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1. Introduction

RenGIS (i.e. Reindeer GIS) is a participatory GIS (PGIS) with a bottom-up approach (Brown and Kyttä 2014, Sandström et al. 2020) and one of several Participatory tools (Ptools) in the ArcticHubs toolbox. The original aim of RenGIS was to be a custom-developed tool for Sami reindeer herding communities (RHCs) to compile and communicate their Reindeer Husbandry Plans (RHP; Sametinget 2022a, Sandström et al. 2003, Sandström 2015). The development of RenGIS has been a continuous process since 1998, initially led by the Swedish Forest Agency and lately by the Sami Parliament, when RHCs initiated the process in order to address their need for a GIS-tool to be used in consultations with forestry. They specifically wanted a map-based tool that resembled and would be comparable the forestry plans used by the forest companies in the consultations (Sandström 2015).

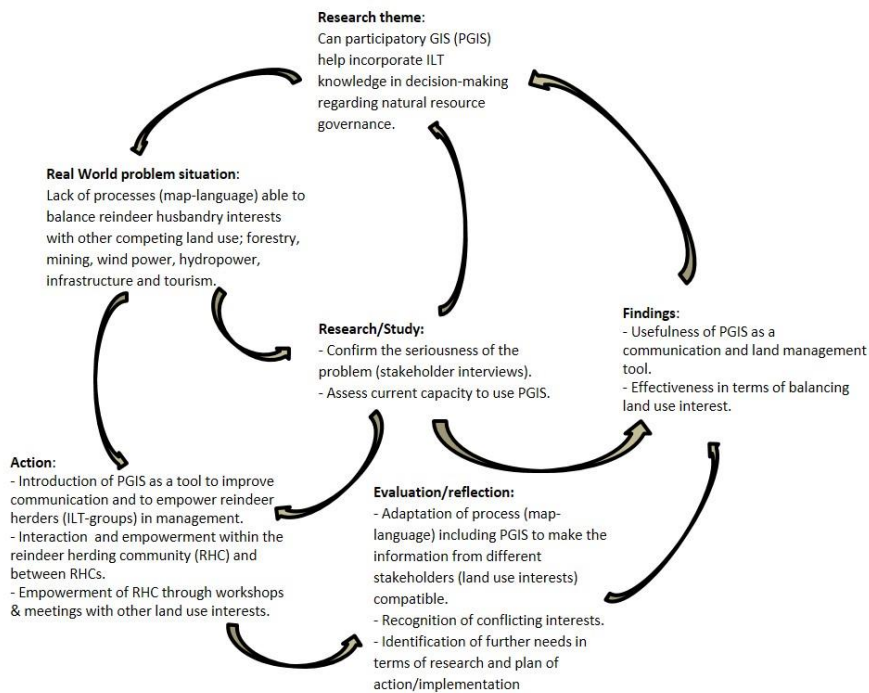


Figure 1 showing the iterative process used to co-produce RenGIS (adapted from Poudyal et al. 2015).

Researchers from the Swedish University of Agricultural Sciences (SLU) were involved from the very beginning and initiated a process of co-production of knowledge to develop a custom-made GIS to allow the RHCs to combine indigenous, local and traditional knowledge (ILT) with data demands from a diverse body of





decision-making processes. The work followed an iterative process that allowed for a constant inventing, testing, evaluation and development of the tool (Figure 1). The mapping focused on producing digital maps of the reindeer grazing lands, but other important sites or areas could also be mapped, e.g. culturally important sites.

RHCs requested maps that were comparable to maps produced by other land users (Sandström et al. 2003, Sandström 2015) and compatible with other available GIS systems to facilitate data exchange with other land use actors. RHCs participation have been crucial in the development and design of RenGIS. The RHCs involvement throughout the process has allowed for specifically targeting the tool towards communities with no prior knowledge in using GIS. One of the most important features of RenGIS is that after the introduction of the tool to the communities the data collection and data ownership is fully under their control.

In the beginning, the Swedish Forest Agency was coordinating the RHP process, forestry being identified as the major land use impact on reindeer husbandry and reflecting the similarity to the forestry plans used in forest management. However, early on in the process reindeer herders asked to adapt RenGIS so that it could be useful in consultations with all competing land users, including e.g. mining and wind power. This has led to the usage of RenGIS in all types of land use issues regarding reindeer husbandry and as a direct consequence, the responsibility for the Reindeer husbandry plans was transferred to the Sami Parliament in 2016 to reflect this broader implementation. The specific aim of RenGIS as a useful tool for both expert and non-expert computer users has remained in focus. The Sami Parliament, like the Swedish Forest Agency before, administrates the project, hosts the RenGIS platform and organizes training sessions with the RHCs through a process where SLU plays an important role in many of the training sessions. However, the data collection and storage remain in the hands of the RHCs. The strategy is that the data will be available in consultations with competing land users or state agencies when it is needed rather than being collected by a state agency in advance. The RHCs have been reluctant to share such information in the past especially to government representatives. However, the state's effort to map reindeer husbandry areas (also a Sami Parliament responsibility), to describe and digitise them, and make them





publicly available was and still is an on-going parallel process, resulting in the presence of two different versions of the maps (Sandström et al. 2020). Our experiences show that maps created and controlled by the RHCs themselves are more accurate than those publicly available, but also that many of the reindeer herders have become skilled users of GIS.

The original version of RenGIS was based on the ESRI, ArcView platform (ArcView 2002). In 2008, the development of the RenGIS software was transferred onto the programming environment Tatum (2022) which is where RenGIS continued to be developed until its latest version RenGIS 2.0. The platform was developed and managed by a single consultant making the system highly vulnerable. Therefore, the Sami Parliament initiated the process to develop a new version of RenGIS (3.0) with the intention to transfer the new version back to the ESRI platform as a web based system. The platform and the update from RenGIS 2.0 to RenGIS 3.0 is a process performed by the Sami Parliament. They will also be hosting the platform in the future. This technical work was not part of the ArcticHubs project although SLU and the RHCs among others were consulted by the Sami Parliament. As such, it is still very much a co-creation process.

RenGIS 3.0 launched in May 2023 but the work continued until it was finally ready in November that year. By the end of the year, 27 RHCs had transferred their data from RenGIS 2.0 to the new platform. The Sami Parliament had organized 15-16 training opportunities with ca. 100 participants in total. According to the Sami Parliament, the RHCs were positive towards the new platform. The Sami Parliament will continue to lead the technical development of the platform and organize training sessions for the users while SLU will be responsible for specific training sessions such as the field inventories. In accordance with the philosophy of the process, it is voluntary for the RHCs to use either RenGIS 2.0 or RenGIS 3.0. However, there is no longer any technical support for the older system. The RenGIS 2.0 program was (and still is) free to download from the Sami Parliament homepage and included access to all background data. The web version is still free to use by the RHCs but, there is a licence fee of 8 000 SEK per user and year if you are not associated with a RHC. For the time being selected researchers from SLU have access to the platform albeit





without the editing functionality. So far, not all functions of RenGIS 2.0 have been adapted to RenGIS 3.0. It is possible to map grazing lands, register field inventories, and access the collected data from other land users. The RHCs can also register data points or create maps on topics of their choice. During spring 2024, around 30 RHCs had received a training session. To our knowledge, several RHCs have already used the tool in real life consultations. The Sami Parliament not only administer the platform, they also administer the user access. However, it is the individual RHC that decides who should have access to the program and their data. This includes both internal users as well as outside users. As was the case with RenGIS 2.0, SLU only has access to the program itself but not to any data produced by the RHCs.

However, the specific task in ArcticHubs was to develop new functions in RenGIS and make improvements of the tool based on input from the partner Gran RHC, RHCs in the hubs as well as previous suggestions stemming from our extended work with other RHCs.





2. Aim of RenGIS in ArcticHubs

The original aim in WP4 at the beginning of the ArcticHubs project was to build on the already existing RenGIS 2.0 and to improve the tool “for a more effective field data entry via cell phones (hand held devices), digitising, better visualisation of GPS movement data as well as incorporation of drone footage and photographs”.

Furthermore, WP 4 aimed to use the tool in the Swedish hubs to identify and communicate solutions to ongoing land use conflict. Another aim and role of RenGIS in ArcticHubs was to function as the instrument for expert users and knowledge holders (e.g. reindeer herders) to create and manage geographic data. As such, RenGIS is already designed and used as the foundation for co-production of knowledge among indigenous communities and researchers.

However, soon after the project started the Sami Parliament opted for the web based version instead, which prompted the researchers to re-evaluate the plan i.e. focusing on collecting requested data sets rather than improving the program itself.

The core of the development and use of RenGIS has been centered in the Gran, Malå, Gällivare and Jokkmokk hubs, but knowledge, experiences and methods were also made available to all participating hubs as a learning case. Hence, the RenGIS platform provide tools for enhanced and advanced levels of participation as it targets participation of specifically selected expert knowledge holders to work side by side with researchers to co-produce new knowledge. This report outlines the development of the new components in the RenGIS 3.0 version.

At the upstart of the ArcticHubs project, RenGIS 2.0 already had numerous functions, purposes and roles. In addition to being a data collection tool, RenGIS has become the main data storage and display tool for a whole series of internal and external data sources. In addition to specific data about reindeer husbandry, RenGIS contain and are continually updated by the Sami Parliament with the most recent satellite image mosaics, topographic maps as well as data about all other land user’s footprints, including hydropower dams, present and prospected mines, wind power parks, forestry and other infrastructure. In ArcticHubs, researchers from SLU, supported by project partner Gran RHC, have added to that by introducing new functions and data





sets to RenGIS such as historical maps covering state initiated mapping of reindeer husbandry as well as the industrial and infrastructure development within the reindeer herding area. SLU will also explore and add new functions to RenGIS to facilitate analysis and visualization of data by reindeer herders as a direct response to their presented needs. Needs communicated to us during the continuous cooperation and communication between the research team, RHCs, land use planners and other land users.

As much of the development of RenGIS in ArcticHubs is carried out in close connection with the Reindeer husbandry planning project and its project leader the Sami Parliament, new functions and improvements developed in ArcticHubs will be instantly available to all RHCs in Sweden for further testing and implementation. Today, RenGIS is not only in use in all 4 Swedish hubs, but also in 50 of the 51 RHCs in Sweden. Overall, a total of more than 400 reindeer herders have participated in RenGIS user trainings and workshops in previous years. After being in operation for 20 years, new versions of RenGIS have continually been developed and improved as new user-needs and user-demands called for realization. For this process, ArcticHubs, with participating RHCs, in each hub, played key roles. In all Swedish hubs, RHCs cooperated with researchers to identify new needs, as well as acted as testbeds for newly developed modules. Within the framework of the ArcticHubs project, we have organized a series of additional, full-day trainings and workshops with participating RHCs. In addition, we have also held a two-day workshop in Umeå together with project partner Reindeer Herders Association (Paliskuntain yhdistys) and participants from LUKE and SYKE, where we compared the mapping strategies in the two countries and discussed advantages and disadvantages with the systems to map reindeer husbandry areas in Sweden and Finland.

The first version of RenGIS was developed to be a digitising tool for reindeer herders to delineate important grazing lands based on on-screen digitising with satellite images as background. However, over time RenGIS has developed to not only be the GIS tool in use by reindeer herders, but it has also become the main GIS tool used by the Swedish researchers in ArcticHubs. In the project, we emphasise the





role of participatory tools and define the tools as activities or methods rather than focusing on the tool itself. The researchers as well as the users among the RHCs use RenGIS for all or some of the identified purposes of a participatory tool as defined by ArcticHubs. This include, a. to collect data and knowledge; b. to store collected data; c. to communicate data among partners and stakeholders; d. to engage and inspire participation; e. to visualize and explain issues; f. to produce and communicate results, consequences and impact assessments; and h. to communicate and explain proposed solutions.

In the following section, we will describe some of the specific improvements and developments towards the new RenGIS version. The need and idea behind these improvements all originated from RHCs who either expressed lack of functions in the tool itself, or experienced communication shortcomings in consultations or noticed a lack of adequate data sets. Therefore, new improvements and developments include new modules, methods and datasets, which will be explained in the following section.





3. New methods and modules in RenGIS 3.0 developed in ArcticHubs

3.1. A new mobile app for cell phones for field data collection

For more than 20 years, all field data collection has been carried out using pen and paper in the field and consequent later data entry into RenGIS in front of the computer. This has been cumbersome, as well as risky, considering data quality. Encouraged by RHCs, as well as the Sami Parliament we developed, tested and implemented a new field data collection system using an app for mobile phones. The risks of losing paper protocols or incorrect transcription of field protocols have thus been minimized. After data collection with the mobile app is completed, data including field photographs can be directly linked into RenGIS. Reindeer herders from Gran, Malå, Gällivare and Jokkmokk hubs have all participated in development, tests and implementation. The system is described in detail in Swedish in the user manual co-authored between researchers from SLU and reindeer herders from the Gran and Jokkmokk hubs (Sametinget 2022c).

3.2. New field inventory methods and a system for re-inventorying field plots

Reindeer herders have expressed concerns about the decline of ground lichen cover, a critical food resource for reindeer winter grazing. Changes in forest conditions are in part a result of forestry practices but its effects on the lichen resource is not completely understood (Sandström et al. 2016). SLU and RHCs in ArcticHubs attempted to add knowledge to this issue. As part of the long-time ongoing project with reindeer husbandry plans, 15 - 20-year-old field inventory data already exists. During meetings between SLU and RHCs in cooperation with the RHP project, ArcticHubs developed, tested and implemented a re-inventory protocol. The new system was initially introduced and put to work in Malå and Jokkmokk hubs by Malå and Sirges RHCs. Malå and Sirges RHCs represent some of the original RHCs that first digitised their RHP and carried out field inventories of their grazing lands. With the re-inventories carried out complemented with the new mobile application we can start to learn more about the relationship between changes in forest conditions and lichen cover.





3.3. Improved drawing tools in the “Mina Omvärldsfaktorer” module

RenGIS contains a number of different editing functions with the module "Mina omvärldsfaktorer", i.e. my environmental factors, being the one most in use. The module is used to map different geographical data other than what is already possible in the program or data that is not publicly available (e.g. cultural sites, predators, competing land use). Easy to use digitising tools have always been requested among the users of RenGIS. We are continually working on improving drawing and digitising tools to better fit the needs of the users. Based on demands from ArcticHubs participating RHCs we have now improved drawing tools to map reindeer husbandry land use.

3.4. Terminology definition for RenGIS

The Sami Parliament as well as many RHCs have informed us that other land users do not know or understand many of the terms regarding the grazing lands mapped in RenGIS 2.0. This could cause misunderstandings between parties during land use consultations. We therefore produced a list of reindeer husbandry terms and how these terms are defined by reindeer herders in RenGIS. This list is now published on www.sametinget.se to facilitate communication with other land users as well as decision and policymakers.

3.5. New datasets in RenGIS

To facilitate the consultations it is important that the background information about other land users is available in RenGIS and that the data is updated regularly. As part of the collaboration with the Sami Parliament, it is a yearly task by SLU to update available datasets in RenGIS. However, during the ArcticHubs project we made an effort to find new datasets presently not available in RenGIS and added those into the RenGIS database. This task was done by going through Geodataportalen (i.e. The Geodata Portal; Lantmäteriet 2024) The geodata portal is developed by the Land Survey, in collaboration with many authorities, to be a common entrance to geodata services in Sweden, it also constitutes Sweden's connection and contribution to the European geodata portal, INSPIRE Geoportal. The geodata portal is managed by the





Swedish Land Survey in its role as geodata coordinator. One important dataset found was e.g. the geographical data on moose hunting districts and moose management areas. Many RHCs are actively taking part in the yearly moose hunting, but the data sets also give information on moose hunting districts overlapping reindeer grazing areas. In addition we discovered a highly requested dataset showing snow mobile paths registered by users with GPS which gives a good overview of where snow mobiles are used (Skoterleder.org 2023). While snow mobiles could disturb reindeer, reindeer often use the tracks and could be led astray from their natural migration routes or grazing areas.

3.6. Adding data on historical land use development to RenGIS

In consultations with the RHCs, other land use interests only want to discuss impacts or changes from their specific activities and from a present day situation. The RHCs on the other hand express a need to present the effects of earlier encroachments by the specific company, industry or by other land use interests combined. When considering the combined or cumulative effects of different land users and how they impact reindeer husbandry, it is thus important to understand changes over time. Earlier studies have often used as starting point the current situation in the landscape and have not taken into account how historical events have impacted land use (e.g. Papworth et al. 2009). Which starting point do we choose to discuss and consider the overall impact on the landscape?

The first task was then to establish a reasonable starting point. We decided to choose 1886 as a starting point for mainly two reasons. Firstly, this was the year the first reindeer husbandry act was introduced, establishing the Sami peoples' legal land use rights. Thus, reindeer herding rights to land use were formalized in law and also applied to the entire reindeer herding area. Secondly, around this time the concept of individual land ownership was introduced and finalized in the northern part of Sweden. In a two-step process, there had first been a partitioning of land between the state and non-state actors, mainly village communities in a process called "Avvittring", that partitioned the land between the state and private land (villages). The next step was "Laga skifte" where village land was divided and demarcated





between individual tax paying landowners (farmers) who thereby also received forestland allocated to their properties. This introduced the concept of private property that we recognize today. Reindeer herding by the Sami did not confer land ownership rights, as they were not considered to be cultivating the land. However, Sami who owned farms had their properties determined in the same way as other farmers.

However, reindeer herders' right to move their herds to and use traditional grazing lands would be protected as well as other land use rights attached to their livelihood, e.g. hunting and fishing. At the time, reindeer husbandry and agriculture were the only land use operating on a landscape level. The reindeer husbandry act was introduced to regulate these two land use systems to secure both land use rights and to mitigate conflicts. Even if today, reindeer herding rights were to be renegotiated, it is unlikely that the concept of private property would be changed.

After 1886, the state has continuously tried to reconcile the opposing interests of reindeer husbandry and agriculture at the same time as many more interests have emerged over time. Soon after 1886 industrialization begun in northern Sweden, notably by the establishment of the mines in Kiruna and Gällivare and the consequently constructed railway from south of Sweden to Gällivare via Luleå to Narvik in Norway. These first encroachments on reindeer herding land took place without any considerations to the Sami or reindeer husbandry.

Early 20th century reindeer grazing inquiries indicate that the Sami RHC grazing areas were considered sufficient to support the reindeer herds of the time (Investigations regarding grazing conditions in Västerbotten County). Only a relatively small proportion of the pastures was unusable for reindeer grazing due to other land use activities and migration of reindeer was mainly directed by landscape features such as lakes and rivers. There were only a few man-made barriers in the landscape and the reindeer herds could move freely from the mountains to the coast along migration routes that had been established and used for a long time.

Over time, additional land users have subsequently been added within the reindeer herding area with greater or lesser impact on reindeer herding. These





encroachments on the reindeer herding area could locally have major consequences for reindeer husbandry, but the state's attitude remained that the Sami people and reindeer husbandry had to give way for the good of the nation.

After some early projects in the 1910s and 1920s, a strong and intensive expansion of hydropower began in the reindeer herding area, which did not stop until the 1980s (Össbo 2014). The dam facilities meant that large areas of pasture ended up under water, but also many Sami camp sites and settlements. In addition, the reindeer migration routes between the mountains and the coast were severely impacted because the routes were often carried out along the ice-covered waterways.

Forestry, which also reached the northern areas at the end of the 19th century, changed its character around 1950 when an intensive management system of clear cutting followed by soil preparation methods (prescribed burning and later replaced by soil scarification) were introduced (Östlund et al. 1997). The forest ecosystem produces the raw material for both forestry (trees) and reindeer husbandry (ground and tree lichens) but maximizing these products requires different management methods where, simply put, forestry prefer dense forests while reindeer husbandry prefer thin forests. This is the core issue in the conflict between forestry and reindeer husbandry and data as well as numerous studies have shown that forestry has the upper hand (Kunnas et al. 2019, Eggers et al. 2024). Lichen-rich forests have declined by ca. 70% since the 1950s (Sandström et al. 2016).

Wind power is the latest addition among land use interest with a documented impact on reindeer husbandry and there has been a strong expansion of wind farm establishments during the 21st century (Skarin et al. 2018).

The work started with available shape files in public databases. In some cases, e.g. for national parks and nature reserves, information on the year of the decision is in the database. At first, the same relationship also seemed to apply to hydropower dams, mines and wind power, but on closer analysis, it turned out that the year only applies to the most recent decision. A dam that was constructed in 1920 and then raised in several steps until 1990 is listed as 1990 in the database. Thus, each dam needed to be checked against other sources to find out the actual year of





construction. This was also possible to do for simple shape files such as the railway network. By starting from the current shape files, it was possible to date each section based on available source material.

The major and most time-consuming work was to illustrate the development of the road network, because the amount of data is too large and there is a lack of easily accessible information about when the roads were constructed. In addition, the impact on reindeer husbandry has changed radically since 1886. The roads of that time lacked cars and even when the car became more common, the road network did not pose a huge problem for reindeer husbandry. On the contrary, the roads could be used for reindeer migration but also to transport the families and the necessary equipment. After ca. 1950, however, both the cars and the road network had developed to become a problem for reindeer herding, a development that has continued with larger and improved roads to allow for faster traffic and today traffic accidents are responsible for many reindeer deaths each year.

As already mentioned, the road maps have been the most difficult and time-consuming material to work with. Complete shape files of the road network are available from 1999 onwards, but are completely missing from the time period before that. The reindeer husbandry area covers approx. 55% of the area of Sweden so mapping all roads in detail by hand every year is not possible. The strategy chosen was to focus on the major roads and try to find representative maps covering the time between 1886 and 1999. Various road maps were found, scanned, rectified and digitised in batches and those that have been completed represent approx. 1900, 1926 and 1946. Maps from each decade 1960-1990 have also been collected, but have not yet been digitised. But, since the road network was basically completed already around 1960, these maps will not differ much from the layers that are available. What has happened to the road network is that the road standard has been improved (widening, asphaltting, etc.), which has increased the problems for reindeer husbandry, but which cannot be read from the map image.

The digitisations are time-consuming, which means that accuracy unfortunately must give way. The maps used are on the same scale as the maps described for the



historical reindeer husbandry maps. The idea behind the mapping is the same, i.e. that they should be used to give an overview of the total land use over time and not to zoom in on a certain point, which several RHCs had requested. The maps can of course be used as a starting point for such a study.

Not all land use is mapped. The project has focused on the land use interests that have had and still have the greatest impact on reindeer and reindeer husbandry, such as mines, hydropower and forestry. Such data sets would also benefit the RHCs the most in connection with consultations with these and other land users.

In RenGIS 2.0 it is possible to create land use maps for specific years by changing the year in the theme properties of the shape files. This function is currently not available in RenGIS 3.0. Pending a technical solution for this matter, a number of representative maps have been created and are supplied as images that can be used in presentations or for other information purposes.

The goal of showing the historical development of the competing land use within the reindeer husbandry area is to allow the RHCs to illustrate the possible encroachments that have occurred and to be able to explain the adaptations that have been involuntarily forced upon the RHCs.

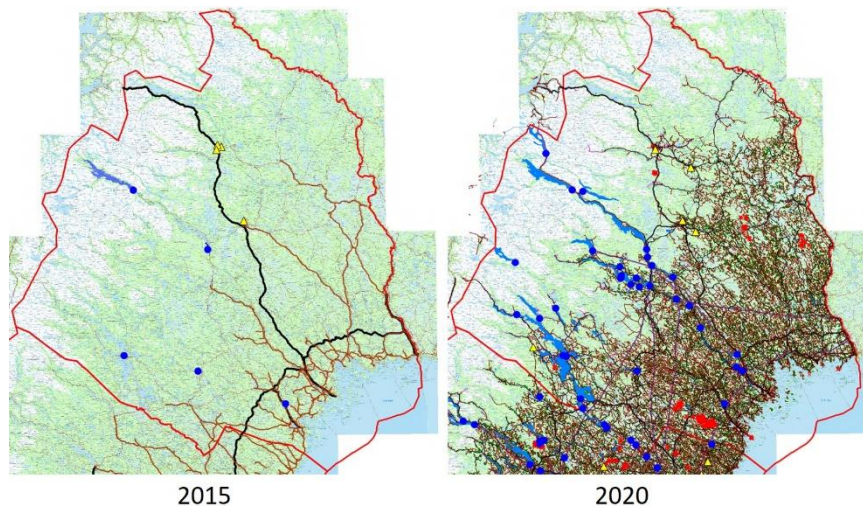


Figure 2. Industrial development of Norrbotten county using RenGIS as a tool



The goal of showing the historical development of the competing land use within the reindeer husbandry area is to allow the RHCs to illustrate the apparent encroachments that have occurred and to be able to explain the adaptations that have been involuntarily forced upon the RHCs.

Figure 2 also illustrates that major changes have already taken place a long time ago and that contemporary expectations of a new industrial wave can be difficult to implement without major problems for reindeer husbandry, as the room for adaptations and rationalizations has begun to run out.

3.7. Historical RenGIS

Reindeer husbandry rights have strong legal protection in Sweden and are based on claims from time immemorial. However, the outer boundaries of the reindeer husbandry area have not been strictly determined (SOU 2006:14). The implication in Sweden is that if a property owner challenge reindeer husbandry rights on the property in question, the burden of proof is placed on the RHC (Melin and Wikland 2014). Subsequently, reindeer husbandry land use rights have often been challenged by other land users and court rulings have been both positive and negative for the RHCs involved. Even if the RHCs have adequate mappings of reindeer grazing lands presently in use they do not have maps of past reindeer husbandry.

Fortunately, a large number of Government Inquiries and other compilations have been carried out in Sweden over the past 140 years with the aim of describing and mapping reindeer husbandry land use, mainly focusing on reindeer pastures and migration routes. Unfortunately, the original maps are difficult to access and are so far often not available in digital format. During the work with the reindeer husbandry plans, some of the historical original maps have been collected in the form of scanned or digitally accessible copies.



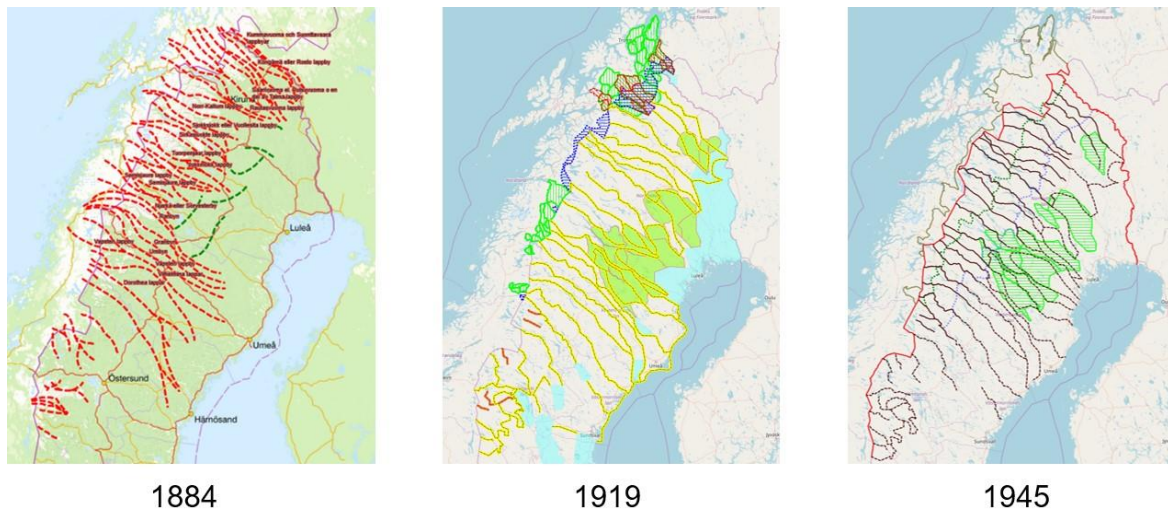


Figure 3. Examples of digitisations of three early maps of the reindeer husbandry area.

We have therefore digitised some of these maps and adapted them to RenGIS 2.0 (Historical RenGIS, Figure 3).

These maps were first rectified to fit modern background maps and the information on the maps was manually copied (drawn) and compiled as shape files using an ArcGIS program. Where there were no original maps available, the digitisations (Sami Parliament, not publicly available) carried out as part of the Government Inquiry on traditional Sami lands (SOU 2006:14) have been used. During the work of digitising the maps, we noticed that our digitisations often differed from the digitisations that were carried out in connection with the work that later formed the basis for the final report (SOU 2006:14).

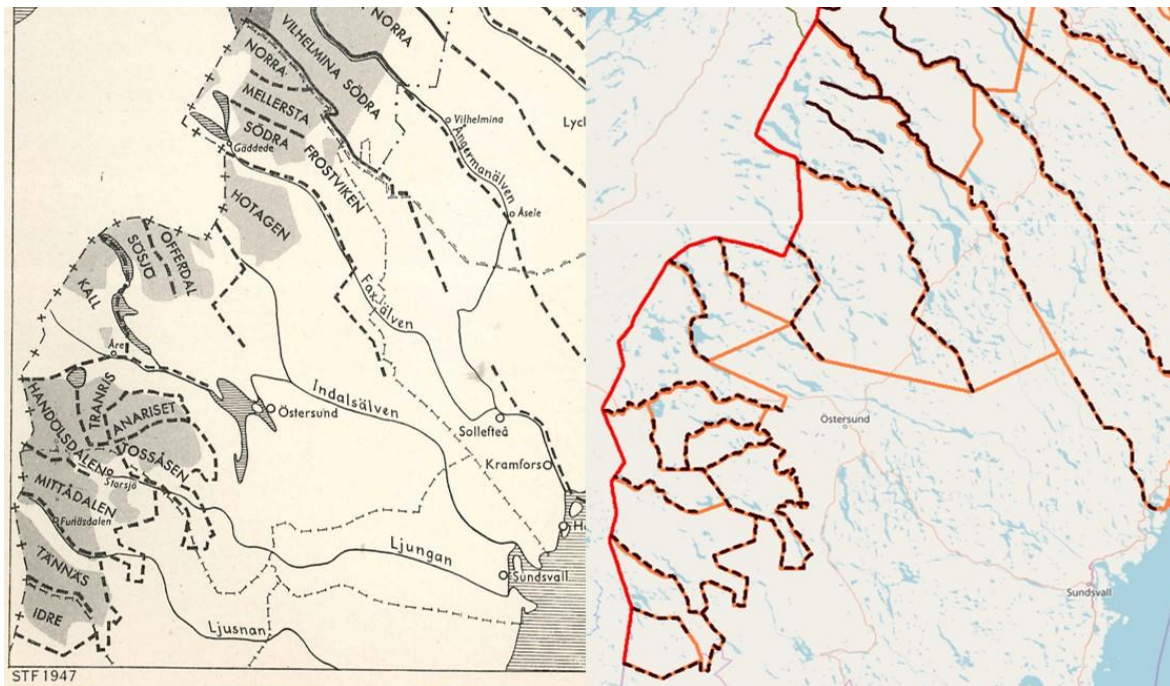


Figure 4. Left) Manker's original map. Right) orange lines depict the digitisation used in the Government Inquiry; black dotted line is the digitisation by SLU.

These differences have apparently been added during the digitisation event, as they are not found on the original maps (Figure 4). It is unclear why this discrepancy exist but it illustrates the importance of this map material being available to the RHCs.

The strategy of the digitisation was simply to copy the original maps as far as possible. Therefore, the lines, polygons and symbols produced in the shape files have been chosen with the aim of being as close to a copy of the original map as possible. Colours, symbols, lines, names and legends were consequently chosen to mimic the original map to facilitate a potential comparison with it. Adjustments were however inevitable as the maps must also be clearly visible in RenGIS. However, it should be noted that even if what is shown digitally in RenGIS is an exact copy of the original map, it does not imply that the original map was correctly drawn in the first place.



Furthermore, there are some important aspects to take into account when using the digitised maps.

1. The digital maps are not an original source, which means that various errors may unintentionally have been added. However, there are references to the original maps so that they can be compared to the produced digitisations.
2. All the original maps are schematic and often made in a standardized manner, which means that borders and positions must be considered approximate. In digitising, the ambition has been to try to recreate the original maps, not to reconstruct the real situation.
3. In order to transfer the original map information, the map must first be rectified, i.e. be fitted onto a modern map. Since the older base maps often appear to be standardized, it is often necessary to process them quite heavily in order for them to fit. This process makes the digitisation itself more accurate, but can also introduce inaccuracies.
4. Sometimes, the digitisation did not follow the layout of the original map. This applies, for example, when several different lines coincide, e.g. overlapping RHC boundaries, roads, waterways or migration routes used by several RHCs. On the original paper map, these lines have been drawn parallel to each other to make them visible. However, during digitisation only one line was selected.
5. In some cases, "errors" in the original map have been corrected during the digitisation, but only if they are errors that clearly occurred during the drawing itself, corresponding to typos in a text.
6. The maps have been made for different purposes, while the meaning of words and designations have varied over time. Even if the maps accurately reproduce what the Sami have told, it is not certain that the cartographer understood what the meaning was. It is also not obvious that we today have the same understanding of what the words meant at the time. What is designated as migration route in 1914 is probably not the same as a migration route today. The same applies to the RHC boundaries, which have had different functions over time.



Finally, every map of the reindeer husbandry area has been produced for a purpose of the state (SOU 2006:14) or has been part of Ernst Manker's extensive documentation for Nordiska muséet (Manker 1953, 1968). None of the maps were produced as a consequence of a demand from the Sami collective. Therefore, the maps are inevitably an outsider's view on what constitutes the Sami people and reindeer husbandry. The state policy aimed to separate the indigenous Sami population from others and at the same time decided who belonged to the defined Sami group (Axelsson et al. 2018, Sametinget 2021). The Sami people became synonymous with reindeer herders excluding other indigenous livelihoods like hunting, fishing or small-scale farming, which is then missing from the produced maps. The state have also been the decider of what proper reindeer husbandry is or should be and this has also varied over time (Löf et al. 2022).

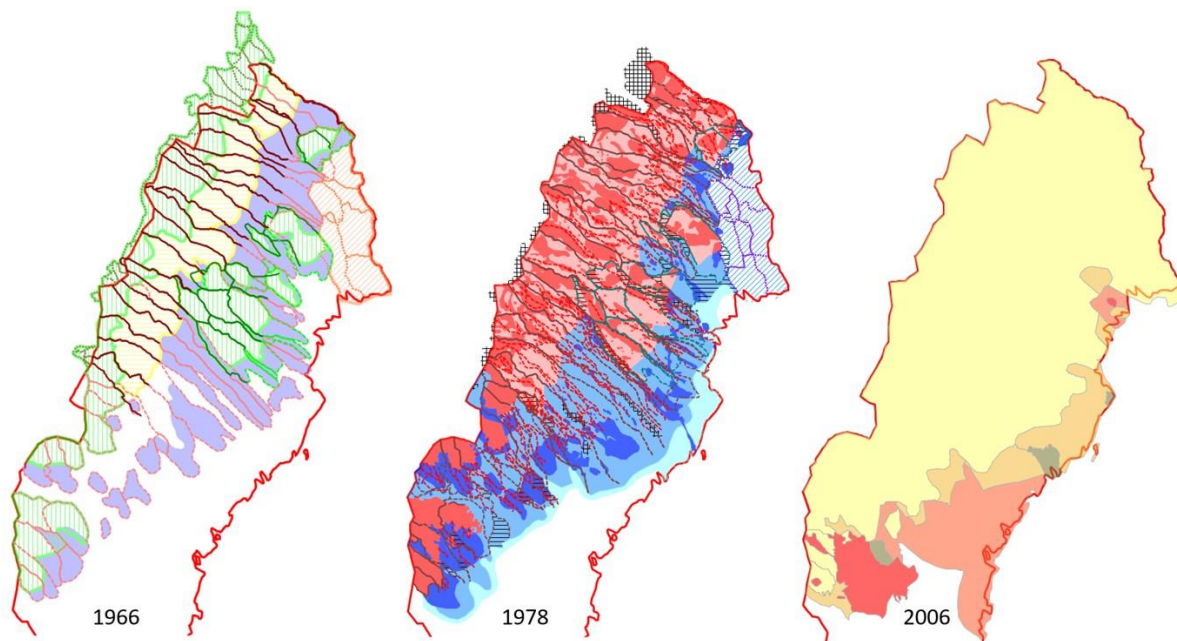


Figure 5. Digitisations of the three latest mappings of the reindeer husbandry area. The 2006 map is part of SOU 2006:14 and was already publicly available as a shape file.

The maps are usually made with a specific aim e.g. to support new legislation which means that not all aspects of reindeer husbandry have been taken into account. The maps tend to be similar but still different so it is important not to use them out of context (Figure 5).



Very few of the inquiries or maps have been shared or distributed to the RHCs, despite the fact that many reindeer herders were involved as informants or contributed in some form. The created maps with associated texts have since been used as a basis for important decisions and legislations that have had a dramatic impact on Sami society without the Sami themselves having had anything other than representative insight into the processes.

This is a first step towards bringing all this knowledge back to the Sami RHCs.

Just like the reindeer husbandry plan, Historical RenGIS is an ongoing process where new data, new details, better digitisations and other changes are continuously added. Therefore, there is always a date added to the project name showing when the last change was made. Thus, the user can see which version is the most recently updated. The various maps that have been digitised follow in chronological order from the so-called Hahr's map 1883 up to and including the Government Inquiry of 2006. Altogether, almost 140 years of history are presented in different shape files that can be combined with each other or displayed together with the present RHP, the RenGIS environmental database or data from a competing land use interest in a consultation procedure.





4. Using the new tools in ArcticHubs

In this section, we will briefly describe a few examples where the new functions have been tested in real life cases in the Swedish hubs. The researchers have not been involved in the consultations per se, only provided needed data using the new RenGIS tools.

Kiruna, consultations with mining industry

The researchers were approached by Gabna RHC who asked if we had access to maps showing historical encroachments of reindeer grazing lands around Kiruna where LKAB operates mines dating back to the 1890s.

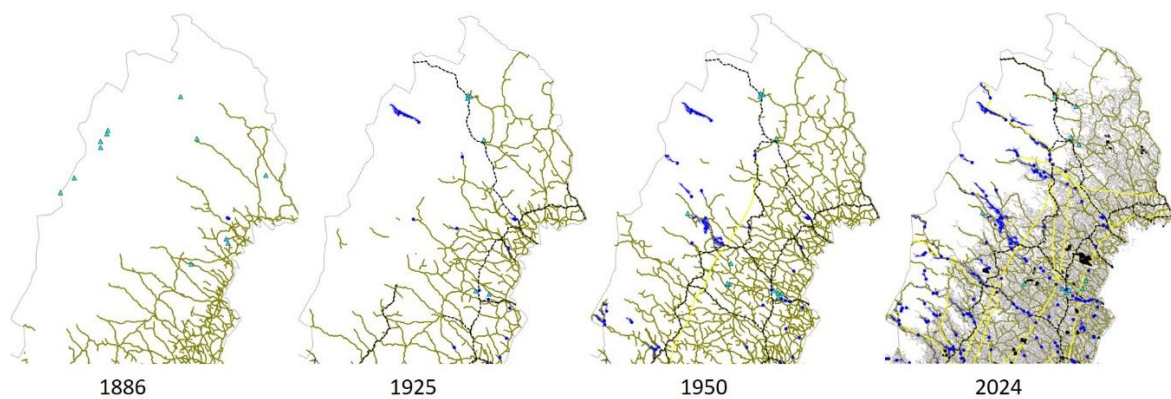


Figure 6. The industrialisation of Norrbotten county 1886-2024.

The data was needed for an environmental court proceeding, where the RHC wanted to emphasize that large areas had already been historically lost and that this should be taken into account in the present case. As a result, we sent a figure produced in RenGIS illustrating the industrial development of northern Sweden (Figure 6) using the compilation of historical land use. However, the court decided to rule in favour of the mining company.

In a separate occasion and during the finalizing of this report (May 29 2024), the Sami Parliament contacted the researchers about the planned opening of the Gállok mine in the Jokkmokk hub. During consultations with other authorities, the question had been raised whether the Sami Parliament had any available information on the



historical industrialization of the region. The same maps as above were sent to the Sami Parliament as it was exactly what was requested (Figure 6).

Gällivare, consultations with mining industry

Results of mappings produced in "Mina omvärldsfaktorer/My environmental factors" in cooperation with Gällivare RHC describing seasonal use and movements of reindeer in 1960, are shown in figure 7, and illustrates reindeer use in the Aitik area prior to the development of the mine.

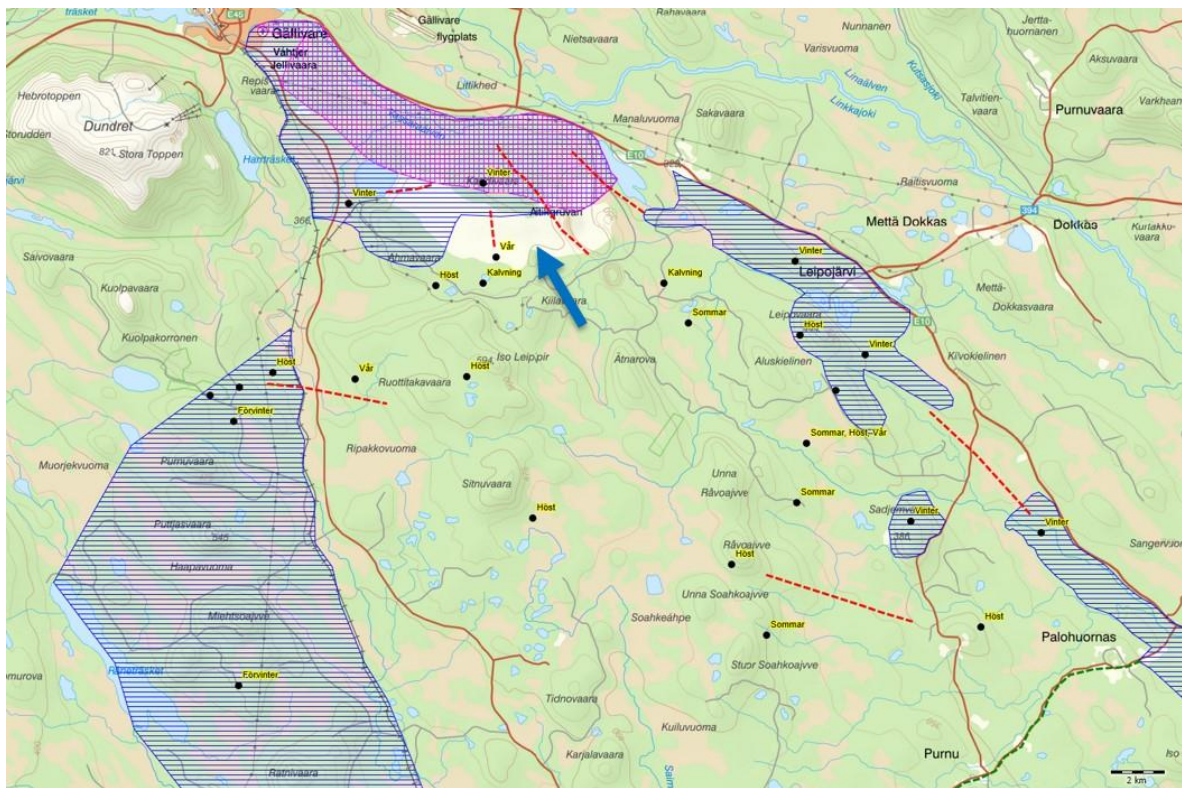


Figure 7. Co-produced map by SLU and Gällivare RHC. Polygons show important grazing lands 1960, red lines show migration routes used 1960 and seasonal lands 1960 are indicated with a black dot and the season name (in Swedish). The blue arrow indicate the present day Aitik open pit mine in white.

The data illustrates both the grazing areas that have been lost to the industrial area including the mine, but also that the links between grazing areas have been cut off. In addition, the co-produced map was almost identical to the digitised historical map of the RHC dating from 1948, supporting the validity of both maps.



Gällivare RHC also received maps of the historical land use development in the area to be used in consultations with the mining company Boliden AB and with forest companies. The RHC contacted the researchers from SLU asking if it would be possible to specifically highlight the recent development of the forest road network because that would be a good indicator of how forestry has changed the reindeer pastures. Forest roads are used to transport the logs by trucks from the felling site to the next destination. The traffic itself is seldom a problem, but the road network fragment the grazing lands and invite the reindeer to move away from their location, sometimes ending up on a connecting major road where they risk being killed by traffic. This prompted us to specifically look for available shape files and it was possible to retrieve data from 1999 and onwards. The data clearly showed that there had been an extensive development of the road network during this 20-year period confirming the RHC's perception. The forest road data was then compiled and sent back to the RHC to be used in the consultations and shape files covering the total reindeer herding area were subsequently added to the historical land use database.

Ängeså, Cultural heritage project

Ängeså RHC, overlapping the Gällivare hub, used the digitised historical maps in an effort to localize and document older sites used in reindeer husbandry with the purpose of proving Sami presence in the area covered by the community. One of these sites was identified and included the remains of a Sami hut (Figure 8) and reindeer fences.





Figure 8. Remains of a Sami hut. Foto Anna-Carin Mangi.

An archaeologist later documented the site and concluded that the constructions were at least 100 years old (Mangi 2022). Many other sites were visited by the RHC, but those sites had already been destroyed by modern forestry activities, predominantly soil scarification. The problem with forestry unintentionally erasing traces of past Sami activities is a well known issue (Andersson 2022), again emphasizing the importance of digitised historical maps which in many cases are the only “proof” of Sami presence in an area, especially where Sami presence is currently disputed.

Gällivare/Jokkmokk, Legal case

In an area between Luleå and Boden within both the Gällivare and Jokkmokk hubs, Sami reindeer husbandry has been challenged by a number of private property owners. The area was regularly used as winter grazing lands until ca. 1900 when the visits ceased for unknown reasons. Reindeer returned to the area in 1967 during an exceptionally bad grazing winter, but due to shrinking winter grazing areas further inland, the grazing lands are used every year since ca. 2000. According to Swedish



law the RHCs now have the burden of proof to explain if and why the grazing lands were not used between 1900-1967 and that this choice was not a voluntary one. Maps from the ArcticHubs project was combined in RenGIS to illustrate the historical reality at the time (Figure 9). Contemporary sources suggest that the arrival of the railway in 1890 through this area is the reason the reindeer herders moved away from their grazing lands.

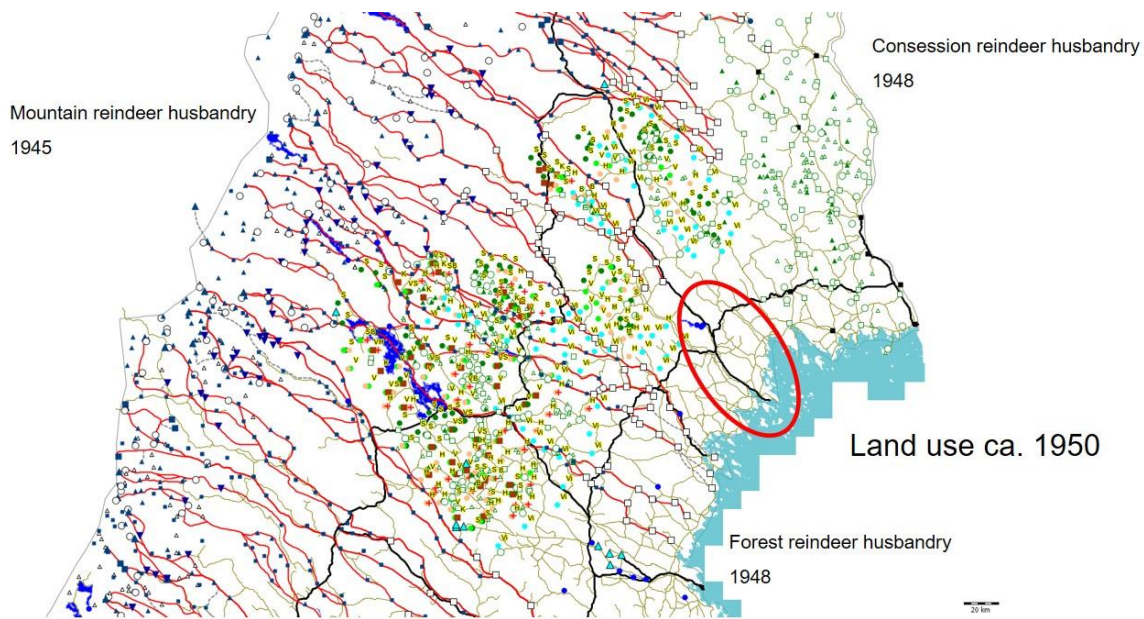


Figure 9. A combination of four historical maps illustrating the landscape ca. 1950. The red circle indicate the disputed area between Luleå and Boden.

The maps could support this argument, as there seemed to be enough winter grazing lands available for both the mountain and forest RHCs north-west of the area in question. Further south, where the forest RHCs occupied most of the inland forest area the mountain RHC still needed to cross the railway to reach the coastal grazing areas.

Malå, consultations and ArcticHubs Future Forum

Malå RHC in the Malå hub have also expressed the need for maps showing the extensive exploitation from other land use interests. Historical maps from ArcticHubs describing both reindeer husbandry and other land use development have been





made available to the RHC to be used in consultations with the mining company Boliden AB and the state owned forestry company Sveaskog (Figure 10).

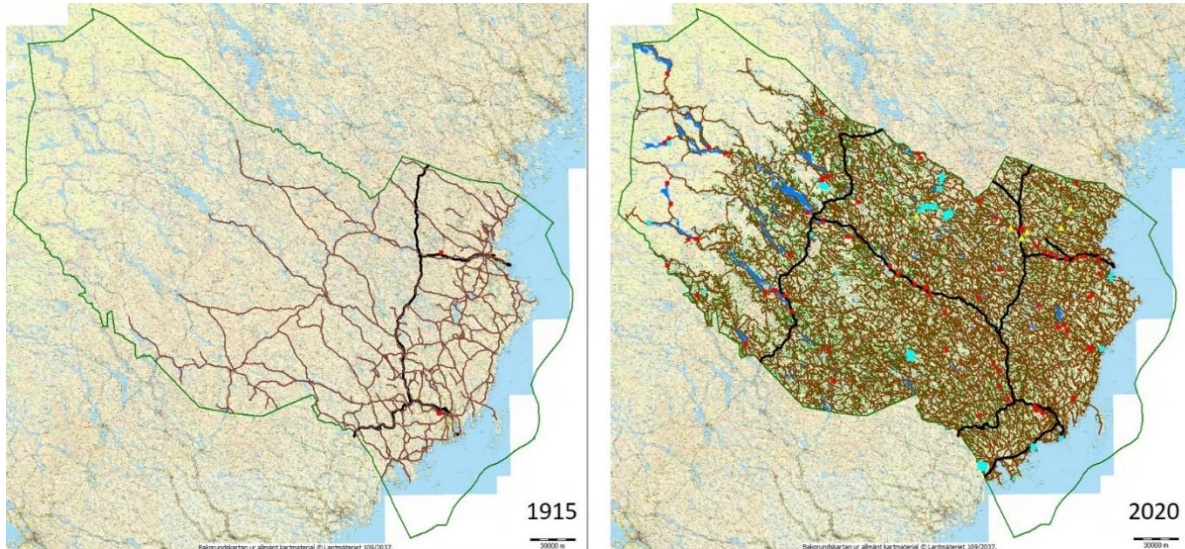


Figure 10. The industrialisation of Västerbotten county including the Malå and Gran hubs.

The maps were also used in the ArcticHubs Future Forum held in Malå June 3-5 2024, where the maps were used during the discussions with different stakeholders in the hub. The maps illustrate the geographic complexity of different land use and how land use has developed over time within the Malå hub. This was nicely supported by the Malå DPSIR figure (D 2.5 ArcticHubs), which supports the complexity of how different land use interests impact each other.





5. Conclusion

ArcticHubs has contributed in several ways to the development of the new version of RenGIS 3.0 (Table 1). The work has been carried out in close cooperation between SLU, ArcticHubs partner Gran sameby, participating RHCs in each hub and many other RHCs not involved in the project. The new data sets and applications in RenGIS build on earlier experiences with development of user-friendly modules and tools. Testing and implementation of new modules and tools have been tried, tested and evaluated by ArcticHubs participating RHCs.

New module or function in RenGIS 3.0
New mobile app for cell phones for field data collection
New field inventory methods and a system for re-inventorying field plots
Improved drawing tools in the “Mina Omvärldsfaktorer” module
Terminology definition for RenGIS
New datasets in RenGIS
Adding data on historical land use development to RenGIS
Historical RenGIS

Table 1. New modules or functions developed as part of ArcticHubs

During the test and development phase, data produced is owned and controlled by participating RHCs and SLU. Developed methods and tools will eventually be available via the Sami Parliament and thereby available to all RHCs as well (Figure 11). During consultations with other land use interests the data will be part of the information exchange and thereby serve the broader societal interest. The specific SLU created data apps will be made public via the Sami Parliament if it is in accordance with the open data policy and ArcticHubs data management plan.





Home Galleri Karta Sida Grupper Evenemang Organisation

SLU Sanktandén 04/2023

Applikationer för Samebyar

-> Använd "RenGIS 3 - App" om du vill se eller redigera din renbruksplan.

-> Använd "Renbruksplan Karta" om du vill ha full funktionalitet och kunna bygga egna kartor, lägga till egna lager, ändra utseende och spara dina ändringar.

<p>Web Mapping Application Omvärldsfaktorer 2023 APP</p>	<p>Web Map Renbruksplan - karta Det här är huvudkartan som används vid arbetet med Renbruksplaner.</p>	<p>StoryMap Renbruksplan 3.0 Utbildningsmaterial för dig som vill bekanta dig med de verktyg som finns i applikationen.</p>	<p>Web Mapping Application RenGIS 3 - App</p>	Land Use History
<p>Web Mapping Application SMHI 2018 APP</p>	<p>Web Mapping Application SNÖ 2021 SMHI App</p>	<p>StoryMap Theme Utbildning Tema</p>	Reindeer Husbandry History	

Figure 11. The start page of RenGIS 3.0 with current apps. The plan is to add land use history and reindeer husbandry history as integrated apps.





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Further access to specific information about RenGIS 3.0 in Swedish;

Link to RenGIS 2.0: <https://www.sametinget.se/renGIS>

Link to RenGIS 3.0: <https://gisportal.sametinget.se/portal/home/>

Link to RenGIS 2.0 manuals: https://www.sametinget.se/RBP_manualer

Link to instruction films: https://www.sametinget.se/RenGIS_film

Link to information films: <https://www.sametinget.se/informationsfilmerRBP>

