

Spatial land-use accounting for climate action

Guro Voss GABRIELSEN, Norway

Key words: land-use, spatial planning, climate change

SUMMARY

The green transition has increased the need for new sources of energy. Green industries, such as battery plants and wind turbines, have a massive land-use footprint. The nature's own great keepers of CO₂, such as swamps and old forests, decline. Settlements are flooded and cultivated land become scarce. In short: The battle of land is increasing.

The world is aiming for net zero climate emissions in 2050, and most analysis' build on the premises that rich countries, such as Norway, and countries with the best opportunities for collecting or storing carbon, need to reach net zero before 2050. That's impossible without conscious land use and spatial planning.

This paper present some of today's incentives for land accounting and some key components in building a land account. It elaborates on how accounting contributes to surveying past, present and future land use. Lastly it makes space for some notes on what it takes to make land accounting useful for both the national statistics and the local planner.

Spatial land use accounting for climate action

Guro Voss GABRIELSEN, Norway

1. SHARED CONFLICTS

Buy land, they don't make it anymore, said Mark Twain. And he was right. There won't be any more land available than there is today. And it is needed for several different things, all at the same time. An increasing population needs food and water, and the green transition demands new energy sources. At the same time more land than ever is flooded or dried out because of climate changes.

Land use and land use changes are fundamental for sustainable resource use and the delivery of ecosystem services, including the provision of food, nutrient cycling, and climate change mitigation. The green transition means a shift towards economically sustainable growth and an economy that is not based on fossil fuels and overconsumption of natural resources.

There is, however, a potent conflict of interests embedded in the green transition. Leaving fossil fuels will inevitably lead to the need of other energy sources. Most of them in the need

for new land. As such, the word “overconsumption” is key. How many mines, wind turbines or solar panels can one build in the nature before it is overconsumed?

In this paper, I will share some of the conflicts we are facing in Norway, and how land use accounting may enlighten the decision making. Land accounting requires uniform and harmonised data on gains and losses in different land categories. We find it key that the data used, and the APIs provided, must be tuned to the ones used for spatial planning.

One may ask, what’s in it for me reading about conditions in as far north as you can get? Not a bad question as there are of course differences between countries around the world. It seems however, that land use conflicts have a lot in common. Ghana is, for example, the second largest producer of gold in Africa. In addition, the country has rich resources of diamonds, manganese, limestone, and bauxite, as well as fertile soils and forest. Often, mining for minerals conflicts with preserving the forest and its wide variety of species, as is the case in the Atewa Forest. The same goes for Norway. Different kind of forest and different minerals, but they provoke the same conflicts. What’s the best use of the land we’ve got?

2. WHAT YOU HAVE IS WHAT YOU GET

To account for land is making spatial foundations for policies. Land accounts can inform land and resource management, conservation policies and land tenure. Land accounts can answer several crucial questions for spatial planning.

The distribution of and quality of, different types of land is bottom line for all spatial planning. If a land account is repeated over time, it may provide insight into what the trends of land use is, what is lost and what is gained over the years, and what type of transformation is most common. When combined with data from physical spatial plans in progress, it may show the effect of a plan on different types of land use and how much space is left over for future development. When combined with datasets on wildlife and natural species, land accounting can visualise information on concentration of different species, how much of their habitat is taken and how much is left.

And when combined with knowledge of soil and vegetation, land accounting can answer important questions concerning climate emissions. The planner can then see the location of areas rich on carbon (such as wetlands) or areas rich on carbon consumers (such as forests), and how much carbon needs to be collected elsewhere if a specific area is developed and we’re still.

2.1 Land conflicts in a Norwegian context

As an introduction to land accounting, this story is told from the land I know best. All countries will have their own conflicts of land. Yet, we all share the knowledge of loss and gain.

growth, some stability, and yet others a population decline. Only 1,8 % of the total land in Norway is built-up land and most of this is infrastructure, housing, industry, and secondary homes. In addition, 3,5 % of the land is used for agriculture. Most of what is not built-up, is covered with mountains, plains, and forest. Herein space where animals, such as sheep and reindeer (both wild and livestock), graze. To limit climate emissions, guidelines for urban development have for a long time been densification and transformation, rather than urban sprawl. Protection of agricultural land is high on the agenda, not least because it has been steadily declining over the years.

2.2 Reduction of nature diversity

Early January this year, the Norwegian Broadcasting Company reported a detailed map showing that between 2017 and 2022, no less than 44 000 land use interventions in valuable

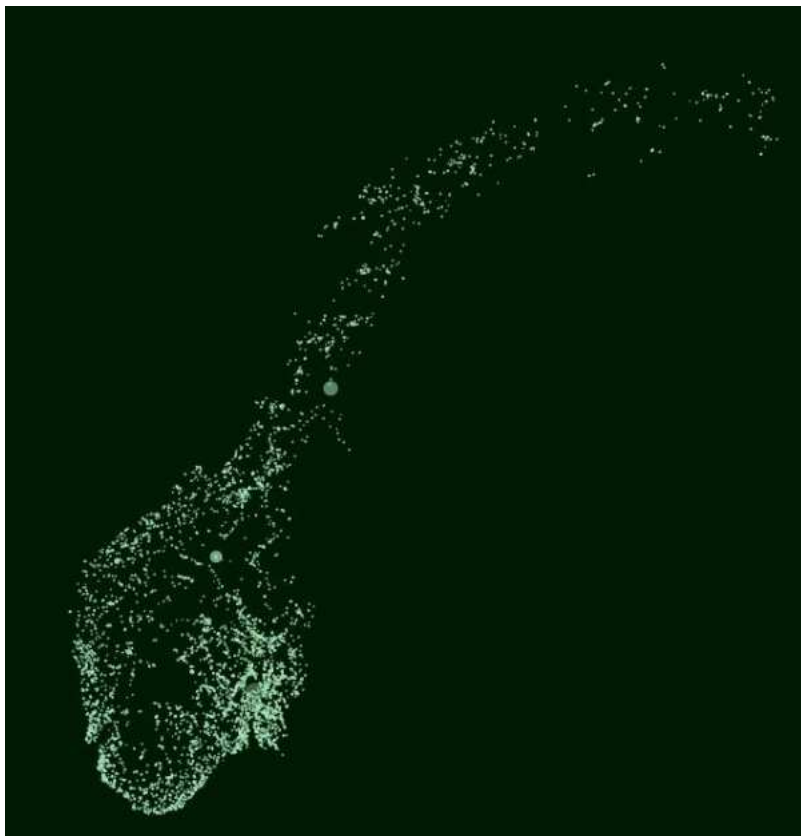


Figure 2 Intervention in valuable nature (NRK, 2024)

nature took place in Norway (Støstad et al. 06.01.2024). Using artificial intelligence as well as investigative reporting, the journalists could point to that almost every municipality reused valuable nature for different purposes despite strict guidelines from the government that nature needs to be protected.

Each municipality is only guilty of reusing a little bit of land, and as such it doesn't seem like a big deal. It is the total that is devastating.

In most cases, the municipalities have good reasons for wanting to reuse land. Industrial fields,

housing and green energy creates local workplaces and income. It is in fact a

classical dilemma of the need on a local level, where people live their lives, versus the state's need.

In the debate that followed, a regional and national spatial account of nature diversity was called for.

2.3 The green but also greedy, transition

The climate crisis has created a need for a green transition. The green industry, however, demands a lot of space. Wind turbines, battery parks, hydrogen, mining, and green data centres, are ways to reduce climate emissions. But if the land used for such green industries used to be nature collecting carbon, we have an issue of calculation. Wetlands and forests are two common types of nature in Norway that store a lot of CO₂.

Wetlands are vital for human survival as they are among the world's most productive environments. Norwegian wetlands constitute about 5 % of the total land area but stores at least 950 million tons of carbon, which is equivalent to about 3500 million tons of CO₂. In addition, 47 out of Europe's 50 different sorts of moss, is to be found in Norway, and they are home to more than 3000 species (NIBIO, 2018).

Just like wetlands, the forest is an important part of the global carbon-cycle. Both as a storage and through absorption of CO₂ in the atmosphere. In 2021, the net absorption of CO₂ from Norwegian forests were 20,4 million tons. Most of the storage is found in areas that has been a forest for more than 20 years. In other words, replanting does not hold as much carbon as an old forest.

Wetlands and forests are two types of natural efficient green agents that very often come short to green industries. Wind turbines, mining, and battery parks is seldom, if ever, located in populated areas. They need space, and the space is found in nature. When calculating the actual impact of the new green industries, the land it is built on should be taken into consideration. To do that, a land account is asked for.

2.4 The case of secondary homes

Norwegians love spending time in the mountains or along the coast and, together with the other Nordic countries, have a strong tradition for secondary homes.

Secondary homes make an interesting case for land use conflicts. As shown on the map to the left, many of the secondary homes are located in scarcely populated areas. Traditionally, a

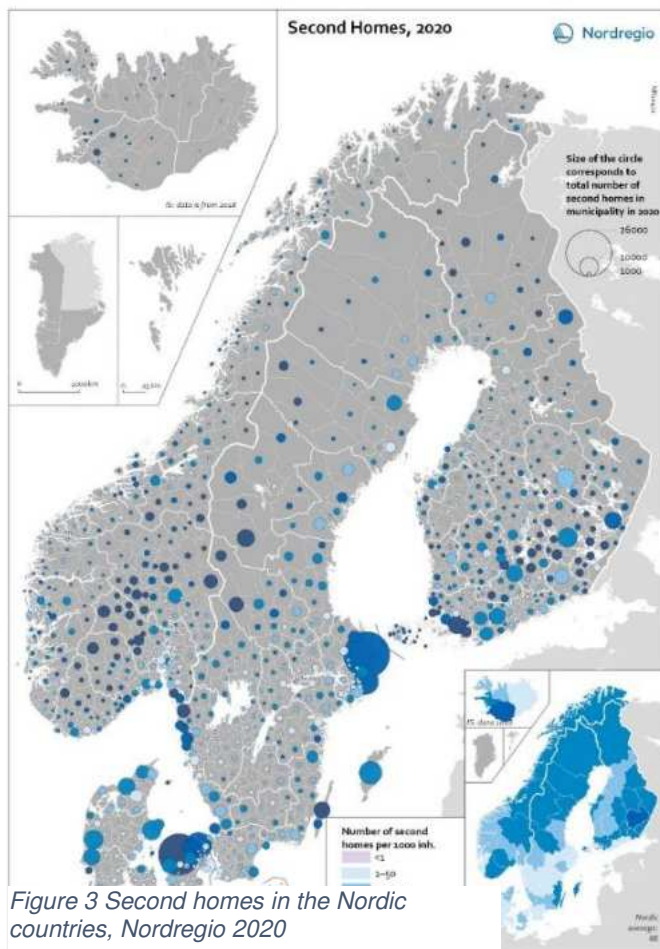


Figure 3 Second homes in the Nordic countries, Nordregio 2020

Norwegian secondary home, would be a of moderate size and standards. Typically, about 30 to 40 m². Many of them without running water or electricity. Over the last decades that has changed significantly, and secondary homes built after 2020 have an average size of 96 m², but 120 – 150 m² is not unusual either.

While the traditional secondary home was located on a lonely spot that could only be reached by car in the summertime. The new secondary homes are built as small villages with the standard of an ordinary house. On the one hand, building in clusters is land efficient but on the other hand, modern infrastructure and the number of buildings is not. In addition, most Norwegians use their secondary home to be in nature, and as such trails for hiking and skiing occupies vast areas. Not to mention the alpine slopes and its logistics.

Most municipalities welcome the establishment of secondary homes as it brings people and business. Some places the number of inhabitants in the secondary homes outnumbers the permanent inhabitants by far. The building of secondary homes on new land very often results in a conflict between the need of a prosperous development in the local community, and natural diversity.

As the municipalities are the spatial planners in Norway, the need to see beyond borders is key. Every municipality may only want to reuse a little bit of nature to secondary homes. And as such it doesn't seem like a big deal. But when a lot of municipalities only want to reuse a little bit, it adds up to rather a lot. We need to look beyond borders to grasp the full picture of our land use.

3. LAND USE ACCOUNTING

Land use accounting is nothing new. What is new is the opportunities offered by technology and digitalisation. The UN is working on land accounting, the European Union does it, and most countries work on how to translate these into national accounts. Same goes for Norway, but in addition the Ministry of Local Government and Regional Development seek ways to make this useful for municipalities. A national report on, let's say land used for agriculture, is valuable for comparing the development in different countries. But it is not detailed enough to provide local and regional planners with the information they need.

The Ministry of Local Government and Regional development has just launched a manual to municipalities on how to use land accounting in spatial planning on a local level ([Bruk av arealregnskap i kommuneplanprosesser - regjeringen.no](#)). The ministry recommend that all municipalities create a land use account.

3.1 For all practical purposes

The terms land cover and land use are present in most land accounts. They are however, somewhat overlapping.

The UN defines land cover as “The observed physical and biological cover of the Earth’s surface and includes natural vegetation and abiotic (non-living) surfaces” (Ying Chan, 2017). Current land cover is then seen a function of natural changes in the environment and of previous and current land use. Land use, on the other hand, is defined as to “reflect both a) the activities undertaken and b) the institutional arrangements put in place; for a given area for the purposes of economic production, or the maintenance and restoration of environmental functions” (Ying Chan, 2017). Land that is “used” implies existence of some human intervention, including active management, e.g. protected areas. These classifications is based on a system (FAO), developed for use in Arica. The authoritative reference today is ISO standard 19144-2. The same specifications goes for s INSPIRE in the European Union .

The divide between land cover and land use is somewhat academic. For most practical purposes, the two dimensions are mixed in most mapping programs, such as the European Environment Agency (Strand and Arnold). In the context we’re talking about here, municipality’s ability to include land accounting in their spatial planning, we’re openly mixing the categories based on a utility value.

Keeping the land account broad and simple is not the same as simplifying the data themselves. The infrastructure of spatial data in Norway is based on a well-developed partnership between different public partners. Data is harvested from the data-owner and shared on a national website for map data and other location information in Norway, called [Geonorge](#). Users of map data can search for any such information available and access it there. For instance, the owner of dataset for predator management areas is The Norwegian Environment Agency, for avalanches it is the Norwegian Water Resources and Energy Directorate, and for distribution of marine mammals, it is the Institute of Marine Research. Planners are free to use all these datasets and does so when making spatial plans.

As already noted, Norway is in the making of ecosystem accounting according to the UN standard (SEEA EA). The standard provided from the UN is a giant leap from traditional accounting standards based on values and goods created by humans. With time, it is likely that all countries in the EU and EEA will report data for a European ecosystem account through Eurostat. There is an ongoing process on which datasets are needed. To align a local planning process with the national commitments for reports to the EU and the UN, we keep a close watch on these processes.

3.2 Land accounting in spatial planning processes

The Ministry of Local Government and Regional Development has been working on land accounting for spatial planning for a while. The municipalities need to consider all land use in their planning, also nature.

The aim is to make it easier for the municipalities to understand and communicate the amount of land that is about to be developed, and what this land consists of in terms of for instance agriculture and biodiversity. Put together with population forecasts, a land use account can contribute to a critical review of the local land use and support spatial planning processes.

A mapping of different practice in the municipalities showed us that a map-based land use account can improve the dialogue between local and regional authorities, public and private sector, and between local management and the inhabitants (Rambøll 2020). Such an account can contribute to an increased mutual understanding of available land and the rules and regulations involved. In connection with the sustainable development goals, a land use account can prove helpful for keeping track of what has been achieved and what's left to reach the goal.

However, to prove a successful tool, it is crucial that the intention behind a land use account is obvious for everyone involved. Such a tool must provide the municipalities with an overview of the potential in development areas, and at the same time set a value to the areas before and after development takes place. Developing tools for better land use accounting, is also linked to work undertaken on calculating the climate gas emissions. The Norwegian Institute of Bioeconomy Research, the Norwegian Environment Agency and Statistics Norway calculates the yearly climate emission and capture for Norway, and report it to the UN National Inventory Submissions Report ([National Inventory Submissions 2023 | UNFCCC](#)).

The Norwegian Ministry of Local Government and Regional Development now recommend that all Norwegian municipalities make their own land use account as part of their municipal planning. Several municipalities have already done it, some of them in a very detailed matter, but some have also just begun. Making a land account can be done in several ways, and there is no correct answer to how it shall look or what it should contain. Our main concern is that datasets from the national platform are used. Municipalities that want to, and have the capacity to do so, may of course add local datasets that matters to their development.

The manual we have developed provides answers to questions such as: What is a land account in connection with spatial planning on a municipal level? What should it contain, how to use it and how to communicate it. And what sources of data do we have?

Spatial plans must be realistic and possible to carry out. There's a lot happening around land use accounting, and we will update the manual continuously. The municipalities are the prime users, and the ministry has therefore a link on the website for feedback.

4. LAND USE ACCOUNTING, STEP BY STEP

In this section, I'll go through the manual to land use accounting that we've made for local planners. And I'll do it just like it's done in the manual itself; simple, practical and step by step.

First step on the way to making a land account, is to agree on the terminology. That may be harder than it seems. Different public bodies use somewhat different words to describe the same matter, and even datasets. A second home is for instance not classified as a second home in all registers, and built-up environment should be classified in terms of what is included and what is not. Making a list of the terminology used in your land account is a baseline for a manual.

4.1 Why make a land use account?

Why make a land account may not be totally obvious yet still good to point out. In addition to the use noted above we have, based on a pre-study, emphasized the use in communication. Both to the public and between planners and politicians. In our web site version of the manual, we have also highlighted some thematic words for each chapter, so that it will be easier to use as an encyclopaedia.

The two main aims of land accounting for spatial planning on a municipal level are:

- the need for an updated and agreed on base of knowledge that sums up what use is present in each area and what future use is regulated in existing masterplans
- to be a planning tool before deciding future land use

As a base of knowledge, the land use account gives an overview of actual land use today, and as a planning tool it is used to make well founded decisions for future use. The land use account can be used to underscore:

- characteristics of different areas within the space set aside for development but not yet built, in the municipal masterplan
- whether or not the need for building is aligned with the size of land regulated for it
- size and qualities of areas suggested for development, to better consider the sum of influence a plan might have

Our manual is a first version. There are a lot of themes that can and should be included in a manual to land accounting, and we've therefore made some notes on what this version can

and cannot give to a local planner. As we've set out with housing, secondary homes and nature, the manual is specially useful for describing and showing the change of land use on cultivated land and valuable nature.

4.2 How to communicate?

This part of the manual is meant to help the planner in participation processes and when communicating with the politicians. Conscious approach to the use and communication of land accounting is important as it can provide a better understanding of the situation and support for sustainable land use. In all spatial planning, politicians should be involved at an early stage of the process. Both because making a land account can create a need for more planners, and because the politicians should be familiar with the land use situation.

Politicians are only rarely experts on spatial planning. The planners therefore need to limit their use of exclusive professional terms and use as much everyday language as possible. That is also a very good rule to live by when it comes to participation processes.

A land use account is also useful in participation processes with different stakeholders. When there's a lot of public interest in the development of an area, for instance a forest that will be lost to industry, an early dialogue with both developers and interest groups is beneficial. The foundation for such participation should be the account for land set aside for development but not yet built.

We've identified four factors for a successful communication. The land account must be:

- seen as relevant
- experienced as trustworthy
- be understood
- be visible

For the latter, an interactive [story map](#) can be useful. Here the user can easily turn on and off different layers on the map with additional texts.

4.3 What do the planner need to know?

The first a planner need to know is what competence and software is needed. The answer is that there are a variety of software that may be used, and the planner need to get an overview to gather the right people around the project.



A solid knowledge of spatial planning processes is of course necessary, but so is an understanding of the local community. In addition there is a need for someone who knows how to use the digital tools, such as programs for budgeting (Excel for instance) and GIS-software for developing simple geospatial analysis. If the municipality doesn't have such software themselves, the manual shows where to

find free software on the internet. Many municipalities in Norway are scarcely populated but have vast spatial resources. Their planning capacity may vary, and therefore it is important that the manual shows how to get hold of basic support.

For the land use account to work, the planner needs to know how much space is “enough” for each purpose of development. How many houses are needed, how many second homes etc. In addition, the planner must get an overview of the different geospatial datasets available, and where to get them.

We've identified five main types of sources for the necessary datasets for use in Norwegian municipalities:

- statistics of population development, housing and secondary homes
- land use objectives
- space available for development
- datasets of nature
- geographic divisions

To decide what datasets is most necessary for the purpose of land accounting in each municipality, the staff's capacity and competence need to be taken into consideration. All communities can add more datasets if they want to. In Norway, most of the data is free and can freely be reused without restriction, but there are some exceptions, for example, for the most detailed data. The manual also come with a checklist before setting off to work.

4.4 What land is set aside for development but not yet built?

A land account of areas regulated for development but not yet built, lay the premises for what to add and what to withdraw. To get an overview of this land, it is necessary to establish a data foundation in GIS and then export it to Excel. The data basis is made by combining datasets of planned and actual spatial use, plus data of nature, with an overlay-analysis in GIS.

Making a map of such areas may come with a surprise. In the map to the right, all the streaked areas are set aside for development, but not yet built. When a Norwegian county made a land account like this, they discovered that they had set aside as much land for development as they'd ever built since the ice-age. A good reason to reconsider some of their spatial plans.

When communicating land accounts like this, a diagram that highlights the different purposes for development, may be useful.

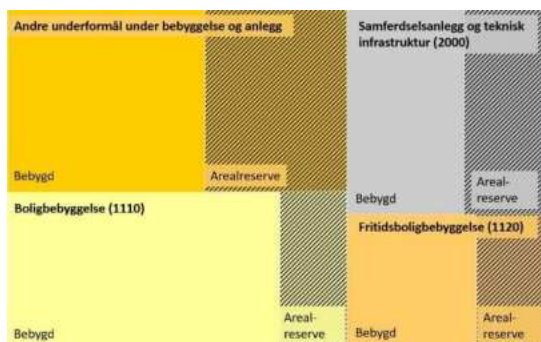


Figure 5 Example of a diagram that show the amount of different purposes

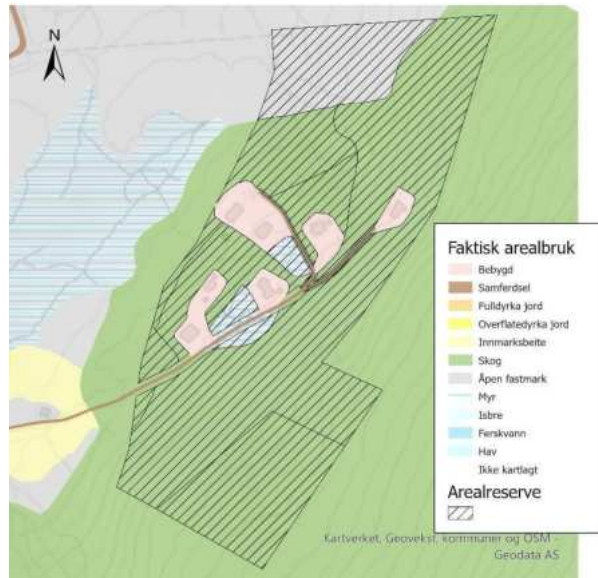


Figure 4 Map of actual land use, regulated land use and nature types. We've included a detailed technical manual on how to make such maps.

For a land account to be trustworthy, one needs to add information of where it is possible and not to build. Areas exposed to land slide or areas where the terrain make the technical infrastructure too expensive, are for instance not ideal for further development. It should also include what areas are well mapped and not. Often there are areas where we have detailed knowledge of nature diversity, and areas where we haven't got that information yet. Before regulating for further development, one should make sure the knowledge at hand is updated.

4.5 How to make a complete account for the land use element of the municipal masterplan?

When the proposal for a new masterplan is made, the complete land account need to follow. To make such, the planner takes the account made for the spatial reserves, the land not regulated but not yet built, and add the suggested land use in the new masterplan. The differences between the old and the new plan should be described, emphasizing non-built areas, agriculture, and nature types.

Below a land account on a county level, combining all land use, both existing and planned, for all municipalities are included. Such an overview has the benefit of showing a totality beyond municipal borders. As each municipality sometimes forget to look outside themselves,

such a presentation advantageous. Making the presentation interactive, as the example below shows, all users can search for specific areas and datasets. The program sums up the total amount used for each purpose.

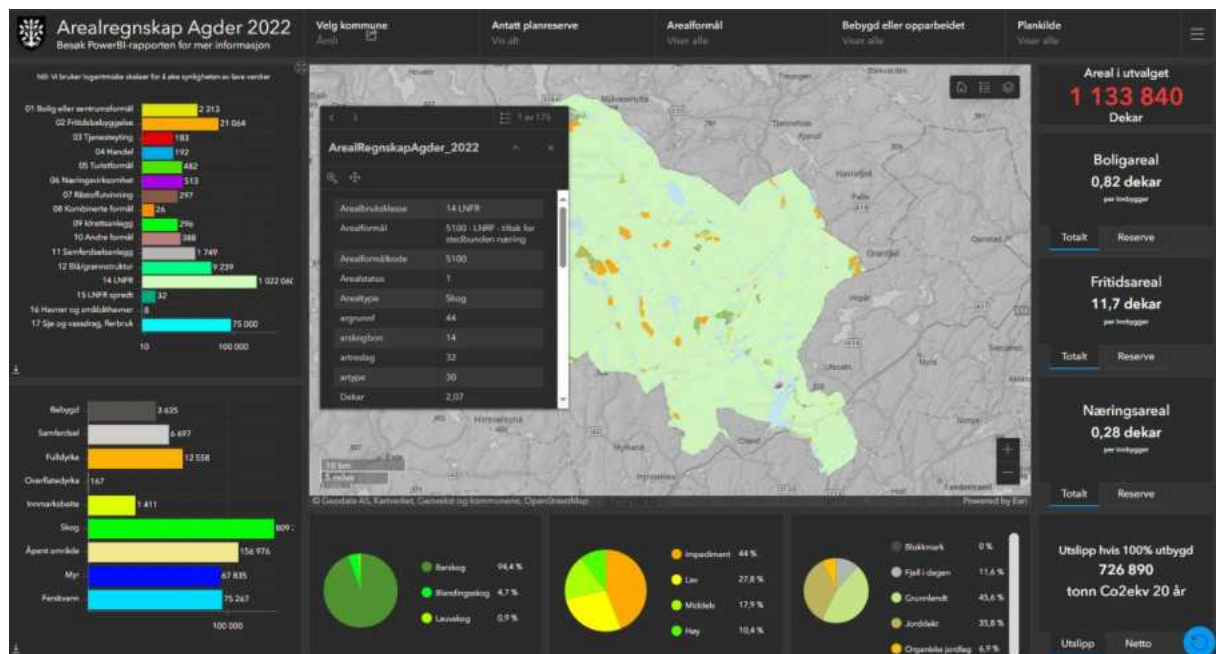


Figure 6 A complete land account for the whole county of Agder

4.6 The devil is in the details

Despite the transparent and structured planning processes in Norway, and the free to use datasets, many of the municipalities lack the human resources needed. GIS competence is rare in scarcely populated areas, and a spatial planner is often needed in more tasks than spatial planning.

We've therefore added a technical manual on our website that walk the planner through the process. Product standards, the use of software, additional datasets, vector and raster data, polygons, datasets with different coordinator systems, outdated datasets with different times for updating, and so on, are all described in the technical manual. The planner can find screenshots of where to click and what to do on each level in the process.

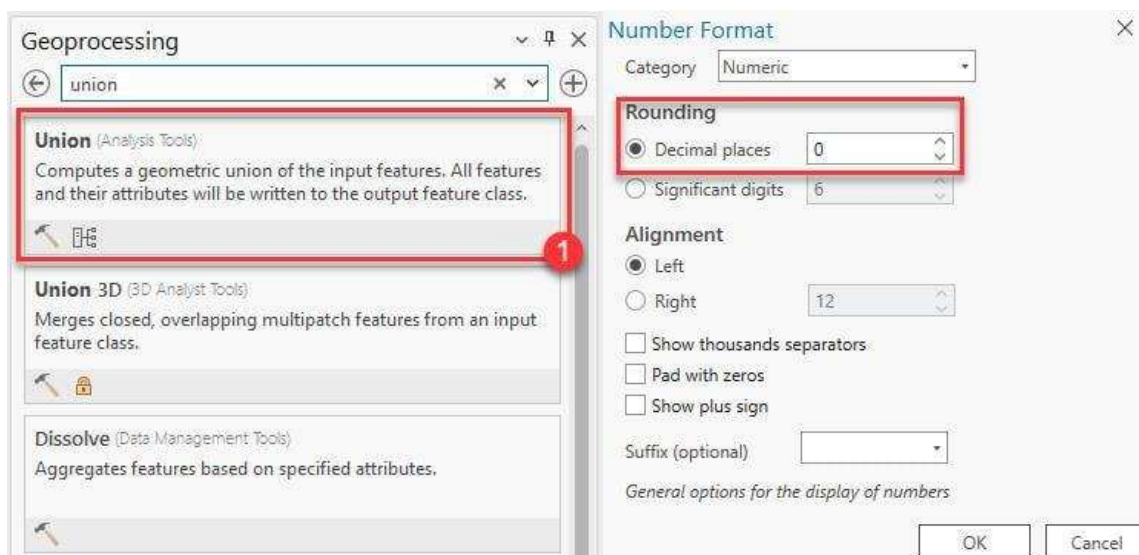


Figure 7 Detailed description of how to do it is added in the technical manual

5. USEFUL OR NOT

January 2023, a Norwegian Official Report was published on the state of the society's preparedness (NOU 2023:17). One of their conclusions was clear: Spatial planning is crucial to safety, climate adaption, future climate change, food security and biodiversity.

In October, the Climate Committee 2050 presented the Norwegian Official Report on what it will take for Norway to achieve the goal of becoming a low-emission society by 2050 (NOU 2023:25). The report leaves no doubt that the pressure on land and other scarce resources will increase. Land use is key to reaching the goals, and land use accounting is a useful tool.

The manual from the Ministry of Local Government and Regional Development was released in December 2023. Already in the first month, it had made it to the top 10 of our most popular websites. The feedback is that a concrete, hands on manual is just what is needed.

We've made some effort to reach out to local planners, and over the last years we've published an increasingly popular newsletter. Here we include all news from the ministry that may be useful for the municipalities. When we manage to reach out to the planner him or herself, we experience that the feedback we get is also much more practically oriented. That again, help us improve our services.

The manual for land use accounting, is never going to be quite finished. New technicalities, new themes and new possibilities will always pop up. The implementation of AI is for instance one of them. To us, it is therefore even more crucial that each municipality are fit to make an account themselves, without the need of consultants that come up with yet another

technical platform the municipalities then become dependent on for further development. So far, we seem to be successful in our stride.

6. REFERENCES

Norwegian Ministry of Local Government and Regional development, 2023 *Arealregnskap I kommuneplan (a guide to land accounting in spatial planning)*, Oslo

Norwegian Official Report (NOU) 2023:17 *Nå er det alvor – Tustet for en usikker fremtid*, Justis- og beredskapsdepartementet

Norwegian Official Report (NOU) 2023:25 *Omstilling til lavutslipp. Veivalg for klimapolitikken mot 2050*, Klima- og miljødepartementet

Norwegian Institute of Bioeconomy Research (NIBIO), 2018 *Bærekraftig skogbruk i Norge*

Rambøll, 2020: Kartlegging av praksis rundt bruk av arealregnskap i kommuneplan, Rapport, Oslo

Statistics Norway, 2023 *Arealbruk og arealressurser*, web page: [Arealbruk og arealressurser – SSB](#)

Strand Geir-Harald and Arnold Stephan in Feranec, Jan et al (eds), 2016: *European landscape dynamics, corine land cover data*, CRC Press.

Støstad Mats Nyborg et al, 06.01.2024 [44 000 inngrep i norsk natur på fem år](#), NRK (Norwegian Broadcasting Corporation)

Ying Chan, Jessica 2017 [Introduction to land accounting](#), United Nations Statistics Division.

BIOGRAPHICAL NOTES

Educated in Human Geography, with a specialisation in urban development from the University of Oslo. Philosophiae doctor in urbanism from Oslo school of Architecture and Design, with a PhD on spatial planning and area-based strategies. Leading positions in projects on sustainable urban development, both nationally and in a Nordic context. Now deputy director general at the Norwegian Ministry of Local Government and Regional Development.

CONTACTS

Spatial Land-Use Budgeting for Climate Actions (12576)
Guro Voss Gabrielsen (Norway)

FIG Working Week 2024
Your World, Our World: Resilient Environment and Sustainable Resource Management for all
Accra, Ghana, 19–24 May 2024

Deputy Director General, Guro Voss Gabrielsen
Norwegian Ministry of Local Government and Regional Development
Akersgata 59
Oslo
NORWAY
Tel. +47 90034131
Email: Guro-Voss.Gabrielsen@kmd.dep.no
Web site: www.regjeringen.no

Spatial Land-Use Budgeting for Climate Actions (12576)
Guro Voss Gabrielsen (Norway)

FIG Working Week 2024
Your World, Our World: Resilient Environment and Sustainable Resource Management for all
Accra, Ghana, 19–24 May 2024