a long and mutually influential relationship (Buisseret, 1998; Corner, 2011; Söderström, 1996). On the one hand, planning has contributed to the development of the cartographic discipline; on the other hand, the conceptualisation of land areas through maps is an integral part of spatial planning and a necessary tool to facilitate the move from social to spatial logic (Dühr, 2007; Söderström, 1996).

Planning theorists from the 1960s and early 1970s shared a faith in instrumental rationality. This instrumental rationality is based on a positivist ideal and puts spatial reasoning and scientific analysis at the core of planning. It assumes a direct relationship between the available information and the quality of planning and decision making based on this information (Innes, 1995). In the early 1990s, the communicative turn in the planning perspective evolved. This communicative rationality differs from an instrumental rationality by postulating an open and inclusive planning process focusing on public participation, dialogue, consensus building and conflict resolution (Healey, 1992; Innes, 1995).

Instrumental and communicative theories in planning are seen as competing perspectives. But map data is arguably relevant for both perspectives even though the type of data and the way in which the data are processed to obtain information differ. In an instrumental planning perspective, mapping is carried out as a quantitative and analytical survey that includes a range of relevant conditions such as economic and ecological values, social conditions and aesthetic aspects (Corner, 2011). The maps are intended to be taken as stable and accurate, mirroring the reality and thereby providing a basis for decision making. Such an understanding is based on trust in map data because it is regarded as quantitative and objective and therefore true (Corner, 2011; Giddens, 1994; Porter, 1995). The maps thus create legitimacy. Mapping typically precedes planning because it is assumed that the map will objectively reveal and identify the terms around which a planning project may be rationally developed (Corner, 2011; Scott, 1998; Söderström, 1996). In the communicative planning perspective, map data is understood as socially constructed and context dependent. Access to and control over the production of map data used in the decision-making process can be argued to play an important role in participation because maps produce knowledge of the land and therefore what to decide on. In this respect, access to and control over the production of map data are also highly relevant to land management.

Both indigenous mapping and PPGIS are theoretical and methodological contributions aiming to provide access to knowledge production in planning and management for all parties involved. Contributions from indigenous land-related knowledge in land use planning and decision making represented a shift in cartography from the notion that mapping only reflects the interests of the powerful (Corbett et al., 2009). Along with the communicative turn in planning, PPGIS came to the GIS community from the planning profession (Obermeyer, 1998) and positioned GIS within participatory research and planning (Craig, Harris, & Weiner, 2002). Such methodologies open up participation in knowledge production through participation in the definition of land, thereby providing opportunities for power sharing in land management and planning processes where land maps are used.

3. Methodology

Several methods can be applied to study the practices of map production. GIS-based change analyses were carried out to investigate the impact of technology and technological restrictions on map production. Overlay analyses were conducted based on existing land cover map data from different points in time, and various analyses were used to investigate the uncertainty of the resulting land cover changes. To investigate the impact of the social context on the map product, an ethnographic method with observation and participation in different mapping contexts was used. Findings were further explored through semi-structured interviews with key informants. To investigate the impact of individual assessments on the map product, GIS-based overlay analyses were carried out based on data produced by several professional and calibrated interpreters interpreting the same remotely sensed image. Several analyses based on the overlays were performed to explore the differences between the map products.

In the following sections, I will present three aspects central to the methods used in this PhD project. Most of the aspects are touched upon in the papers but will be presented more thoroughly in these sections. Section 3.1 presents the important aspects of combining qualitative and quantitative methods. Section 3.2 reviews ethnography and grounded theory. Section 3.3 outlines the basics of the GIS analyses.

3.1 Combining quantitative and qualitative methods

Cartography and GIS, and therefore map production, have long been rooted in a technological and quantitative approach where accuracy and data quality have been the central themes of discussion. More recently, this focus has expanded to aspects of uncertainty and the influence of the social context on map production. GIS has increasingly been positioned within a qualitative research approach (see Section 2.2). Elwood and Cope (2009) promoted this through a multi-dimensional understanding of GIS as technology, methodology and situated social practice. A qualitative approach to GIS has many entrances; one is that the spatial data in GIS are representations of characteristics of a complex ‘real world’. When characteristics are translated into measurements and categorisations, contextual and qualitative information is no longer visible. Such contextual information is imperative for understanding how spatial data can or should be applied to inform policy decisions and management (Cope & Elwood, 2009; Schuurman, 2009). Therefore, both quantitative and qualitative methods/approaches are needed to investigate factors influencing the mapping process and to understand their impact when the map product is used for management and planning purposes. This combination or integration of methods is in line with traditions within geographical research (McKendrick, 1999).

In the literature, such a combination or integration is often presented as a mixed-methods or multi-strategy approach (Bryman, 2006). Grimsrud (2012) identified three levels of mixed methods in the literature. The first level includes all studies using more than one method. The second level includes projects that mix qualitative and quantitative methods. The third level is restricted to projects that use the complementarity of qualitative and quantitative methodologies as a research advantage and that include results from both methodologies in the conclusion. In the papers that are part of this thesis, either qualitative or quantitative methods are used. Paper 1 is primarily based on a quantitative GIS overlay analysis of existing map data. Paper 2 is primarily based on qualitative ethnographic methods with observation of field verifications, while Paper 3 is based on quantitative GIS overlays of collected map work from qualified interpreters. The PhD project as a whole uses the results from all three papers, taking advantage of quantitative and qualitative methods. Therefore, the PhD project can be placed at Grimsrud’s third level of mixed methods. Both quantitative and qualitative methods are used to generate the results necessary for a broader discussion and for answering the third research question.

The mixing of methods requires knowledge of both quantitative and qualitative methods. A disadvantage of applying different methods is that there is less room for a thorough treatment of each method. In addition, it can be more time consuming. Nevertheless, in light of the research questions and advantages mentioned above, combining methods is considered a strength and necessity in this project, outweighing potential disadvantages.

3.2 Ethnography

Ethnographic methods can be defined as the researchers' observation of events and phenomena in their natural context and the researchers' attempt to catch the informants' understanding of these events and phenomena (Aase & Fossåskaret, 2014). Ethnographic methods are a methodological and practice-based approach. They were adopted by human geographers in the 1970s as a reaction to the lack of concern for people's everyday experiences (Till, 2009). The purpose of ethnographic methods is to understand parts of the world as they are experienced and understood in people's everyday lives (Crang & Cook, 2007; Till, 2009). In the map-producing context, this can be translated into a data-gathering/creating process, where the aim is to collect information on, and build an understanding of, the mapmakers' social context. Data are interpreted to obtain insight into how differing social contexts, constituted by interests and needs, among other factors, influence the mapmakers' interpretations and mapping work.

3.2.1 Participant observation

Observation is central to an ethnographic approach. In the literature, a clear difference between observation and participant observation can be found (Aase & Fossåskaret, 2014). While observation refers to the collection of objective data through a detached researcher, participant observation aims to 'learn about a particular socio-cultural space and those who inhabit it by taking part and continually reflecting on what is happening' (Walsh, 2009, p. 77). Aase and Fossåskaret (2014) presented the difference between observation and participant observation as illustrative of the separation between quantitative and qualitative methods. In a quantitative method, the researcher engages only indirectly in the processes observed through, for example, statistics or surveys. In a qualitative research process, on the other hand, the researcher must participate in the processes being studied. Participant observation is therefore done by involvement or participation in the studied process. The core of the qualitative method is said to be based on an interaction perspective (*samhandlingsperspektiv*), which requires a connection between observation and participation. According to Thuen (1997, p. 278), it is through involvement with people and their different tasks that one can grasp their purposes, requests and values and thereby take part in their consideration and interpretation of events and shifting relations.

Crang and Cook (2007) claimed that it is a task for all researchers to recognise and come to terms with their partiality and situated 'subjectivity' rather than try to achieve an impossibly distanced objectivity. They stated that the 'ability to engage with, rather than withdraw from, this "real world" messiness is seen as perhaps the most valuable contribution ethnographic research can make' (Crang & Cook, 2007, p. 11). Subjectivity and engagement in the field can be seen as a resource for deeper understanding rather than as a problem for objective research.

Participation in field mapping/verifications and the participant observation of a mapping course were carried out in this project to grasp the informants' social contexts and to understand how their social contexts influence their mapping work. During field mapping/verifications and the mapping course, I observed, participated in and facilitated discussions. For example, when representatives from local and national institutions disagreed on the classification (fully cultivated or surface cultivated) of a specific area, I took part in the discussions by asking questions to explore this variation. Additional aspects were brought up in the joint discussions when not taken up by the informants, such as issues related to gradual transitions and ambiguous categories. This was done to further explore disagreements on interpretations at different locations. Discussions during field verifications were recorded to enable analyses of audio files at the office. Important words and groups of words found in the recordings were coded and grouped into analytical categories according to a grounded theory approach (see Section 3.3.)

Participant observation is often described as a time-intensive research practice. In this PhD research, the observations were limited to three days in the field. Although this may be regarded as an inadequate time span for participant observation, saturation was still achieved (see Dey, 2004; Strauss & Corbin, 1990).

3.2.2 Interviews

Ethnography can be understood as a research strategy rather than a specific methodology, including several methods, analytical tools and theoretical perspectives (Till, 2009; Watson & Till, 2010). In this respect, interviews as a method may be part of an ethnographic strategy.

In this PhD project, semi-structured telephone interviews were used to follow up observations of the mapping course. Longhurst (2009, p. 580) defined in-depth, semi-structured interviews as 'verbal interchanges where one person, the interviewer, attempts to obtain information from another person by asking questions'. One of the strengths of interviews is that they provide an opportunity to investigate complex behaviour and motivations and to collect a diversity of meanings (Longhurst, 2010; McDowell, 2010; Rapley, 2004). In this project, the interviews offered an opportunity to verify and enhance understanding of the course observations. During the mapping course, informants were observed in a larger group. Afterwards, telephone interviews were conducted to enable individual communication with selected participants. Telephone interviews were preferred due to the efficiency of data collection and were regarded as a full replacement for face-to-face interviews. Communication was facilitated since informants had already been introduced to the research project during the course observation. The interviews were pre-structured but provided the opportunity for informants to reflect freely on subjects related to the mapping work.

3.3 Grounded theory approach

Research results need to be verifiable and cannot simply be random interpretations (Aase & Fossåskaret, 2014). When a large and overwhelming amount of data is collected or created during ethnographic fieldwork, a coding framework as found in the grounded theory (GT) approach is a valuable tool to achieve verifiable interpretations. Important words and groups of words (or phenomena) are coded and then grouped into analytical categories. This work is performed until theoretical saturation. Such saturation is achieved when new data fit into already existing categories and these categories are sufficiently explained (Briks & Mills, 2011).

The basis for a GT approach is proximity to the empirical data. GT was first introduced by Glaser and Strauss (1967) in *The Discovery of Grounded Theory*. GT is rooted in American pragmatism and developed in the late 1960s (Vassenden, 2008). In an environment where positivism guided most social research, Glaser and Strauss were inspired by the pragmatism of Charles Saunders Peirce (1839–1914). Peirce rejected the claim that scientific truth reflected an independent external reality; he argued that scientific truth was a result of observation and a consensus among observers regarding their interpretation of what they had observed (Suddaby, 2006). Glaser and Strauss observed a large gap between empirical data and theory in sociology and sought for a better integration of the two. They aimed to create room for developing theory from a bottom-up perspective. Their main idea was that theory is discovered through the empirical data as the theory becomes grounded in the empirical data (Vassenden, 2008). The GT methodology has evolved since its first presentation; today, there are several interpretations of the GT approach.

Because of its bottom-up approach, GT has been criticised for being an inductive methodology (Marvasti, 2003; Reichertz, 2010). The criticisms are directed towards GT's assumption that theories emerge without any previous theoretical input. Such an understanding can be linked to the early GT approach. Later, GT split into two directions (Reichertz, 2010). While Glaser (1992) continued to insist that the theory emerges directly from the data, Strauss (1987) and Strauss and Corbin (1990) argued that theoretical pre-knowledge flows into the data interpretation. In this later GT version, the observation and development of theory are always theory guided. As Kelle (2005, p. 41) stated, 'an open mind does not mean an empty head'. The use of GT in this PhD project is in line with this later GT. Here, pre-knowledge is used to aid the construction of a theoretical framework. The important ideas are found in the data, and then analysis and theorising are conducted and, when necessary, further modified due to observation (see Coffey & Atkinson, 1996).

3.4 Quantitative GIS analyses

The quantitative GIS analyses in Papers 1 and 3 were conducted using ESRI's ArcGIS, QGIS and Map Comparison Kit (MCK) software.[1] The analyses consisted of selected overlays (union and combine) (Burrough & McDonnell, 1998; Chrisman, 1997). Basic overlay analysis is a traditional form of geographical analysis, but with GIS, it can map and analyse large quantities of data (Fazal, 2008). In this PhD project, map data (layers) with different attributes were overlaid with each other, and new layers were created with attributes from all the input layers (Figure 1).

[1] QGIS and MCK are freeware that can be downloaded from https://www.qgis.org/en/site/forusers/download.html and http://mck.riks.nl/, respectively.

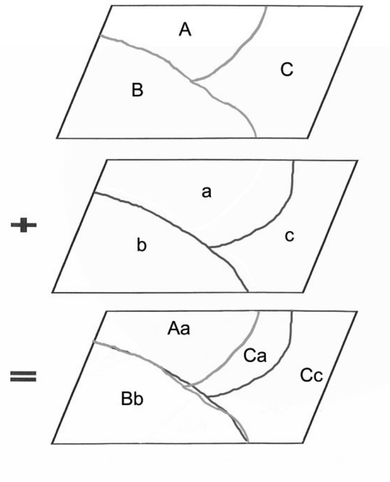

Figure 1. Overlay/change analysis (Ca = change)

Land cover interpretation from aerial photographs has a central role in studies of land change (Ihse, 1995; Ihse & Lewan, 1986; Skånes, 1990; Skånes & Bunce, 1997). When two categorical coverages of the same region are available for two different times, an overlay operation in GIS can detect the changes that have occurred (Figure 1). A similar operation can be conducted with datasets from the same area but interpreted by different interpreters. In this case, agreement and disagreement between the interpreters' classifications can be identified. The agreement can be assessed by rasterising the interpreted data and combining the two interpreted datasets. Cross-tabulations can then be used to explore the site-specific correspondence pixel by pixel between any two maps. In accuracy assessment, which is based on the comparison of an interpreted dataset and a reference dataset (the 'gold standard', Olofsson et al., 2014, p. 50), cross-tabulations are known as error matrices or transition matrices (Congalton, 1991; Congalton & Green, 2008) (Table 1). Overall accuracy, producer's accuracy and kappa statistics are used to quantify the error matrix (Congalton, 1991). To avoid confusion with accuracy assessment, the concepts of 'overall agreement', 'class agreement' and 'kappa agreement' are used to quantify agreement/disagreement between two interpreted datasets. These measurements are calculated in the same way as 'overall accuracy', 'producer's accuracy' and 'kappa' (Table 1).

Table 1. Transition matrix: Illustration with three types of classes (1, 2 and k)

		Reference data j = **columns**			**Row total**
		1	**2**	**k**	$\mathbf{n_{i+}}$
Classification data i = **rows**	**1**	n_{11}	n_{12}	n_{1k}	n_{1+}
	2	n_{21}	n_{22}	n_{2k}	n_{2+}
	k	n_{k1}	n_{k2}	n_{kk}	n_{k+}
Column total	$\mathbf{n_{+j}}$	n_{+1}	n_{+2}	n_{+k}	n

Source: *(Congalton & Green, 2008, p. 60)*

$$Overall\ accuracy = \frac{\sum_{i=1}^{k} n_{ii}}{n} \quad (1)$$

$$Producer's\ accuracy\ for\ class\ \mathrm{j} = \frac{n_{jj}}{n_{+j}} \quad (2)$$

$$User's\ accuracy\ for\ class\ \mathrm{i} = \frac{n_{ii}}{n_{i+}} \quad (3)$$

$$\mathrm{K\ (kappa)} = \frac{n \sum_{i=1}^{k} n_{ii} - \sum_{i=1}^{k} n_{+i} n_{i+}}{n^2 - \sum_{i=1}^{k} n_{+i}\, n_{i+}} \ \text{or}$$

$$K = \frac{probability\ of\ correct\ classification - probability\ of\ chance\ agreement}{1 - probability\ of\ chance\ agreement} \quad (4)$$

Boundary areas are often compounded with large uncertainties because of gradual transitions in a 'fuzzy' land cover. Gradual transitions occur, for example, in the transition between pasture and forest, where it is very difficult to identify the exact boundary between these two area classes. Fuzzy kappa is calculated to take into account that pairs of pixels are not solely equal or unequal but that there are grades of similarity between them (Hagen, 2003; Research Institute for Knowledge Systems [RIKS], 2003). Comparison is done by representing each pixel partly by attributes from pixels in its neighbourhood. Each pixel can then be a partial fraction of several categories depending on the classifications of its neighbours. The similarity of pixels in the compared maps is expressed as a value between 0 (distinct) and 1 (identical) (RIKS, 2003).

4. Case (data and study areas)

4.1 AR5 (Arealressurs kart 1:5000)

To explore the practices of map production, this PhD project used the AR5 dataset. According to Bjørdal and Bjørkelo (2006, p. 3),

> AR5 is a national (for Norway) land capability classification system and map dataset that describes land resources, with emphasis on capability for agriculture and natural plant production. The dataset is primarily intended for land use planning, public management, agriculture and forestry.

The dataset gives a discrete polygon coverage, presented as an area class map. Classes included are fully cultivated land, surface-cultivated land, pasture, developed/built-up land, forest, bog, open land, water and communications/transport network area (for class definitions, see Table 1 in Paper 1). The dataset is updated periodically based on orthophoto interpretation by the Norwegian Landscape and Forest Institute. It is also mandatory for local municipalities to update the dataset continually between these periodic updates through fieldwork and/or local knowledge supported by orthophoto interpretation.

The initial reason for updating the database was to provide a satisfactory basis for calculating land payments (Landbruks-og Matdepartementet, 2009). Land payments (*arealtilskudd*) are available for farmland in use (*jordbruksareal i drift*) classified as fully cultivated land, surface-cultivated land or pasture. The payments are quite important for the farm economy. Their calculation is based on land use; thus, there is a need for reliable information on land use. However, a focus on land cover rather than land use has been introduced in the AR5 database because the abandonment, reassigning and restructuring of farmland causes large and rapid land changes. Therefore, the land cover map must be updated for monitoring purposes. The national authorities focus on land cover rather than land use, and the national mapping guidelines convey that land cover (*arealtilstand*), and not land use (*arealbruk*), should be the decisive factor for area classifications (Bjørdal & Bjørkelo, 2006).

4.2 Study areas

The study was mainly carried out in different municipalities of the county of Hordaland in the western part of Norway (Figure 1, Paper 1; Figure 2, Paper 2; Figure 1, Paper 3). This county experiences large and rapid changes in land cover as a result of changes in land use. The county has traditionally been a sheep-dominated farming region and is characterised by small farms and large areas of rough grazing land (Refsgaard & Prestegard, 2008). Farmland occupies 31.4% of the total area in the region; of this, 13.1% are fully cultivated, 5.6% are surface cultivated and 12.7% are pasture areas (Strand & Eriksen, 2008).

For comparison purposes, a study area in the county of Vestfold in the eastern part of the country was included (Figure 1, Paper 3). This eastern region is characterised by larger fields and farms and less rapid change in land cover.

In recent decades, there has been a clear structural change in Norwegian agricultural production towards fewer and larger farms (Statistics Norway, 2015). In the western region of Norway, the decline in the number of farms has been relatively large (Statistics Norway, 2014a). Although the total farmland in use is relatively stable, farmland is often abandoned or reassigned to other purposes (Grønningssæter, Halse, & Aurbakken, 2007). Since 1999, Hordaland has had the second largest relative loss of farmland in use in Norway (Statistics Norway, 2014b).

5. Results

The process of manual land cover/use mapping is dependent on the available technology, social context and individual interpreter assessment. The three papers in this PhD thesis explore these aspects of the land mapping process and investigate the implications of this dependence on using the map product in land management tasks.

Paper 1, ‘Monitoring Norwegian farmland loss through periodically updated land cover map data’, explores to which extent the periodic updating of a land cover map (AR5)satisfy the need to monitor farmland loss in management and planning situations. The paper explores and discusses technological and human factors creating challenges and opportunities for comparability and change detection. Paper 2, ‘The social construction of a land cover map and its implications for geographical information systems (GIS) as a management tool’, explains the social construction of a land cover map and discusses the implications of such process for the use of GIS in land management. Paper 3, ‘Variation in land cover classification due to individual interpreter assessment: A case study of farmland mapping in Norway’, explores the effect of individual assessment on the map production process.

The results are organised according to how they provide answers to research questions 1 and 2 in Section 1.2.

5.1 Technology, social context and individual assessment inform the processes of land cover/use mapping

5.1.1 Technology informs the mapping process (Paper 1)

The periodic updating of land cover/use data through the interpretation of orthophotos makes it possible to update data frequently for large geographical areas. When updated versions of a dataset exist for two (or more) different times, an overlay analysis can be conducted to detect the changes that occurred between the two periods. In this paper, overlay analyses were performed for two different municipalities, detecting differences in the datasets, which occurred over 9 and 13 years, respectively. Uncertainty assessment is necessary to explore whether differences in the datasets express land cover change or differences in mapping practices.

The results of Paper 1 show that the periodic updating of the AR5 land cover data provides unique opportunities to perform change analysis using GIS technology. Uncertainty assessment shows that the mapping results are challenged by boundary uncertainties and closely related area classes. Further uncertainty studies and exploration of uncertainty modelling is however necessary to understand uncertainty. This is especially important where transitions are vague and categories are ambiguous, such as during ongoing regrowth processes or in areas where fields are small and fragmented and therefore contain a relatively large amount of boundary areas. In these situations, human assessment is very much needed and can lead to differences in mapping practice.

5.1.2 Social context informs the mapping process (Paper 2)

Administrative units with deviating interests and needs represent different social contexts. In the mapping process studied in Paper 2, local municipalities and the national mapping agency were involved. The results show that deviating interests and needs may contribute to different interpretations of area classes, and result in different mapping regimes even if the same area class definitions are used by all involved. The results further show that differences in mapping regimes are most evident when categories are ambiguous and transitions are gradual.

A bottom-up perspective was apparent in the local mappers' focus on the farmers' interests and needs and in the local mappers' interest in maintaining local farming activity. Local managers are influenced by the local farmers' experiential categories, which embody the experiences of their 'lifeworlds' (Habermas, 1987);

therefore, they tend to map land use rather than land cover even if the latter is the stated classification criterion.

At the national level, the social context that informs the mapping process is focused on expert knowledge of field and orthophoto registrations, and it gives managers a top-down perspective of the mapping process. To a large extent, the national representatives apply experiential categories that are analytic. Unlike the farmers' categories, these categories are not created by lifeworlds formed through direct use of the land but through analytic experience in an administrative context. In this situation, the national level focuses strictly on following the stated area class definitions and the practice of mapping land cover, not land use. This focus is then legitimated by the need for expert knowledge to produce an objective map fulfilling monitoring purposes.

When different interpreters from different social contexts interpret the same land cover/use but label it with different land cover/use classes, this can challenge the consistency and comparability of the map product across time and space.

5.1.3 Individual assessment informs the mapping process (Paper 3)

Large mapping projects that rely on manual interpretation usually involve several interpreters. Even if only one mapping regime is involved in the mapping process, variations in land cover classification due to individual interpreter assessment can challenge the comparability and consistency of the map product.

Paper 3 explores the map results of five different expert mappers from the Norwegian Forest and Landscape Institute who mapped the same area in two different study areas. The results show that land cover classification varied among the interpreters. The greatest challenges were found in connection with closely related area classes, but boundaries between categories with gradual transitions also contributed to differences. Individual differences among interpreters increased when pairs of closely related classes were present, e.g., fully cultivated/surface cultivated, pasture/forest, open land/pasture, and when the study area became more complex with smaller patches and more boundaries. The map product is calibrated through regular training of mappers and control procedures of their map product. This will reduce differences among mappers; however, a total calibration of map products excluding all differences is not possible as long as mapping is dependent on individual interpreters.

5.2 Implications for using the map product in spatial decision-making processes

The explored aspects of the mapping process are important not only for the construction of the map product but also for the use of the map product in land management.

5.2.1 Technology and implications for management (Paper 1)

The results from Paper 1 show that the periodic updating of the AR5 land resource data provides unique possibilities for monitoring projects with large datasets, which in turn can inform land management. Although uncertainties are present, the data form a valuable contribution to the study of farmland dynamics and monitoring farmland change. The analysis sheds light on spatially ongoing transformation processes and puts them into perspective. Norwegian farmland protection policy has been focused on the decrease in farmland through processes regarded as irreversible, i.e., decrease through development (Syrstad et al., 2008). However, the results show that the decrease in farmland through reversible processes is far more important than the decrease through irreversible processes. This result calls for an extended farmland protection policy with a larger focus on protecting cultivable land in addition to cultivated land.

5.2.2 Social context and implications for management (Paper 2)

Results from Paper 2 show that the involvement of different mapping regimes embedded in different social contexts has an influence on the map product. This in turn has practical implications for the use of GIS as a land management tool in general. Inconsistencies in map products can create challenges in carrying out land management tasks such as monitoring farmland loss due to land use change or consistent allocation of land payments.

Many of the disagreements regarding the mapping process and its results are related to the political purpose of the AR5, or more precisely, to its multiple purposes. From its initial purpose as a tool for land use policy (assigning and controlling land payments), the AR5 has become a tool for monitoring national farmland resources. The results reveal a clear distinction between local-level interests, which seem to reflect the initial purpose of land use mapping, and national-level interests, which embody the land cover perspective. The study reveals the need to create consciousness about these conflicting interests and about the importance of who has the power to define land cover/use.

The state authority has delegated the mapping responsibility to the national mapping agency. The national mapping agency has produced mapping guidelines, and it performs the periodic updating of datasets with expert orthophoto interpreters and fieldworkers. The local level is responsible for continually updating the dataset when changes occur in between periodic updates, but the mapping agency still has a control over local-level mapping work. During the periodic updating, the local level is consulted if the mapping agency lacks information about the land cover. But when disagreements occur, the experts have the authority to decide on the classification; thereby, they also have the power of land cover knowledge production.

Rather than regarding the presence of more than one mapping regime as a problem for producing comparable and consistent maps for land management purposes, it can be seen as an opportunity for power sharing. Such power sharing by including both mapping regimes can be an important foundation for participatory practices in land management and planning.

5.2.3 Individual assessment and implications for management (Paper 3)

Manual interpretation allowing human reasoning is considered essential when map data are used for management purposes, because human reasoning allows spatial assessment based on field observations, pattern recognition and the integration of expert knowledge (Sirén & Brondizio, 2009). The results of Paper 3 show that land cover classification varied among the interpreters. The challenges were greatest in the most complex and fragmented study area, where consistent mapping is crucial because of rapid land cover changes.

Due to gradual transitions, such as between forest and pasture, not all the interpretations that lacked consensus among interpreters were of equal severity with respect to actual ground conditions. However, mapping results are vital to farmland management, such as the allocation of land payments, and therefore to the single farm economies. For instance, payments are given for pasture areas but not for forest areas.

Paper 3 revealed differences between the individual interpreters' map results. Perfect agreement between different interpreters is impossible to achieve. However, extensive training of the interpreters, provision of adequate support data and good communication between the involved interpreters are critically important tools to improve the results, thereby ensuring more uniform interpretations.

6. Discussion and conclusions

The results show that technology, social context and individual assessment have an impact on the map product and important implications for land management. Monitoring purposes are challenged by the consistency and comparability of the map product; however, the periodic mapping of land cover/use reveals the need for an extended farmland protection focus. The results also show that GIS as a management tool is challenged by power aspects inherent in the map product. The land cover/use map is influenced by who has the power to define the purpose of the map production and to settle the land cover/use categories. This has a direct impact on land payments and in turn on the farm economy. The latter is further affected by challenges of consistency created by necessary individual interpreter assessments during map production.

The following discussion focuses on two main issues: First, based on the results presented in the previous section, maps are explained as a knowledge-producing practice and the inherent power relations in maps and map production are discussed (Sections 6.1 and 6.2). Second, drawing on aspects of planning theory and participatory mapping, the ways in which the map production process creates opportunities and constraints for participation in spatial decision-making processes are discussed (Section 6.3).

6.1 The map as a knowledge-producing practice

The results show that the process of mapping creates knowledge (see also Harley, 1989; MacEachren, 1995). When land categories are settled, decisions regarding boundaries and types of categories construct knowledge about the land. Many subjective decisions must be made about what to include and what to exclude (Kitchin & Dodge, 2007; MacEachren, 1995). Clear-cut categories and borderlines between categories are imposed on the land, and mappings reflect the values and judgements of the individuals (and their professional environment) who construct the maps. Such reflection of individual values and judgements considers the interpretation of remotely sensed images and mapping in the field. Individual assessment is necessary, especially in cases of gradual transitions and ambiguous categories. Even though mappers are trained professionals, maps are always interpretations. Moreover, discussions among mappers show that map production is influenced by and dependent on the map producers' social context. The producers' interests, needs and purposes of mapping direct their work.

In addition, technology plays an important role in knowledge production. The development of remote sensing technology has contributed to the rapidly growing availability of updated map data. Technology influences the possibilities for mapping large areas, comparing results and keeping results up to date. It also enables the increasing availability of map data through a diversity of GIS applications and web access possibilities for non-experts. In this way, the mapping result is made available to a large audience, which is also the case for AR5. Technology further informs knowledge production through what is possible to detect on remotely sensed images. A variety of automated interpretation methods are available, but for management purposes, it could be argued that human assessment is required. Even though land cover/use seldom fit into clear-cut categories but are best illustrated as gradual transitions (fuzzy logic), categorical data are needed for management and planning (Richards, 2013; see Paper 3).

6.2 The power of map production

Harley (1989) argued that all mappings are laden with power. Since they produce knowledge about the world, maps are the products and producers of power (Kitchin & Dodge, 2007). Harley built on the work of Foucault, who observed that there is no way to escape the aspect of power in knowledge production (Harley, 1989; Kitchin & Dodge, 2007). By acknowledging maps as a form of power knowledge, ideological questions also need to be discussed (Kitchin & Dodge, 2007). The power of the mapmaker is not generally exercised over individuals but over the knowledge of the world made available to people in general (Rød, 2002). Maps present selective stories; we map what we value, and we value what we map

(Kitchin & Dodge, 2007; Nyerges & Jankowski, 2010). From this perspective, maps are always political, working to produce and/or reproduce thinking about the world (Kitchin et al., 2011). Therefore, an important question is 'Whose story?' Who has the power to define and settle the land cover/use category and its surrounding borderlines?

In Norway the political power to decide which knowledge is created (through the power to decide on land cover categories) is delegated by the state authority (the Department of Agriculture and Food) to the national mapping agency. The national mapping agency produced the mapping guidelines and holds the mapping expertise. Local managers are consulted if the national agency lacks information to settle a land cover category. Although the national mapping agency is open to input from local managers and indirectly from local farmers, it is the agency that settles boundaries and land cover classes, as well as defines the content of these classes when disagreements occur. Furthermore, the mapping agency works as a controlling administrator of local mapping practices. Thus, even though there is room for the local level to influence knowledge production, the power of mapping is held by mapping experts at the national level to secure objectivity, stability and comparability. In this respect, the map-producing agency can be seen as an epistemic community (Haas, 1992), a network of professionals with recognised expertise and competence in the map-producing domain, with an authoritative claim to policy-relevant land cover/use knowledge.

6.3 Participatory map production

Map data has become a prerequisite for spatial decision making in planning and management. By defining land cover/use and borderlines, the map has the power to impose a certain management regime on the land and therefore plays an important role in the valuation of land. For example, land payments are available only to land classified as fully cultivated, surface cultivated or pasture. When agricultural property is evaluated for sale, fully cultivated land is considered more valuable than surface-cultivated land. Another example is that cultivated land is protected by law (The Norwegian Land Act of 1995, Section 9) against land use changes that do not promote agricultural production (Ministry of Agriculture and Food, 1995). In such ways, the definition of land cover/use influences peoples' opportunities and constraints regarding land use. It can therefore be argued that local land managers' access to spatial knowledge production (participation in the definition and validation of land use/cover) plays a significant role in creating the legitimacy of land management and planning tasks (see Elwood, 2009; McCall, 2003).

Recent participation in planning theory has been characterised by the recognition of planning as a politicised task and by the assumption of political plurality among those involved (Lane, 2005). Participation is seen not only as an adjunct to planning but also as a fundamental element in planning and decision making (Lane, 2005). The ladder of participation adopted in PPGIS research from planning theory (Arnstein, 1969) and then further developed (Elwood, 2009; McCall & Dunn, 2012) has been used to illustrate the range from small to large (public) participation in planning practice. Here it is used to illustrate participation in the map production process. A small degree of participation is characterised by a top-down process, where the mapping and definition of what to map is performed by national experts. A large degree of participation can be illustrated with a bottom-up process, where the local managers perform the mapping and define what to map. McCall and Dunn (2012) identified four stages in such a ladder (see Figure 2): Stage 1, information sharing, implies two-way communication between outsiders (experts) and insiders (local managers), primarily to gather information. The topics are predefined by the outside agency, but a small degree of participation in the map-making process is necessary to extract people's data about their land. Stage 2, consultation, implies that the outside agency refers selected issues to the local manager for refinement or prioritisation, but the outside agency predefines the problems before consultation and holds the controlling function. Stage 3 entails involvement in decision making by all actors; outsiders and insiders jointly identify priorities and select alternatives. Participation is seen as a right and not just as a means to achieve a predefined goal. This stage implies joint mapping. Stage 4, initiating actions, implies independent local mapping initiatives—mapping projects started and owned by the local level, where local people possess full control over the mapping process.

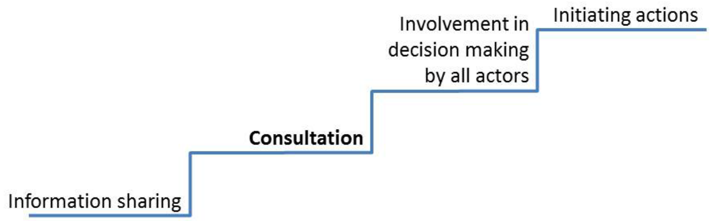

Figure 2. Stages of participation in the map production process (adapted from McCall & Dunn, 2012)

The degree of participation in the production of AR5 can be placed at Stage 2 of McCall and Dunn's ladder. The local level is consulted when the national agency needs support, but the mapping project and priorities are predefined by the agency. Increased participation/democratisation of the map production process, i.e., moving to Stage 3, would imply larger involvement of local knowledge. However, it is important to remember that 'A ladder does not imply that participation should strive always for the maximum intensity, but the intensity should be appropriate to the tasks, competencies and specific relationships between actors' (McCall & Dunn, 2012, p. 83).

In map production, local knowledge is traditionally labelled 'experienced' and 'qualitative' and regarded as less valuable than expert knowledge, which is seen as objective, quantitative and therefore verifiable (see Elwood, 2009). This preference for expert knowledge is also found at the national level in the AR5 mapping project; expert knowledge is considered a requirement to safeguard objective, verifiable and comparable results needed for land cover monitoring purposes. This perspective seems to make it challenging to shift the mapping process towards participatory map production.

To engage participatory knowledge in map production, it can be productive to go beyond the dichotomy of experienced local (soft) and objective expert (hard) knowledge and focus on knowledge as context dependent and socially constructed. In principle, a clear divide between soft and hard knowledge does not exist (see Agrawal, 1995). This study shows that necessary assessments guide the creation of both expert knowledge and local knowledge, especially where categories are ambiguous and transitions are gradual. Thus, as Wood and Fels (2008) argued, maps are propositions, and categories and borderlines should be open to discussion and debate.

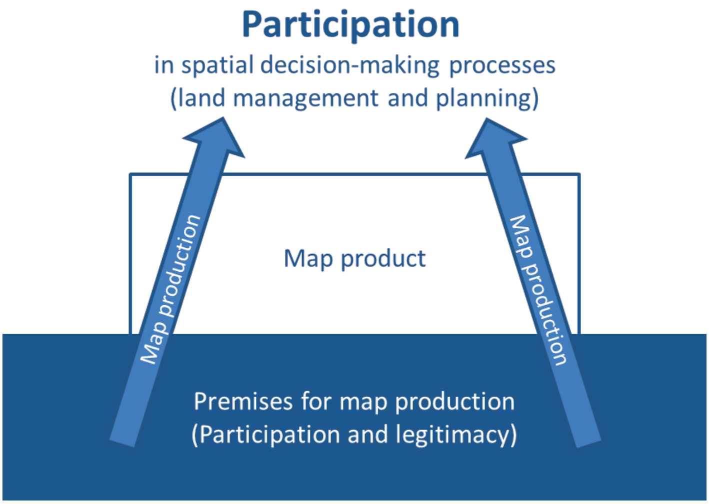

Figure 3. Participation in map production as a necessary foundation for participation in land management and planning

Even though participatory map production can be considered a prerequisite to participatory decision-making processes (see Figure 3), the map product must be objective and consistent to make it verifiable and comparable for monitoring purposes. However, are participatory practices and product objectivity/consistency truly mutually exclusive and incompatible? It can be argued that objectivity and consistency are tied to map standards and definitions and that increased participation implies a larger degree of legitimacy and anchoring of these foundations among the public. Therefore, participation should focus on trying to achieve agreement not primarily on the level of single area classes and boundaries but on map standards, category definitions and the aim of the map product (which seems to be a challenge for the AR5 map).

In planning theory, the concept of consensus can be used to signify such an agreement. Building consensus is seen as a special type of collaborative planning. Such collaboration involves a structured dialogical process engaging a diverse range of stakeholders in what has been called a deliberative democracy, which is characterised by equality and symmetry among stakeholders (Innes & Booher, 2014; Mouffe, 1999). The concept of consensus has been criticised for requiring perfect communication with equalised power between stakeholders, and has been considered impossible because antagonism and power are ineradicable in decision-making processes (Mouffe, 1999). In this view, consensus building is criticised for peer pressure and for papering over conflict rather than confronting it, thus failing to achieve legitimate decision making (Hillier, 2003; Mouffe, 1999). Innes and Booher (2014) addressed this critique by building on Castells' (2009) communication theory of power, where communication is seen as an action that changes power relations and the realities of the social world. They argued that dialogue and debate (communication) in the public sphere is necessary to create conditions for a legitimate exercise of power, representing the values and interests of citizens and thereby ensuring democracy and participation (Innes & Booher, 2014). Successful collaboration depends not on altruism but on participants working to achieve their interests (Innes & Booher, 2014).

Therefore, if increased participation is achieved through increased communication at the more fundamental level in the map production process (map standards, category definitions and the aim of the map product), there may be fewer disagreements and less need for discussion and debate to achieve local legitimacy when empowered mapmakers decide on concrete borderlines and categories in the field. Moreover, increased communication at the fundamental level creates a greater likelihood of producing a more verifiable and consistent map product that is useful for decision-making processes and monitoring purposes.

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