Participatory GIS to mitigate conflicts between reindeer husbandry and forestry in Vilhelmina Model Forest, Sweden

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ABSTRACT

To improve communication between reindeer-herders and other land users, we developed and implemented a system to produce reindeer husbandry plans together with Sami reindeer-herding communities. A central component of our communications strategy was the introduction and use of a participatory GIS (pGIS). We evaluated the potential and limitations of pGIS as a tool for collaborative learning. We concluded that by merging traditional and scientific knowledge in a pGIS, the process of spatial communication has contributed to a more inclusive planning process, and to improved knowledge-sharing. Furthermore, the process has contributed to a more efficient long-term perspective where land use planning focuses on key areas but with solutions applied to the landscape. The Model Forest offered an appropriate platform to facilitate the process.

Key words: collaborative learning, multifunctional land use, participatory GIS (pGIS), reindeer-herding community, reindeer husbandry plans, Model Forest

RÉSUMÉ

Afin d'améliorer la communication entre les éleveurs de rennes et les autres utilisateurs des terres, nous avons élaboré et mis en œuvre un système pour produire des plans d'élevage de rennes avec les communautés Sami. La mise en œuvre et l'utilisation d'un SIG participatif (SIGP) se trouvent au cœur de notre stratégie de communication. Nous avons évalué le potentiel et les limites du SIGP comme outil d'apprentissage en collaboration. Nous avons conclu qu'en fusionnant les connaissances traditionnelles et scientifiques dans un SIGP, le processus de communication spatiale favorisait une planification plus inclusive et l'amélioration de l'échange de connaissances. De plus, le processus a contribué à l'amélioration de la perspective à long terme dans le cas où la planification de l'utilisation des terres est axée sur des régions clés, mais où les solutions sont appliquées au paysage. Les Forêts Modèles ont offert une plate-forme qui a facilité le processus.

Mots clés : apprentissage collaboratif, utilisation polyvalente des terres, SIG participatif (SIGp), communauté d'élevage des rennes, plans d'élevage de rennes, forêt modèle

Setting the Scene

Combining reindeer husbandry with other competing land use interest is one of the major issues on the Vilhelmina Model Forest agenda (Svensson *et al*. 2004). To mitigate competing land use needs, increased knowledge about and understanding among stakeholders (Khadka and Vacik 2008) is needed. Incorporating a participatory GIS (pGIS) in the planning process has promising potential as a tool for collaborative learning processes. Several partners in the Model Forest have developed a pGIS, which involves mapping indigenous ecological knowledge combined with other data sources. In this paper we examine the potential and limitations of pGIS as a tool for collaborative learning, using indigenous knowledge as a main input. We draw experience from the case of reindeer husbandry and forest management, and examine how stakeholder involvement and participation in combination with new and innovative technology can facilitate communication to circumvent and resolve conflict among diverse land users. Additionally, we evaluate if these tools and solutions can be spread to other communities and Model Forests to support functioning partnerships with a strong commitment to sustainable development, networking and knowledge-sharing.

In northern Sweden, as well as in much of northern Fennoscandia, reindeer *(Rangifer tarandus* L.*)* are part of the native herbivorous fauna and play important roles ecologically and socio-economically. For the indigenous Sami people, reindeer husbandry plays a key role in their cultural identity and traditions; its importance cannot be overemphasized (Lundmark 2008). The Swedish Reindeer Husbandry Act (1971:437) defines 55% of Sweden's total land area as reindeer husbandry area. In these areas, the Sami have exclusive rights to graze their reindeer (Fig. 1) on all land regardless of ownership. The Swedish reindeer husbandry area is divided into 51 reindeer-herding communities, each one managed separately and large enough to take in all seasonal needs of the reindeer. The Vilhelmina Model Forest encompasses parts of two reindeer-herding communities—Vilhelmina North and Vilhelmina South—that together cover almost 30 000 km^2 (Fig. 1).

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Fig. 1. Location of the Vilhelmina Model Forest, Sweden.

Each year the Sami reindeer-herders of the two Vilhelmina reindeer-herding communities follow their reindeer from the Norwegian border in the Scandian Mountain Range in the west to the Gulf of Bothnia in the east and back to the mountains, a round trip of about 700 km. The reindeer spend the late spring, summer and fall in the mountains grazing and calving, and migrate east during pre-winter to their grazing lands in the coastal area. As such, traditional reindeer husbandry uses a very extensive landbase.

Forestry is an important Swedish export industry and employment business, but also has, due to its intensive land use, an impact on many other industries and interests, including reindeer husbandry. About 50% of the total forest area in Sweden, and about 40% of the standing forest volume, is found within the reindeer husbandry area (Sandström *et al.* 2010). Forestry and reindeer husbandry use the same land but for different purposes and this multiple use of the forest is a source of conflict. Modern forestry has been argued to be one of the major threats to the future of reindeer-herding, and to the Sami culture (Danell 2004). There is, therefore, a need to find tools to augment co-existence of the two sectors.

In 1979, the Swedish Parliament introduced consultation procedures between the two sectors to help find solutions to the conflict (SKSFS 1993: 2). About 20 years later the procedures were extended to cover a larger geographical area through the Forest Stewardship Council (FSC) certification system (Swedish Reindeer Husbandry Act, 1971: 437; Swedish Forestry Act 1979: 429; Svenska FSC n.d.). However, judging by the ongoing conflicts, the procedures do not appear to fulfil their purpose. Widmark (2009) argued that ongoing conflict with reindeer husbandry is due to unresolved issues concerning property rights and from inefficient consultation procedures. Because issues concerning property rights are a political concern, the call to develop the functioning procedures for consultation must involve both the reindeer husbandry and the forest sectors. Moreover, case studies are needed where solutions are developed, implemented and evaluated. The Model Forest represents a suitable arena to understand and address natural resource management conflicts and to share results and lessons learned through networking to improve existing governance at the landscape level.

Our Work

Reindeer husbandry plans in Vilhelmina Model Forest

To improve communication about land use in reindeer husbandry, the Swedish Forest Agency, researchers and the reindeer-herders initiated a process of developing Reindeer Husbandry Plans in the Vilhelmina North reindeer-herding community in 2000. In 2006, the Vilhelmina South reindeer-herding community was also included in the work, which now covers the entire Model Forest (Fig. 2). The goal of a Reindeer Husbandry Plan is to provide clear and understandable information about habitat use and movement of reindeer across the landscape, which would improve consultation procedures with other land users. In addition, a Reindeer Husbandry Plan would facilitate planning of the operational reindeer management for the reindeer-herding communities (Sandström *et al.* 2003). The production and use of the Plan was made easy by our construction of a custom-made GIS specifically designed to meet our needs, combining a user-friendly interface and advanced features. The foundation for the production and use of Reindeer Husbandry Plans as a communication tool for reindeer husbandry fits well as components of a pGIS. The data collection process represented a novel user-oriented effort largely based on the work carried out by the principal end user—the reindeer-herders—similar to the concept of indigenous mapping (Chapin *et al.* 2005,

Rambaldi *et al*. 2005, Dove 2006, Green 2008). Such a pGIS combines a range of geo-spatial information management tools and provides the possibility of enhancing dialogue, information exchange, decision-making, conflict resolution and collaborative learning.

The work to develop Reindeer Husbandry Plans has been completed in the Vilhelmina North and South reindeer-herding communities as well as in 24 other reindeer-herding communities in Sweden (Jougda *et al*. 2011). In the Model Forest, about 35 reindeer-herders participated in training of satellite image interpretation, GIS, GPS and field inventory techniques. The two reindeer-herding communities currently have 25 computers with the custom-made pGIS installed. Additionally, both communities have equipped reindeer with GPS collars that provide reindeer positions on Web-based maps in real time, as well as important data input to the pGIS. The spatiotemporal indigenous knowledge about habitat use and movement patterns of reindeer, combined with other geographic data, are the contextual components of the pGIS.

PGIS as a tool for collaborative learning

Collaborative learning is increasingly cited as a crucial component for successful co-management of natural resources. However, no common conceptual understanding of the term seems to exist, hence, the empirical research is still limited (Schusler *et al*. 2003). Nevertheless, the concept is often defined as a learning process in an adaptive manner among a group of actors seeking to improve a situation by developing common knowledge as a base for collective decision making (Argyris and Schön 1978, Keen *et al*. 2005). The pGIS approach presented here is one example of a technical tool for collaborative learning. Another, and more common example, is internet-based learning. Based on the existing literature (e.g., Daniels and Walker 2001, Mostert *et al*. 2007), we assume that collaborative learning, supported by pGIS, may generate:

- knowledge-based dialogue between the forest and reindeer husbandry sectors;
- improved understanding of how the two sectors affect each other;
- better tools to communicate how reindeer husbandry operates;
- better understanding of how to lessen negative effects of forestry;
- more integration of scientific and traditional knowledge;
- increased communication, respect and trust among the participants; and
- improved relationships between the two sectors, with respect to both the consultation process and to the outcome of the process, measured in terms of increased consideration given to each other's needs.

Collaborative learning, thus, includes the negotiation and exchange of ideas to improve the understanding of facts, information and knowledge. In this respect, collaborative learning can be seen as a form of governance, guiding and coordinating the allocation of resources in a sustainable way. The collaborative learning process has a lot in common with principles and attributes of Model Forests with respect to broad partnerships, large landscapes, a commitment to sustainability, participatory governance and knowledge-sharing, capacity-building and networking.

Results

Approach

The study of the potential and limitations of pGIS as a tool for collaborative learning is based on qualitative, semi-structured interviews with reindeer-herders (n = 14), forest companies (n = 14) and forest agency personnel (n = 5), with a primary focus on the extent to which the Reindeer Husbandry Plans have contributed to collaborative learning. The latter two categories are combined into a forest sector category (n = 19). We summarize the results from our interviews under the following three questions.

What experiences do the forest and reindeer husbandry sectors have from the introduction of the new technique in the form of Reindeer Husbandry Plans and pGIS?

The interviews show that the work to develop and use Reindeer Husbandry Plans and pGIS has had a substantial impact on reindeer husbandry, but less impact on the forest sector. An important result of the process to introduce the Plans was the interplay between the reindeer-herders and the researchers as the researchers provided the herders with the necessary knowledge and tools (e.g., GIS, GPS-collars, analysis tools, laptop computers) to collect and compile relevant information. As well, the researchers responded to feedback from the herders in applicability and practical handling issues. Because the respondents carried out the collection and compilation of the data, they are also able to understand the data and the outputs (e.g., through thematic maps). All the respondents agreed that if agency personnel or researchers had produced the Reindeer Husbandry Plans and delivered the Plans to the reindeer-herding communities without such active involvement by the herders, the data quality would most likely have been lower. But even more important, the reindeer-herders' ability to efficiently use the Reindeer Husbandry Plan would have been inferior. The analyses of the interviews show that the adoption of new techniques succeeded in two main ways. The custom-made GIS presented the reindeer-herders with new and advanced techniques, which made use relatively easy for them as non-GIS experts. The project participants learnt that knowledge about GIS techniques needs to be maintained and practiced continually.

GPS data from collared reindeer compiled by the researchers depicting actual habitat use and movement patterns by reindeer for the entire annual cycle of reindeer-herding provide important information for improved identification and delineation of important grazing lands. Though the GPS collars have had some functional problems, reindeer-herders have started to rely on the technique for locating the reindeer. The forest sector respondents indicated that the Reindeer Husbandry Plans have made information about the land use needs of the reindeer-herding communities much more open and transparent. The analysis of the interviews clearly indicate that the Plans have provided a better general overview, but also, however, that the respondents cannot clearly distinguish between the information gained from the Plans and the information from the indigenous ecological knowledge that existed before the introduction of the Plans.

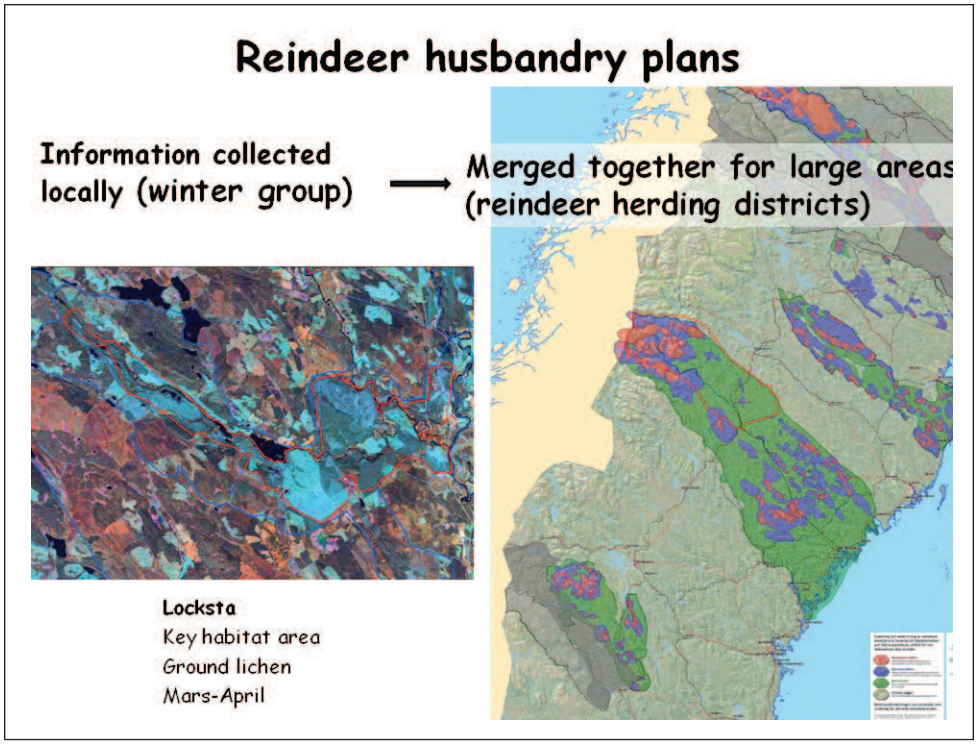

Fig. 2. (a) The basis for development of Reindeer Husbandry Plans consists of several components. First a collection and digital systemization of traditional ecological and landscape knowledge of reindeer habitat use, both in space and time, was carried out by the reindeer-herder with the most knowledge about habitat use by reindeer in the local area. The herder digitized the identified important areas with a satellite image as background; in this example, the Locksta area (20 km^2 in size) within the winter grazing lands of Vilhelmina North reindeer-herding community (15 000 km^2 in size). This work was done for each of the eight reindeer grazing seasons. Digitized information was integrated with the results from field inventories carried out by the reindeer-herders. **(b)** Locally collected information for each grazing season was then merged to include the entire reindeer-herding community with key habitat areas shown in red and core habitat areas shown in blue. The combined information was compiled in a custom-made GIS. The collected information was subsequently used as a basis for our pGIS in consultations between representatives from reindeer husbandry and forestry. The red boundary represents the Vilhelmina Model Forest which covers portions of both the Vilhelmina North and South reindeer-herding communities.

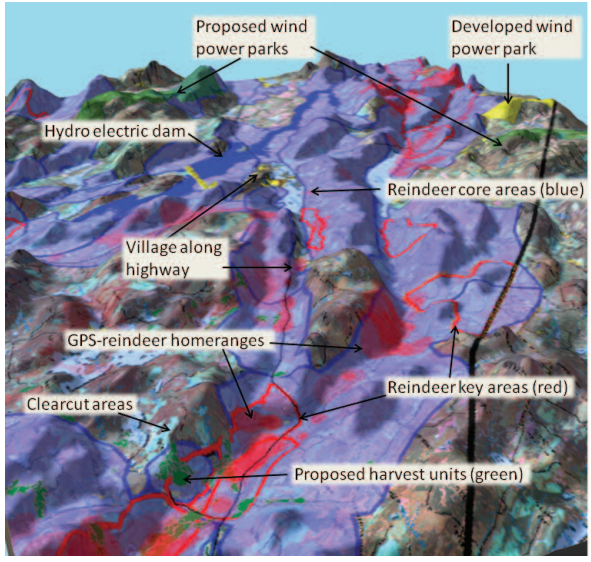

Fig. 3. Example of information from a Reindeer Husbandry Plan used by Vilhelmina North reindeer-herding community in consultation with a forest company. The Plan was developed in close cooperation between researchers and Sami reindeer-herders. Green small areas represent areas of proposed timber harvest imported to the custom-made participatory GIS. Key (red boundaries) and core (blue) areas represent important grazing lands identified and digitized by the reindeer-herder with the most knowledge about the local area based in satellite image interpretation. Transparent red areas represents high-use areas estimated with the Brownian Bridge method from GPS positioned reindeer. Other land use activities are also displayed in the pGIS. Such information in a Reindeer Husbandry Plan provides important information for land use planning and consultation between the reindeer-herder, forest companies and other land users.

How have the herders and foresters used the Reindeer Husbandry Plans in their daily work?

The development of the Reindeer Husbandry Plans has allowed the reindeer-herders to better plan for sustainable use of the grazing lands. The forestry sector mainly points to the fact that the Husbandry Plan is a familiar planning tool because the sector uses similar techniques in their day-to-day work. The Plans are to a large extent adapted to the tools used within forestry planning.

The respondents reported on several specific examples where operational reindeer husbandry has benefitted from the Plans. For example, strategic planning improved during larger gatherings of the reindeer at times of slaughter, the marking of the calves, and before the common migrations between seasons. Especially valuable were the Web-based real-time updates with positions of GPS-equipped reindeer. Also important was the constant contact during critical times with "the communication center", where a pGIS user can deliver hourly up-to-date information about reindeer whereabouts to the reindeer-herders in the field.

An additional long-term benefit from the work on the Reindeer Husbandry Plans within the reindeer-herding communities is that the knowledge on reindeer habitat and grazing preferences, which previously was held exclusively by those who have herded for many years, is now more easily available and shared by many. Those herders who have worked on interpretation of satellite images, digitized grazing lands, took field measurements, and followed the movements of the GPS-equipped reindeer have relatively quickly gained a deeper knowledge about reindeer husbandry. This has been especially true for youth and female reindeer-herders. The geographic knowledge about reindeer husbandry has become more evenly distributed as women and young reindeer-herders become involved in the work with the Plans. This is especially apparent in the Vilhelmina North reindeer-herding community were pGIS workshops have been held with a wide range of community members spanning in age from 10 to 70 years.

The interviews with respondents from the forest sector also highlight that the forestry sector has benefitted from more transparent Reindeer Husbandry Plans, particularly as a preparation and information-sharing process. The understanding of the land use needs of reindeer husbandry has increased among the respondents of the forest sector.

How have the Reindeer Husbandry Plans improved the consultation process and the outcome of the consultations?

The interviews clearly show that the Plans are used extensively in the planning and preparation of consultations between the reindeer-herding and forest sectors. Now it is standard that the forest companies supply the reindeer-herding community with forest harvesting plans as a GIS-layer that is incorporated into their pGIS. As mentioned above, the ability to view forest management plans in relation to the other information in the Reindeer Husbandry Plans provides a better prerequisite for integration of planned forest activities with reindeer-herding needs (Fig. 3). Digital communication of harvest plans becomes especially important when dealing with long-term harvest plans that include many hundreds of objects. According to the reindeer-herder respondents, the landscape perspective provided via the annually updated satellite images showing the latest timber harvests has improved the planning process among the reindeer-herders. Satellite image-based information is the only source of landscape information that covers all land independent of landownership. Creating printouts in the pGIS with satellite images as background has become routine in the reindeer-herding communities and they request the latest updated imagery as a standard.

Reindeer-herders report that the consultation procedure has improved because arguments are based on maps that explicitly show the needs in reindeer husbandry in relation to forest management plans. The study also shows that different reindeer-herding communities release different extents of material to their forest sector counterpart, varying from releasing all grazing land classification in digital form to only providing printouts of the current issue under consultation. Limited exchange of information may affect the effectiveness of the consultations and our analyses of the interviews show that the differences between the reindeer-herding communities can reflect the amount of trust between parties. Our results indicate that the communities who do not share the Reindeer Husbandry Plans during consultation procedures do not trust that the forest sector counterpart will use the information in a correct way.

The results from the interviews with the respondents from the forest sector show that a majority have come in contact with the Reindeer Husbandry Plans in the form of either digital files or printed maps. This contact has improved the forest sector's knowledge about the conditions and needs of reindeer husbandry. Most forest sector participants think that the improved databases relating the spatial and temporal categorisation of the grazing lands has contributed positively to the consultation procedures. They agree that understandings between the parties have improved regarding land use needs as seen by the increase in amendments to the planned measures. However, like the reindeer-herders, forest sector respondents find it difficult to distinguish among factors that may have improved or affected the consultations, like forest certification schemes and environmental policies.

Both stakeholder groups largely agree that pGIS has improved the consultation procedures but have had a limited impact on the outcome of the consultations. The Reindeer Husbandry Plans have provided valuable support in the planning processes with respect to other land use such as recreational hunting, hiking and snowmobile tourism in relation to reindeer husbandry activities. pGIS has improved the coordination with other land users, agencies and researchers in complex issues regarding land use in reindeer husbandry.

Discussion

Although the work on Reindeer Husbandry Plans follows some of the common techniques of indigenous mapping (Dove 2006, Green 2008), the methods used by the two reindeer-herding communities in Vilhelmina are unique in that all of the actual data collection and compilation is carried out by the end-user—the reindeer-herders themselves—rather than by outside experts who interview, sketch and later transcribe the information (Fig. 2). This system of strong end-user involvement in data input processes can be used in many other circumstances to increase trust in and knowledge about fundamental land use premises for different types of stakeholders.

The study has shown that relatively advanced technical tools such as GIS, satellite images and GPS-positioning can be successfully introduced to previous non-expert users. Training and continuous support was necessary throughout the course of data collection and compilation, with the focus on capturing as efficiently as possible the reindeer-herders' extensive, indigenous knowledge of reindeer autecology. The continuous participation of forestry experts in the process of training and data collection creates premises for a growing mutual trust in the process and the end result.

Through the process of compiling and explaining the complex land use needs of reindeer husbandry, the reindeer-herders have learned both from their own personal experiences as well as from interacting with others. The process of describing and documenting land use both locally and at the landscape level has developed into an important pedagogical tool within the reindeer-herding communities. The process has confirmed what many of the reindeer-herders already knew. In other words, the new technological approach confirmed the traditional approach, and the sum of many known things becomes new information, even for the principal expert. This has had positive impacts both within the reindeer-herding community and in its relation to other land users. This positive effect of working with the Reindeer Husbandry Plan becomes especially apparent in Vilhelmina North which has continually developed and improved its Plan for 10 years. Vilhelmina North has, through its deep involvement in this and related projects, become the leader of all 51 reindeer-herding communities in all land use communication issues. Other reindeer-herding communities are learning from Vilhelmina North as they implement methods and techniques first developed and tested there.

Compiling reindeer's GPS-data from six reindeer-years has provided an important additional contribution to the work in identifying important grazing lands, and has served as an excellent pedagogic tool both within the reindeer-herding communities and in communications with other land users. Information from the GPS-collars has a great pedagogical value as the basis for discussions between reindeer-herders, forest managers and other land users as well as scientifically and for education. Also, Vilhelmina North has taken the lead among all reindeer-herding communities as the group that tested and developed the first real-time GPS positioning system on reindeer. The group has now collected more than 500 000 positions from over 200 reindeer over the last six years. The data set depicting reindeer movements and the ability to communicate this information in the pGIS are unique and have become extremely valuable and useful communication tools.

An important contribution to the consultation process is the fact that the forest sector often sends its proposed harvest information as GIS layers to the reindeer-herders, who include the information in their pGIS when preparing for consultations. This has contributed to the empowerment of the reindeer-herding communities to be on more equal terms during consultation since printouts that display proposed forest harvest areas can be prepared both at local and landscape scales, together with other information from their pGIS (Fig. 3). The interviews show that the consultation and dialog with the forest sector could and should be improved further. Currently, all educational efforts in the process of developing Reindeer Husbandry Plans have focused on data compilation. We have only recently begun focusing on how to analyze the data to further support the consultations or how to communicate and visualize the data during consultations. We have an ongoing project that specifically focuses on increasing the competence of using and communicating the information in the Reindeer Husbandry Plans.

The use of pGIS has empowered the reindeer-herding communities by improving the knowledge base and the dialogue between the two sectors. Almost all of the respondents agree, however, that the use of pGIS has not led to increased considerations from the forest sector to the needs of the reindeer-herding communities. There may be several reasons for this. It is possible that the reindeer-herders involved in the process have focused on internal processes such as working with improvements of the database, and have focused less on the dialogue and negotiations with the forest sector. Another possible reason is that the reindeer-herders may not have been able to communicate the needs due to a lack of knowledge about alternative forest management methods. A further possible reason is that the consultations between the reindeer-herding and forest sectors occur relatively late in the forestry planning process which makes it difficult to make major changes in the plans. A likely interpretation here is that the forest companies, whose primary purpose is to satisfy their shareholders, have no strong incentives to satisfy the needs of reindeer husbandry. More insights are needed, however, to cover this issue in more depth. Because there appears to be no incentive for forest companies to adapt to reindeer husbandry voluntarily, it is necessary to have an institutional framework that can support this development. FSC is one such framework in which a new standard has entered into force in Sweden in 2010 (Svenska n.d.).

Conclusions

We conclude that the process of introducing the pGIS to communicate Reindeer Husbandry Plans has contributed to the development of a more inclusive planning process (e.g., women and youth) but also to improved information-sharing between the two sectors through a more open and transparent planning process. By merging traditional and scientific knowledge, the process has added a more efficient long-term perspective where the land use planning focuses on key areas but with solutions applied to the landscape. We believe many components of the process would work well in other landscape arenas.

Lessons learned from our experiences with collaborative learning through a pGIS include:

- The use of advanced techniques such as GIS, GPS and satellite imagery by non-experts works well as long as the tools are made easy to use and if training is prioritized.
- This work can serve as a model for stakeholders to gain better knowledge and understanding among, about and between each other through a commitment to achieve sustainable land use.
- Expert knowledge (indigenous knowledge) about the resource, in our case the given circumstances in reindeer husbandry, was the most important component for successful spatial documentation.
- pGIS as a tool for collaborative learning has the potential to play important roles to support planning and mitigate conflicts.

- Knowledge-sharing, capacity-building and networking can be achieved under the common umbrella of a pGIS among partners within a Model Forest as well as with other Model Forests, and applied elsewhere as shown by the success in developing Reindeer Husbandry Plans throughout extensive areas of northern Sweden.

Our study show that the use of Reindeer Husbandry Plans has improved the preparations for consultations and has contributed to a more knowledge-based dialogue between forestry and reindeer husbandry. The use of pGIS has also improved the understanding of how the two sectors affect each other, and has provided prerequisites to integrated new knowledge and tools for communication. A majority of the respondents from all three groups argue that although the process of consultations has improved, the outcome of the consultation has not led to a shift in power relations. Additional development of the process, especially in the area of communication, is needed for further processing and implementation of more transparent and balanced land use procedures with respect to integration of forest management and reindeer husbandry in northern Sweden.

Acknowledgements

We thank the reindeer-herders of Vilhelmina North and South reindeer-herding communities in the Vilhelmina Model Forest, Lennart Bergsten for carrying out the interviews, and respondents from the 12 other reindeer-herding communities, the Swedish Forest Agency and forest companies. This work was supported through the Swedish Forest Agency from Swedish National Budget and by the Sami Parliament in Sweden.

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