

Report

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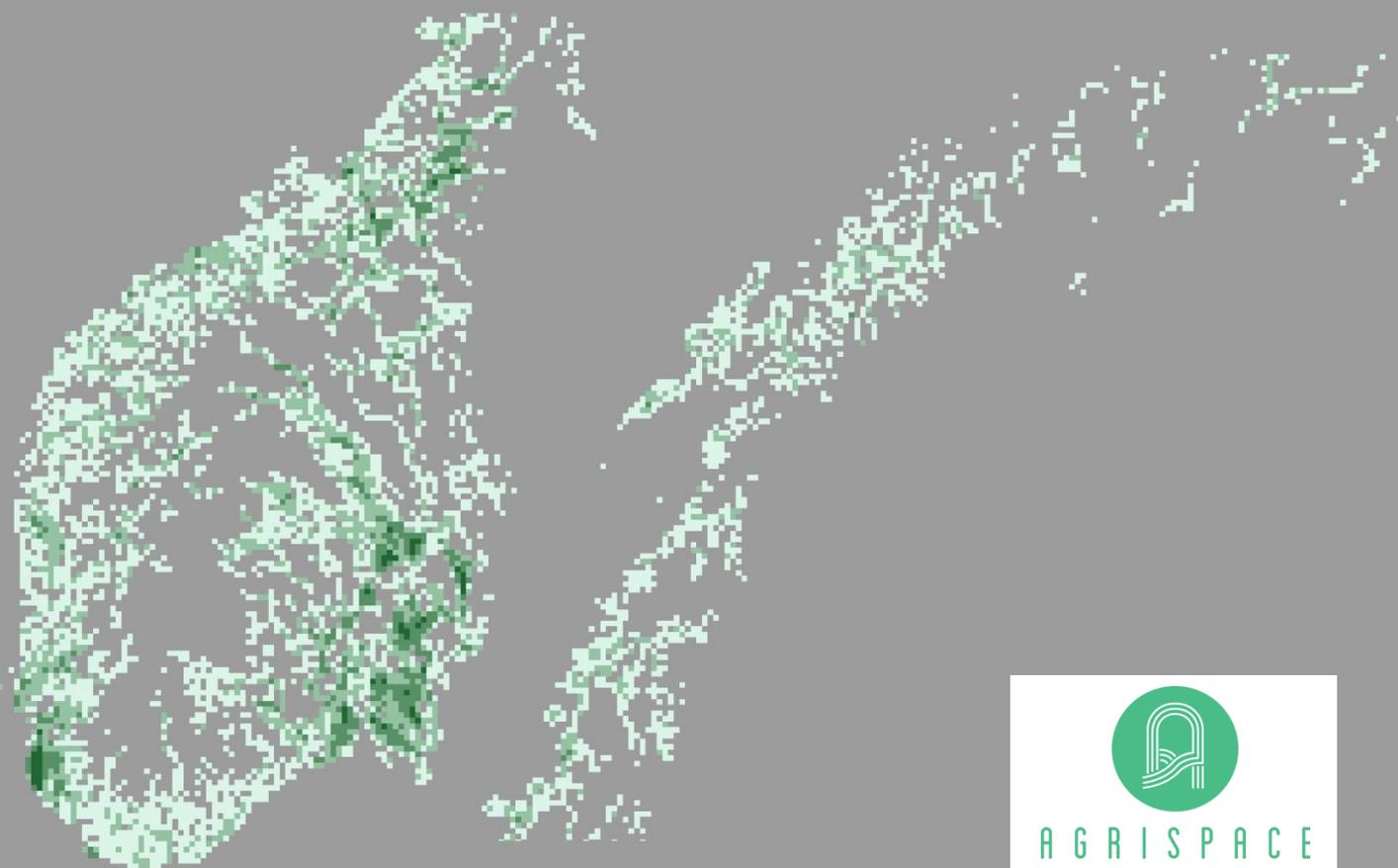


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Norwegian Forest and
Landscape Institute

AGRISPACE: BACKGROUND, CONCEPTS AND FRAMEWORKS

Edited by Grete Stokstad and Sebastian Eiter



AGRISPACE
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Cover illustration: Amount of agricultural area in Norway within 5*5 km grid cells

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FOREWORD

This report is a means to help establishing a common foundation through providing a brief summary of different themes of importance for scientists involved in the research project “Space, land and society: challenges and opportunities for production and innovation in agriculture based value chains” (AGRISPACE) funded by the Research Council of Norway. Researchers from the project owner Centre for Rural Research as well as from the partners Norwegian Agricultural Economics Research Institute, Norwegian Forest and Landscape Institute, Veterinary Institute and Department of Sociology and Political Science, Norwegian University of Science and Technology (NTNU) have contributed to this report.

The report also helps to identify the “state of the art” of the topics covered by work packages (WPs) 4 and 5 in the project. Further, it will provide us colleagues in the project with relevant background information for the various WPs, and raise awareness of our different perspectives and theoretical foundations. We thus hope this report will facilitate dialogue and cooperation within AGRISPACE.

Ås, 1st June 2015

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1. INTRODUCTION

Grete Stokstad, Norwegian Forest and Landscape Institute

The overarching objective of AGRISPACE is to provide comprehensive knowledge on challenges and opportunities for sustainable growth in production and innovation in land-based bio-production across space.

In AGRISPACE we will explore four interrelated thematic areas:

- 1) Spatial variation and its effects on the utilisation of land resources
- 2) Spatial variation in products and production methods (types)
- 3) Factors and conditions that promote or restrict value creation in biobased value chains
- 4) Goals and goal conflicts in agricultural policy and policy instruments - and their impact on a bio-economic transition in land-based production.

AGRISPACE will further discuss different development trajectories or scenarios for Norwegian agriculture and suggest policies to achieve desirable outcomes.

Founded in to the overall objective of AGRISPACE this report begins with a discussion of the bio-economic perspectives in production and innovation in land-based bio-production. This is chapter 2 which is entitled “Spatial development and the bioeconomy”.

Growth in bio-economic businesses is not necessarily sustainable, and we thus need a common understanding of what sustainable agriculture and sustainable development imply. Sustainability is an important issue to consider when future development is to be discussed, and this is the theme of chapter 3. “Sustainable agriculture – leading the way to the future we want”.

Change in land based production will often influence more than the product itself. Thus if we are looking for sustainable productions, the total local impact of a production change should be considered. This involves accounting for changes in all ecosystem services. Chapter 4 “Ecosystem services” provides a brief background of the term ecosystem services, a summary of some of the most important definitions, and an outline of the policy context of the concept in the EU and in Norway.

Chapter 5 “Agricultural policy regimes 1999-2014” is a review of the agricultural policy system with emphasis on changes during the last 15 years. This is a natural starting point for WP 5, where different scenarios for the future development of agricultural policies will be compared. However it is also a helpful for understanding the structure in the agricultural sector today which is equally relevant for work in the other WPs.

In chapter 6 a general classification system of policy instruments is presented, which will be used in the analysis in WP 4.4. The chapter also provides some examples of geographical differentiation in policy instruments, and discusses briefly how different policy instruments may affect the spatial distribution of agriculture in Norway. The title of the chapter is “Policy instruments and spatial distribution in agriculture”.

As a member of EFTA, Norway has accepted the principle of free movement of goods across national borders. However the SPS Agreement (Sanitary and Phytosanitary Measures) which was part of the WTO agreement in 1995 still restricts trade, particularly with living animals. Import regulations help to protect Norwegian production, but it is also essential for maintaining a healthy animal population. In chapter 7 the Norwegian import regulation for living animals and animal products are described.

Climatic change and policy measures designed to give incentives to reduced emission may also influence future production changes and may cause spatial variation, thus chapter 8 “Production and policy responses to climate” is highly relevant in a project forecasting future farming.

Spatial economics dates back to von Thünen’s model for how producers distribute themselves in space, given that some resources are immobile. The model suggests a link between agricultural production and population, which is one of the hypotheses outlined in chapter 9 “Space and agriculture”.

WP 4.2 “Types of production” also looks at where agricultural production is localised and how change in production occurs. In chapter 10 “Spatial diffusion and innovation” the proposed work is discussed in relation to previous work of diffusion and innovation in agriculture.

Spatial variation is central in AGRISPACE. We will use a range of maps to illustrate variation across space. However, how we map data and the variation is the data mapped, are important for the message communicated. This is discussed and illustrated in chapter 11 “How to measure and visualise spatial variation”.

Common or collective goods from agriculture include the aesthetic qualities of the agrarian landscape. In WP 4.1 one of the tasks is to look at human preferences for landscapes. Our objective is to be able to classify changes as more or less desirable from an aesthetic point of view. Thus factors influencing the preferences for agrarian landscapes and potentially helpful indicators to classify agrarian landscapes are the topic of chapter 12 “Preferences for landscapes”.

Analysis of farm productivity is the topic of chapter 13 “Farm-level productivity in a spatial context”. Impacts of farm size and production on productivity will be central in the proposed analysis, however it is also planned to analyse the effect of spatial interaction.

JORDMOD II is a dynamic and spatial multi-commodity model of the agricultural sector in Norway. It will be developed as part of AGRISPACE. Chapter 14 “The JORDMOD II market model” gives a brief introduction to the market part of the model, its theoretical assumptions and implementation.

AGRISPACE is an interdisciplinary research project. Cooperation between disciplines can take various forms, and can also be difficult. It is important to be aware of factors that can help us ensure good integration. Thus the last chapter, chapter 15, “Interdisciplinary perspective” discusses types of cooperation and what the literature suggests one can do to improve the chances for a successful integration.

2. SPATIAL DEVELOPMENT AND THE BIOECONOMY

Robert Burton, Centre for Rural Research

Modern society is facing many challenges. Climate change, population growth and depletion of oil reserves are all problems for which our current neoclassical economic paradigm has no easy answers as they require fundamental changes in the way society uses resources. One solution that has emerged within the last decade is that of a paradigm shift to a “globally integrated” bio-economy (Swinnen & Riera, 2013) – an evolutionary transition from an economy based on the mining of non-renewable resources to the farming of renewable ones (Zilberman et al., 2013). This move has been facilitated, according to Sheppard et al. (2011a) by the rapid growth of biotechnologies, demand for sustainable resources, demand for food and energy, the need to decouple economic growth from environmental degradation and the development of eco-industrial clusters. The value of the bio-economy is potentially huge with the EU’s bio-economic sectors being worth €2 trillion and providing 22 million jobs (EC, 2012b).

However, as Brunori (2013: 48) observes, “bioeconomy” is a contested term. One of the most accepted definitions, he observes, is that provided by the OECD and focuses on the role of biotechnologies in transforming biological processes, such that “a bioeconomy can be thought of as a world where biotechnology contributes to a significant share of economic output (OECD, 2009)”. Within this definition biomass is seen as a raw material that can be transformed through technological innovations into a variety of products – from food to pharmaceuticals to clothing – with the origins of the biomass (farming, forestry, fisheries) being of limited concern. Some biotechnological developments promise to be completely revolutionary. The development of “BioCouture” (the growing of clothes using bacteria - Businessweek, 2013), or, transforming wood chips to biofuel (Science Daily, 2013), are examples of biotech that could revolutionise multiple value chains and economic sectors. To supply these developments with feedstock, the provision of biomass is essential. Consequently, Levidow et al. (2013) refer to biomass as the “oil well” of the 21st Century – a perception that, according to (McMichael, 2012) is currently creating a “gold rush” for bio-resources.

The language of European governments makes it clear that this is the futuristic vision of the bioeconomy they/we wish to pursue. A 2012 press release from the European Commission (EC, 2012a: 1) defines the bioeconomy as:

“an economy using biological resources from the land and sea, as well as waste, as inputs to food and feed, industrial and energy production. It also covers the use of bio-based processes for sustainable industries.”

In this definition, no specific mention is made of agriculture, rather the talk is of biological resources, bio-based processes, industry and energy. Marsden (2013: 218) similarly perceives the “bio-economy paradigm” as not focused on agriculture, but rather:

“The bio-economy paradigm (BEP) actively merges areas such as medicine, nutrition, agriculture, energy, industrial biotechnology, the environment and security, and expresses itself in the (largely corporate-controlled) production of biomass and bio-fuels, together with other strands including biotechnology, genomics, chemical engineering and enzyme technology”

What this effectively means for the future of agriculture (and other bio-industries) in Norway is that a massive reconfiguration of both the bio-sectors (farming, forestry, fisheries), the industrial (processing sector) and even wider society is required to meet bioeconomic objectives.

However, despite its positive and revolutionary vision, bioeconomic development has been criticised on a number of grounds. Primarily the concerns centre around fact that way bioeconomic development appears to be entrenched (and motivated) not by sustainability or food security debates, but rather economic debates – particularly those associated with neoliberalism. Neoliberalism displays a preference for industrial scale technologically oriented agricultural investment over possibly more traditional forms (e.g. Minoia, 2012; Schilling et al., 2012) not primarily because such approaches are more sustainable, but because they are not organised in a manner that optimises production and profitability. For example, Arancibia (2013) argues that the narrative of a bioeconomy (bearing in mind that many of the necessary technological revolutions have yet to take place) has become a key-stone for the development of policies that favour the promotion of the biotech industry – such as the development and sale of GMOs. Birch et al. (2010) similarly observe that the concept of a KBBE (Knowledge Based Bio-economy) is being used to frame the sustainability issue as one of production inefficiency that needs to be overcome using a “techno-knowledge fix” thus promoting the commercialisation of nature.

With its emphasis on commercialisation, critics of the bioeconomy have been quick to point out that the envisaged bioeconomic future is unlikely to be one that benefits all. One key problem is that bioeconomic development focuses on the optimisation of agricultural (and other biomass) production but, as Brunori (2013) observes, has been criticised for failing to place sufficient emphasis on agriculture’s “public goods” provision (such as landscape, water quality, or biodiversity) (see Jordan et al., 2007). Consequently, regions that are low in agricultural productivity but high in public goods provision are likely to be neglected in a bioeconomy unless additional measures are put in place to protect them.

A similar issue has been noted for regions where the social benefits from traditional agricultural production are more important than biomass production. This has led rural sociologist Terry Marsden to suggest an alternative vision for rural areas. Rather than an integrated, corporate and technological bioeconomy where enhanced productivity and competitive advantage are achieved through global value chains that operate at global economic levels, Marsden proposes the development of a sustainable bioeconomy (or “eco-economy” (e.g. Kitchen & Marsden, 2009, 2011; Marsden, 2012)) to be achieved via the “recalibration of micro-economic behaviour and practices that, added together, can potentially realign production–consumption chains and capture local and regional value between rural and urban spaces” (Kitchen & Marsden, 2009: 275). Again, regions where agriculture is not of a scale suited for a technological bioeconomy but are nevertheless multifunctionally productive (based on short value chains) could be neglected in a bioeconomy unless additional measures are put in place to protect them.

The potential for regions to be left out of any national bioeconomy strategy has led some to suggest the possibility of pluralistic agri-innovation pathways within the bio-economy, such that some regions become more heavily embedded in the bioeconomy than others (Levidow et al., 2013). This raises an important issue for Norway. The Research Council of Norway’s (RCN) Work Program 2012-2021 on sustainable innovation in food and bio-based industries (RCN, 2013) presents itself as a “visionary framework” for the development of a bio-based society – the “bioeconomy” and sets out the objective of increasing production in Norway. While these components seem to fit together, it must be remembered that tens of thousands of Norwegian farms across the country are currently embedded in a multifunctional eco-economy (Rønningen et al., 2012), and that many of these are concentrated in particular regions leading to potentially strong regional disparities.

A second problem with the development of a market-based bioeconomy lies in the assumption that such an intensive productive system will automatically lead to greater food production and therefore food security in Norway. There are two reasons why this may not occur:

First, without the development of technological innovations that are able to convert Norway's abundant forest into food a new and "economically efficient" bioeconomy is likely to be vulnerable to supply problems. Climate change, political instability, Intellectual Property (IP) disputes on biotechnology, natural disasters (major volcanic eruptions) and pandemics – all events which are likely at some stage – have the potential of devastating Norway's agricultural sector if it were to become reliant on long and complex value chains. Given that some have expressed concerns that biotechnological advancement has stalled in recent years (Cooke, 2013 – see below) the creation of the "market" innovations for a bioeconomy (corporatisation and globalisation) prior to the development of the necessary technological innovations could create problems for food security.

Second, problems may occur if policy and economic resources are overly focused on bioeconomic growth as the means of providing the desired production increases. The issue here is that if increases in food production in the bioeconomy are matched by losses from Norwegian farms located within the multifunctional eco-economy, the total gain in production is likely to be limited (if there is any at all). Corresponding losses in landscape and rural communities could turn the overall economic benefit of bioeconomic development into a net economic and production loss.

The implication of these two factors is that, while bioeconomic development should lead to greater and more economically efficient production when the system is functioning properly, increased vulnerability to forces outside of Norway's control could result in lower, rather than higher food security. This raises the particular spatial concerns that are addressed in the AGRISPACE project. Norway has both the biotechnological knowledge and renewable biomass required for a conventional bio-economy (e.g. OECD, 2009). However, at the same time existing agriculture has predominantly localised public goods and social outputs and, consequently, many regions may not be suited to a commercialised, technological, and competitive bio-economy but rather favour a micro-economic-based "eco-economy". If maintaining food security in Norway is a policy goal, the maintenance of those farms (and regions where they dominate) must be considered in the course of 'bioeconomic' policy development.

Investigations into the spatial development of the bioeconomy are required to understand where supporting policies may be necessary. Undoubtedly, policies supporting the development of a bioeconomy would benefit some regions of Norway. However, experience elsewhere suggests that this development could be highly focused around certain locations as such developments have tended to occur in locally or regionally limited biotechnological "clusters". Chiaroni & Chiesa (2006) define clusters as:

"a geographical concentration of actors in vertical and horizontal relationships, showing a clear tendency of co-operating and of sharing their competences, all involved in a localised infrastructure of support".

The history of clusters in bioeconomic development is a long one. Researchers have observed that since the beginning of the biotech industry "biotechnology has developed in a few centres of excellence identifiable as biotech clusters" (Chiaroni & Chiesa, 2006: 1064). Marsden (2013) notes similarly, that the bio-economic paradigm involves the development of "distinctive economic clusters ... where geographical proximity facilitates knowledge 'spill overs' among neighbouring and 'related' industries" and contends that these synergistic networks, in turn, foster localised diffusion of innovation. The idea that science and industry can work together is clearly an appealing one, but also one that introduces strong possibilities of regional disparities in bioeconomic growth – with the location of biotech clusters being of critical importance to the outcome for agriculture.

Chiaroni & Chiesa (2006) contend that there are three major ways in which clusters are created, namely; (a) spontaneous clusters that result from the spontaneous emergence of key factors, (b) policy-driven clusters driven by deliberate decisions of political actors to foster biotechnological development, and (c) hybrid clusters that occur where government

resources are directed towards a spontaneously developing bioeconomy. Cooke (2013) divides the “spontaneous” clusters into three categories; (a) those where entrepreneurship develops around the initial innovation (or “star scientists” – see Birch, 2007), (b) where the bankruptcy of a large firm leads to innovation amongst redundant employees, and (c) ‘chance clusters’ where the initial location of the cluster is based around factors unrelated to the business (e.g. the personal lifestyle preference of a founding entrepreneur or “star scientist”). Given the random nature of spontaneous cluster emergence it is difficult to establish exactly where clusters are likely to emerge. However, Fjellstad & Dramstad (1999) note that in Norway there is a large geographic variation both in terms of availability and suitability of land for bio-economic growth, and the extent and intensity of historic and current use. In particular, with the quality of agricultural land, human capital, and access to trade routes (particularly with the EU) being concentrated in the south of the country it is reasonable to assume that the most significant clusters will develop in this region.

Other aspects of bioeconomic development also have implications for its spatial development. In particular, while current thinking suggests that the development of technologies required for the bioeconomy will be rapid (e.g. the OECD, 2009, predicts that by 2030 biotechnology will play an important role in almost all major commercial crops and the development of nearly all drugs and pharmaceuticals) some have expressed doubts. Cooke (2013), for example, argues strongly that the expectations of scientific advancement will not be met for two main reasons.

The first is that the same political/economic process that supports the private development of the bioeconomy (i.e. neoliberalism and globalisation) does not prioritise science or social benefit, but rather, profitability. This has led to companies with “sunk costs” in biotech developments stalling further advancement until sufficient return on investment has been achieved (e.g. through “patent blocking” – Calvert, 2012). IP systems developed for an industrial economy also act as a barrier to rapid development in a knowledge economy where knowledge is collaborative, cumulative and interdependent (Calvert, 2012). In particular, attempts to develop an “open source” licencing system desired by many scientists (Grand et al., 2012) have met strong resistance – both from established companies concerned about enabling smaller rivals (Vázquez-Salat, 2013) and governments who view IP as a form of national wealth creation (Kearnes, 2013). Clearly the movement to any “open source” IP system, with its facilitation of smaller start-ups, will have strong implications for the spatial development of the biotech industry by providing small regional companies the opportunity to employ the same advanced processes used by major corporations. Major biotech companies, on the other hand, are likely to prioritise economic goals and locate accordingly.

The corporate emphasis on profitability is also indirectly responsible for the second problem with the development of a corporate-led bioeconomy. Cooke (2013) notes that following the banking crisis of 2007/08 much of the highly speculative private funding that had gone into the biotech industry dried up. Again, where concern is for reliable profits and satisfying shareholders, there are less risky investments available than biotech. As a result of this, much of the early political enthusiasm for the bioeconomy in the early 2000s was based around the assumption that investments in biotech would be driven by the private sector – an assumption that, with a second global recession potentially looming, currently appears flawed. The alternative to the private sector – public sector investment – is also under pressure. Here Cooke (2013) observes that the public debt crisis that has caused a “deep retrenchment” in public research budgets has also impacted on the development of biotech industry. With IP viewed as a form of national wealth creation (see above) any increasing emphasis on returns for investment caused by the public debt crisis could further hinder the speed of development of the bioeconomy. In terms of spatial implications, if biotechnological development requires public sector investment (as it may do), the government has the opportunity to promote a more even regional distribution of benefits.

As discussed above, there are a number of ways in which spatial issues are likely to affect the development of the bioeconomy in Norway. The need to prevent regional disadvantage becoming a feature of the developing bioeconomy has already been observed by the European Commission who contend that maintaining balanced territorial development should be a key goal for policy-makers (EC, 2010). Bioeconomic policy has been noted to be fragmented, primarily because within the industrial economy bio-sectors (e.g. agriculture, forestry, fisheries, sciences, and industries) have developed along strongly sectorial lines and, consequently, siloed activity-based sectors such as science/expertise (Centeno, 1993), agriculture (Marsden, 2012) and forestry (Kleinschmit et al., 2014) work on separate problems, have different stakeholders and are governed by different governance/policy-regimes. Bioeconomic policy is also fragmented spatially over global, national, regional and local scales (EC, 2012b). While governance at these different spatial scales may share common objectives, the result is a complex and sometimes fragmented policy environment – particularly when combined with existing sectorial divisions. Bioeconomic transition in Norway, on the other hand, requires integrated development (Valseth, 2012) across regions, sectors, multiple actors and institutions throughout society (e.g. Kleinschmit et al., 2014).

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3. SUSTAINABLE AGRICULTURE – LEADING THE WAY TO THE FUTURE WE WANT

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What is sustainability – historical development and state of the art

The concept of sustainable development became world famous following the work of the UN World Commission on Environment and Development. An outcome of this work was the report entitled “Our Common Future” published in 1987 (WCED, 1987). In this report, sustainable development is defined as;

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

This definition contains two key concepts:

- *Needs*, in particular the essential needs of the world’s poor, to which overriding priority should be given; and
- The idea that there are *limitations* on the environment’s ability to meet present and future needs.

Five years later The United Nations Conference on Environment and Development (UNCED) aimed to follow up on the report from 1987, when a new conference was arranged in Rio de Janeiro. This conference produced several important outcomes; for instance was the Convention on Biological Diversity (CBD) opened for signature. The Rio Declaration on Environment and Development, often shortened to Rio Declaration, was a short document consisting of 27 principles intended to guide future sustainable development around the world. Of direct relevance to agriculture is Principle 8: “Reduction of Unsustainable Patterns of Production and Consumption”. This principle reads: “To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate unsustainable patterns of production and consumption and promote appropriate demographic policies.” Yet another well-known outcome of this Rio conference is the “Agenda 21”.

Agenda 21 devotes an entire chapter to sustainable agriculture and rural development (SARD) (United Nations, 1992). The major objective of SARD is to increase food production in a sustainable way and enhance food security. Water use is another topic in the Agenda 21 report, where it is stated that agriculture must not only provide food for rising populations, but also save water for other uses (ibid, p. 215). Also research is requested in The Agenda 21 report; Governments and appropriate international organizations, in collaboration with national research organizations and non-governmental organizations should, as appropriate: a. Develop environmentally sound farming technologies that enhance crop yields, maintain land quality, recycle nutrients, conserve water and energy and control pests and weeds; b. Conduct studies of high-resource and low-resource agriculture to compare their productivity and sustainability (United Nations, 1992). The research should preferably be conducted under various environmental and sociological settings (ibid, p. 299).

In its broadest sense, the strategy for sustainable development aims to promote harmony among human beings and between humanity and nature (WCED 1987). In the conclusion it is outlined that the pursuit of sustainable development requires (p. 56):

- a political system that secures effective citizen participation in decision making.
- an economic system that is able to generate surpluses and technical knowledge on a self-reliant and sustained basis
- a social system that provides for solutions for the tensions arising from disharmonious development.
- a production system that respects the obligation to preserve the ecological base for development,
- a technological system that can search continuously for new solutions,
- an international system that fosters sustainable patterns of trade and finance, and
- an administrative system that is flexible and has the capacity for self-correction.

Of these, particularly the point on production systems is applicable to agriculture, but also the points on technology and trade has relevance. It is further stated, however, that these requirements are more in the nature of goals that should underlie national and international action on development. And the paragraph concludes “*What matters is the sincerity with which these goals are pursued and the effectiveness with which departures from them are corrected*” (WCED1987, p. 57). And that is indeed relevant to agriculture.

Since the concept was widely embraced in the late 1980s and onwards into the 1990s, many attempts at defining sustainability have been forwarded. Hansen (1996) provides a table illustrating the range of definitions in use already by the mid-1990s. He considers their degree of being system-describing or goal-oriented as a key feature, and groups them accordingly. Costanza and Patten (1995), on the other hand, argue that the problem is not defining the concept of sustainability. Rather, they conclude, the problem is predicting *what* we want to sustain and *for how long* (op.cit.). More recently, White (2013) used a word-cloud to analyse 103 unique definitions and then graphically illustrated the more commonly used words. A number of words occurred frequently, e.g. equity, growth, produce, life and nature (White 2013). In addition, the importance of *sustaining through time* is commonly stated. On the website of the company SustainAbility (www.sustainability.com) for example, it reads;

Among the many ways that sustainability has been defined, the simplest and most fundamental is: “the ability to sustain” or, put another way, “the capacity to endure.” Today, it is by no means certain our society has the capacity to endure – at least in such a way that the nine billion people expected on Earth by 2050 will all be able to achieve a basic quality of life (<http://www.sustainability.com/sustainability>).

Applied to agriculture, the concept of sustainability was in the beginning used to describe an approach to agriculture that was different from what was described as “conventional agriculture” (Hansen 1996 and references therein). This conventional agriculture was described as “capital-intensive, large-scale, highly mechanized with monocultures of crops and extensive use of artificial fertilizers, herbicides and pesticides, with intensive animal husbandry” (Hansen 1996, p. 120). While this description also has been described as a caricature, undoubtedly some elements of this perception probably still remain. In contrast, sustainable agriculture was described with key values being things like decentralization, independence, community, harmony with nature, diversity and restraint (Beus & Dunlap, 1990).

In 2002, The World Summit on Sustainable Development met in Johannesburg. From this meeting, the document entitled the Johannesburg Plan of Implementation was published (see www.un-documents.net/jburgdec.htm). In this document, it is stated “We, the representatives of the peoples of the world ... assume a collective responsibility to advance and strengthen the interdependent and mutually reinforcing pillars of sustainable development - economic development, social development and environmental protection - at the local, national, regional and global levels.” To illustrate this line of thinking, an illustration using three overlapping ellipses have been commonly used (Figure 3-1), indicating that the

three pillars of sustainability are not mutually exclusive and can be mutually reinforcing. Since then, three pillars have served as a common ground for numerous sustainability standards and certification systems, in particular in the food industry. The idea of these three pillars is also the idea underneath the term “Triple Bottom Line” which was coined by John Elkington in 1994 (Elkington, 1994). The concept of “Triple Bottom line” (3BL or TBL) has been gaining importance as an emphasis that all three aspects needs to be integrated in an accounting framework; social, environmental (or ecological) and financial. (These three divisions are also called the three Ps: people, planet and profit). Since then, also a fourth pillar has been added, however; culture (Hawkes, 2001). More recently, though, Seghezzeo (2009) suggest developing a five-dimensional triangle of sustainability, where place (i.e. the three dimensions of space) and permanence (the fourth dimension of time) and persons; the fifth human dimension is included.



Figure 3-1. An example of the representation of the three pillars of sustainability and how they overlap. (Source: <http://solutions.3m.com>)

In general, as pointed to by a range of authors (see e.g. Buckwell et al 2014, Hansen 1996), there is a wide agreement about the general desirability of the concept of sustainability, but there are differences in its interpretation and what it means for policy and practical action. One major problem with this is that it makes it difficult to assess progress in the desired direction (White 2013).

Thus, accompanying the challenges involved in interpreting and translating it to policy and practical action is the challenge of assessing whether something can be described as being sustainable or not. A range of efforts have been initiated to develop a means of quantification, e.g. in terms of indicators of sustainability (e.g. UNCSD, 1996, Eurostat 2001, EEA, 2005, United Nations 2007, Defra 2013). In fact Buckwell et al. (2014) in their review identified 500 different indicators of sustainability, but still concludes that “...there is little convergence on a core set...”. This is unfortunate, given that there is a wide consensus on the need for quantification (Hansen 1996). As concluded by Reyta et al. (2014) “Quantifiable indicators of the environmental sustainability of agriculture will enable policymakers, farmers, businesses, and civil society to better understand current conditions, identify trends, set targets, monitor progress, and compare performance among regions and countries.” (p. 19).

Where is agriculture today?

While the need to focus on sustainability was emphasized already in 1987 and again on numerous occasions since then, we are not there yet. Currently, the focus is on what Ash et al. (2010) entitled “Feeding the future”. And – Ash et al. (2010) continue by underlying that “We have little time to waste” (p. 797). A similar message is conveyed by Robertson (2014) who states “In the years of declining oil supplies, changing climate and economic contraction

that probably lie ahead, the ability of a community to feed its inhabitants will be fundamental to its sustainability” (p. 233).

When is agriculture unsustainable?

Keeping in mind the key idea of sustainability about being able to continue – or sustain - the production, it is apparent that processes jeopardizing this ability must be addressed. Important factors when discussing agricultural sustainability, then, are (Ruttan 1999):

- Erosion / soil loss
- Pest control
- Water use / irrigation
- Climate change

The Agenda 21 report outlines the importance of soil erosion, as a process that can have a devastating impact on the vast numbers of rural people who depend on rainfed agriculture in the mountain and hillside areas. According to Ruttan (1999), however, who is focusing on threats to the world food supply, it is unlikely that soil degradation and erosion will emerge as major threats in the foreseeable future. Locally challenges related to soil degradation and erosion may still be severe though, but there are substantial knowledge and technology available to help reduce problems. Water scarcity is a severe problem in a number of countries, and this number can be expected to increase. Irrigation leading to water logging and salinization are large problems in certain regions, for example the Aral basin. Pest control is according to Ruttan (1999) something that has become an increasingly serious constraint on agricultural production, and Ruttan states *“The problem of pest and pathogen control may have more serious implications for sustainable growth in agricultural production at a global level than either land or water constraints”* (p. 5966). Describing the development of chemical controls going back to the arsenical and copper-based insecticides in the 1870s, a major concern has been and still is the almost parallel development of resistance in various target organisms. Integrated Pest Management (IPM) offered by the entomological community as the solution to the pesticide crisis did however not meet the expectations of dramatic reductions in pesticide use without significant decline in crop yields. Climate change has a number of effects on agricultural productions. Some of these may be positive from a production perspective, e.g. the “fertilization effect” due to the increased CO₂ concentration in the atmosphere. Changes in temperature, rainfall and sunlight, and rise of sea level accompanied by effects of inundation of coastal areas as well as intrusion of salt water can be expected to have severe negative effects (Ruttan 1999). A final point made by Ruttan (1999) is the importance of ensuring an agricultural research capacity to enable meeting the challenges we can expect – and institutions capable of achieving compatibility between individual, organizational and social objectives.

Growth = Development? Green growth?

In discussing sustainable development, Daly (1990) focused on the importance of making the distinction between growth and development. He underlined how growth is quantitative increase in physical scale, while development is a qualitative improvement or unfolding of potentialities (p. 1). This implies that an economy can grow without developing or develop without growing. For the management of renewable resources, Daly (1990) points to two principles of sustained development; harvest rates should equal regeneration rates (sustained yield) and waste emission rates should equal natural assimilative capacities of the ecosystems in which wastes are emitted.

An “alternative” growth strategy, the green / or sustainable growth strategy for agriculture was launched by the Organisation for Economic Co-operation and Development (OECD). At the ESRS 2011 conference at Crete, Dimitris Diakosavvas from the OECD Trade and

Agriculture Directorate defined Green growth as the pursuit of economic growth and development while preventing environmental degradation, biodiversity loss and unsustainable natural resource use. In this interpretation the environmental aspect is limited to preventing more degradation, i.e. a passive approach, rather than to improve the natural resource. Another important aspect of the green growth perspective is the economy, or as stated by Diakosavvas, "... a lot of green is not priced" (Diakosavvas 2011). A green growth strategy will be developed on market based initiatives such as agri-environmental payments, environmental taxes and non-market instruments such as regulation, voluntary agreements and technical assistance. The first step is then according to OECD to encourage governments to "price the environment".

The 2007-2008 food crisis led to a range of new state initiatives in relation to securing food supply. Norwegian agricultural policy responded quickly to what have been labelled a bundle of global shocks (food, fuel and finance crisis, in combination with severe weather events, at the world market in 2007-2008, see e.g Brobakk and Almås 2011) — particularly food security and climate change. A climate report was commissioned looking at the contribution of Norwegian agriculture to climate change and the potential for the industry to respond to new environmental, food production and economic conditions (Norwegian Ministry of Agriculture and Food 2009). A profound rhetorical shift was also seen in the new policy of agriculture and food that was legislated in the Norwegian Parliament April 12 2012 (Meld. St. 9. 2011-2012); "*Multifunctional agriculture*" yield place to "*sustainable growth in Norwegian food production for increased national food security and food sovereignty*" (See also Rønningen and Bjørkhaug, this report).

In accordance with the OECD approach the European Commission has adopted a strategy to what is called: a shift in the European economy towards greater and more sustainable use of renewable resources: "Innovating for Sustainable Growth: a Bioeconomy for Europe" that acknowledge global population growth and limitation of natural resources in the future. The EU strategy will focus on three key aspects: developing new technologies and processes for the bioeconomy; developing markets and competitiveness in bioeconomy sectors; and pushing policymakers and stakeholders to work more closely together. These strategies are important in the Horizon 2020, EU framework program.

This link to research is apparent also in Norway. Building closely on the EU commission's strategy The Norwegian research council program BIONÆR (2013) invites researchers to collaborate on large projects that can develop sustainable production and consumption, sustainable growth (even mentioning the triple bottom line definition) but also explicitly stating that all projects in BIONÆR shall include a perspective on increased value creation and competitive power of bioeconomy industries through market orientation and innovation throughout the value chain. The AGRISPACE project responds to this call.

What is sustainable growth or sustainable intensification then?

Following the recognition that we need a stronger emphasis on sustainability also in agriculture – and the simultaneous need to increase food production – comes the question of whether it is in fact possible to intensify agriculture in a somewhat more sustainable way. One less desirable alternative outlined would be to use more land for agriculture. Buckwell et al. (2014) defines sustainable intensification as something that "...means simultaneously improving the productivity and environmental management of agricultural land" (p. 7). They go on to underline that this does not point to any single development path for all agricultural systems or farms. Further, they underline how "A sustainable intensification path could mean an increase in the output per hectare of environmental services of the farm or an increase in agricultural products per hectare, it does not only mean the latter." (p. 7). They argue that the role of sustainable intensification in Europe is to show how high intensity productive agriculture can be combined with much higher standards of environmental performance. This is in line with Firbank et al. (2013) who point to how sustainable intensification is a process rather than a condition at any time.

A key message from Buckwell et al. (2014) is that sustainable intensification implies – not increased input in terms of chemicals or fertilizers or agricultural encroachment onto new lands – but increased knowledge. The prime objective is to increase the resource efficiency of agriculture. This can be achieved, they argue, through the focus on increasing knowledge. In addition, they forward the need to also emphasize production of conservation outputs, e.g. lapwing fledglings per hectare or pollinators (Buckwell et al. 2014). To know whether environmental output is improved, again the need for being able to quantify emerges. This question was in focus in a study by Firbank et al. (2013). They reported on a study of British farmers applying a very pragmatic approach to what sustainable intensification was; A farm was considered to practice sustainable intensification if food production per unit area increased during the study period, and none of the environmental variables had deteriorated (Firbank et al. 2013). They concluded that some British farms have moved towards sustainable intensification. Yet the reasons of the changes they have conducted in their farming practices having this effect tend to be profit-driven. This leads Firbank et al. (2013) to conclude that “sustainable intensification can be achieved when the correct drivers are in place to influence the actions of individual farmers”.

Who will be affected?

Concerns can be raised about the effects on the sustainability of food production if social and environmental aspects are not given the same weight as economy in policy instruments for agricultural growth. The new aims for sustainable growth, as outlined e.g. in the current Government Whitepaper for agriculture and food in Norway (Meld. St. 9 2011-2012), which are reasonable given the current global and regional challenges in the agri-food system responding to increased market orientation in Norwegian agriculture. At the bottom line it is the farmers and their families that will have to negotiate social, economic and environmental concerns within the natural and human resources they govern. Whether farmers are given sufficient terms and conditions to accomplish the aims needs to be monitored.

The need to communicate sustainable practices and hence influence the actions of individual farmers has been pointed to in several studies, as the farmer is the actual decision-maker, i.e. the person to make the changes on the land (Hodder et al. 2009). In this context, to speed up the process of making agriculture more sustainable it is important to focus more effort into communicating the best approaches to the farmers, and developing the tools that can help farmers make better decisions regarding their own farming practices. Foley et al. (2011) calls for a transformation of agriculture. This transformation, they claim, must address both key challenges; achieve global food security and environmental sustainability. They further call for better data and decision support tools to improve management decisions, productivity and environmental stewardship (Foley et al. 2011). This is in line with the British Society of Plant Breeders (BSPB 2014) who quote Defra minister Lord de Mauley “Unpacking the components of sustainability is the starting point for developing new metrics in agriculture, paving the way for common, agreed definitions of what sustainable intensification mean in practical terms – so that we can benchmark current performance, measure improvements over time, understand the best technologies, farming systems and practices to deliver it, and use all of that information to frame the R&D agenda going forward”.

Next step?

In 2012, Rio+20 - the short name for the United Nations Conference on Sustainable Development took place in Rio de Janeiro. A main statement from this meeting is available at their website (www.uncsd2012.org) and reads:

“It is time to rethink how we grow, share and consume our food. If done right, agriculture, forestry and fisheries can provide nutritious food for all and generate decent incomes, while supporting people-centred rural development and protecting the environment. But right now,

our soils, freshwater, oceans, forests and biodiversity are being rapidly degraded. Climate change is putting even more pressure on the resources we depend on. A profound change of the global food and agriculture system is needed if we are to nourish today's 925 million hungry and the additional 2 billion people expected by 2050. The food and agriculture sector offers key solutions for development, and is central for hunger and poverty eradication." Their slogan is "Leading the way to the future we want".

With the 2011 White paper (Meld. St. 9 2011-2012). Norwegian agriculture got a renewed incentive to increase agricultural production. A remaining question, however, is the location, quality and extent of available land resources, in particular with respect to other landscape functions (see e.g. Bastian 2000, Bastian & Lütz 2006). A reasonable concern in this context is that, a stronger focus on efforts to increase production and efficiency in farming can result in a less sustainable production or loss of ecosystem services, e.g. in "High nature value farmland" (Fjellstad et al. 2012, Henle et al. 2008) unless it can be ensured that recommended growth and change do not jeopardize sustainability (see e.g. Firbank et al. 2013).

At present there is an on-going polarization of the agricultural landscape in Norway, as more intensive use of land and land abandonment take place simultaneously and sometimes even within the same regions. Both these processes may have a negative effect on the production of public goods (Cooper et al. 2009). Farming activity within areas with such contrasting trends requires different measures to increase or maintain the provision of public goods (Westhoek et al. 2013). Land use/land cover is a key issue in this context, and the influence of on-going and possible future changes needs to be analysed and communicated, e.g. through the use of well-functioning indicators (see e.g. EEA 2006, Müller & Burkhard 2012). An analysis and understanding of the spatial variation is thus essential for a sustainable growth and management of cultural landscapes in a developing bio-economy in Norway. In AGRISPACE it is an aim to develop such knowledge.

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4. ECOSYSTEM SERVICES

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Introduction

As discussed in the previous chapter, the concept of sustainable development involves recognition of the fact that humans are dependent upon nature to satisfy their needs. In the attempt to quantify nature's various contributions to human well-being, a large field of study has developed around the concept of ecosystem services.

A major finding of the Millennium Ecosystem Assessment (MEA 2005) was that approximately 60% of the ecosystem services it examined (15 out of 24) were being degraded or used unsustainably, including fresh water, capture fisheries, air and water purification, and the regulation of regional and local climate, natural hazards, and pests.

It became apparent that the global degradation and destruction of nature was undermining the foundation of major economies. The Economics of Ecosystems and Biodiversity (TEEB) study aimed to demonstrate that economic thinking could be advantageous in bringing hitherto invisible values of nature into decision-making. Thus the concept of ecosystem services also became central in attempts to integrate environmental and economic accounting (TEEB 2010, SEEA 2012).

This chapter provides a brief background of the term ecosystem services, a summary of some of the most important definitions, and an outline of the policy context of the concept in the EU and in Norway.

Definitions and classifications

An ecosystem is defined as «a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit» (CBD 1992). Ecosystem services are “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life” (Daily 1997), or more simply put “the benefits people obtain from ecosystems” (MEA 2005).

Jansson (2013) traces the origins of the concept back to 1864 and the book “Man and Nature” by George P. Marsh. Over the years, there has been increasing recognition of the multiple benefits that humans derive from nature, and by the mid-1970s many of the services that are listed today had been identified (Holdren and Ehrlich 1974, Westman 1977).

In spite of this long history, use of the concept “ecosystem services” (ESS) first really exploded with the publication of the Millennium Ecosystem Assessment (MEA 2005). The MEA, building on the work of de Groot et al. (2002), classified ESS into four categories:

- Provisioning services, e.g. provision of food, fibre, water, timber and medicines.
- Regulating services, e.g. regulation of climate, air quality, water quality, and disease control.
- Supporting services, e.g. soil formation, photosynthesis, and recycling of nutrients.
- Cultural services, e.g. aesthetic and spiritual experiences, cognitive development and recreational experiences.

Following the MEA, numerous alternative classifications were proposed (e.g. Wallace 2007, Fisher and Turner 2008, TEEB 2010). It has been argued that alternative classifications are useful and necessary to accommodate different perspectives on ESS and different purposes of analyses (Costanza 2008). However, with the increasing development of national and

international environmental accounting systems, and the integration of these with economic accounts, there have also been calls for a single standardised classification system (Boyd and Banzhaf 2007). To answer this need, the European Environment Agency initiated the establishment of the Common International Classification of Ecosystem Services (CICES) (Haines-Young and Potschin 2013). CICES aims to link both with the framework of the UN System of Environmental-Economic Accounts (SEEA 2012) and with the EU process on the Mapping and Assessment of Ecosystems and their Services (MAES).

CICES classifies ecosystem services into three main categories:

- provisioning ESS
- regulation and maintenance ESS
- cultural ESS.

These categories are the same as those of the MEA, but supporting ESS are no longer included at the same level. The reason for this is that supporting services are a necessary requirement for all of the other ESS and their inclusion would therefore lead to double-counting. It should be noted, however, that CICES provides a framework in which supporting services can be nested and referenced. This means that the classification system can also be used for purposes other than environmental accounting, such as mapping work.

Another much-used term for supporting ESS is *intermediate* services, as opposed to *final* services for the other ESS (Haines-Young and Potschin 2013). Supporting/intermediate services may contribute to several final outputs simultaneously.

CICES has also suggested a stricter definition of services, versus goods and benefits – words that were used interchangeably in the MEA and earlier work. The definitions given by Haines-Young and Potschin (2013) are:

- «**Final ecosystem services** are the contributions that ecosystems make to human well-being. These services are final in that they are the outputs of ecosystems (whether natural, semi-natural or artificial) that most directly affect the well-being of people. A fundamental characteristic is that they retain a connection to the underlying ecosystem functions, processes and structures that generate them».
- «**Ecosystem goods and benefits** are things that people create or derive from final ecosystem services. These final outputs from ecosystems have been turned into products or experiences that are no longer functionally connected to the systems from which they were derived. Goods and benefits can be referred to collectively as 'products'».

Figure 4-1 illustrates the reasoning behind these terms.

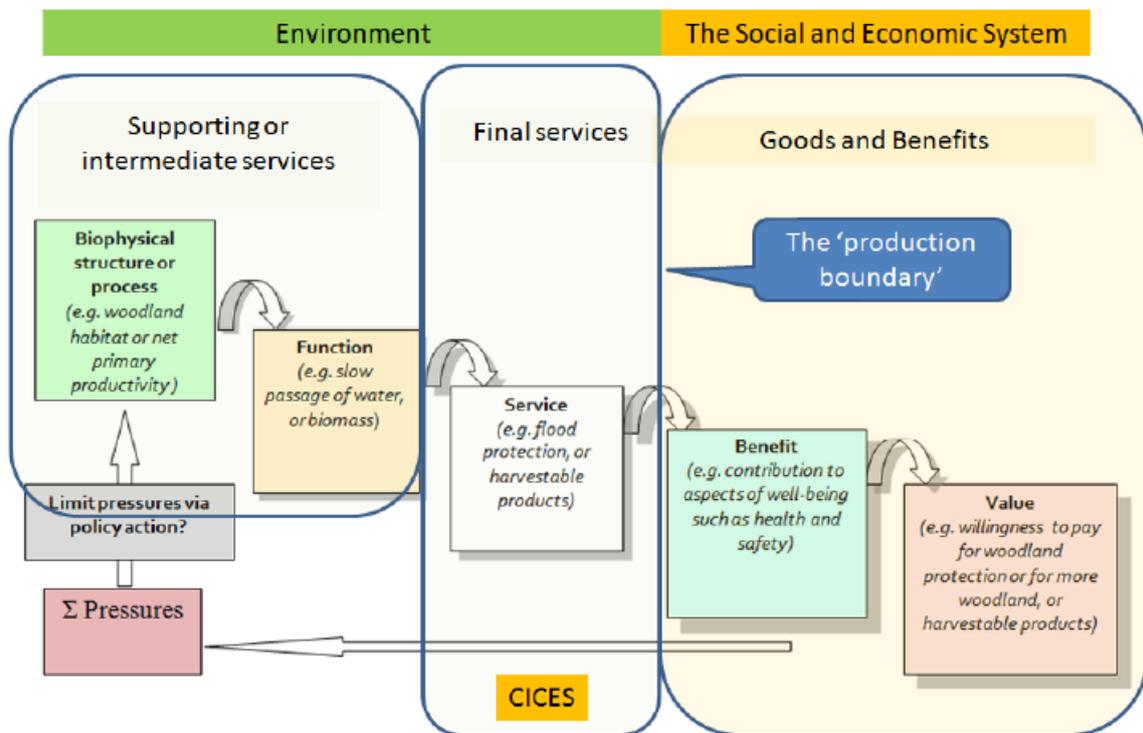


Figure 4-1: The Ecosystem Service Cascade (Haines-Young and Potschin 2013, building on Potschin and Haines-Young 2011)

Policy context

There has been increasing political interest in ESS, as seen in initiatives such as TEEB (2010) and the Intergovernmental Platform on Biodiversity & Ecosystem Services (<http://www.ipbes.net>). This interest is also being integrated in other policy frameworks. For example, payments for ESS are being considered within the European Union Common Agricultural Policy (EC, 2010).

The European Biodiversity strategy to 2020 (EC, 2011: Target 2, Action 5) requires all EU Member States “to map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020”. The MAES working group, mentioned above, was set up to support the member states in this task. MAES has recommended the use of CICES (version 4).

In Norway, work to assess the value of ecosystem services was initiated as a direct follow-up of the TEEB project and resulted in an Official Report (NOU 2013). The general policy questions applicable at the EU level (see Table 4-1) are also applicable for Norway:

Table 4-1: Broad policy questions (Table 1, p.14 in Maes et al. 2013)

Q1	What are the current state and trends of the EU's ecosystems and the services they provide to society? What are emerging trends and projected future state of the EU's ecosystems and the services they provide to society? How is this currently affecting human well-being and what are the projected, future effects to society?
Q2	What are the key drivers causing changes in the EU's ecosystems and their services?
Q3	How does the EU depend on ecosystem services that are provided outside the EU?
Q4	How can we secure and improve the continued and sustainable delivery of ecosystem services?
Q5	How do ecosystem services affect human well-being, who and where are the beneficiaries, and how does this affect how they are valued and managed?
Q6	What is the current public understanding of ecosystem services and the benefits they provide (some key questions could usefully be included in the 2013 Eurobarometer on Biodiversity)?
Q7	How should we incorporate the economic and non-economic values of ecosystem services into decision making and what are the benefits of doing so (question to be addressed 2020)? And what kind of information (e.g. what kind of values) is relevant to influence decision-making?
Q8	How might ecosystems and their services change in the EU under plausible future scenarios - What would be needed in terms of review/revision of financing instruments?
Q9	What are the economic, social (e.g. employment) and environmental implications of different plausible futures? What policies are needed to achieve desirable future states?
Q10	How have we advanced our understanding of the links between ecosystems, ecosystem functions and ecosystem services? More broadly, what is the influence of ecosystem services on long-term human well-being and what are the knowledge constraints on more informed decision making (question to be addressed to the European Commission (DG RTD and Joint Research Centre) and research community in the context of EU mechanism, KNEU ¹⁵ , and SPIRAL ¹⁶).

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5. AGRICULTURAL POLICY REGIMES 1999-2014

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Introduction

Agricultural policies must be understood within the tensions of two competing poles: Multifunctionalism and neoliberalism. The major political groupings linked to the global trade negotiations concerning agriculture after 1985 are relating to these two poles or directions, and they also have represented two contradicting or opposing legitimacy platforms for agriculture (Almås and Campbell, 2012).

The post World War II period can be divided into a productivist period; a post-productivist period from the end of the 1980s; and a neo-productivist period dating from 2007/2008. Powerful political measures such as toll barriers, agricultural subsidies and market regulations stimulated agricultural production in the industrialised countries (Friedman and McMichael, 1989). Increasing production, efficiency and food security were the overarching objectives during the first decades after the world war. However, during the 1980s overproduction and environmental degradation and high budgetary costs soon became pressing issues (EU's Common Agricultural Policy made out 80% of EU expenditures) along with WTO negotiations on liberalization of agricultural trade, lead to European agricultural policies "greening" their subsidies into agri-environmental payments, diversification and "multifunctionality" (Rønningen et al., 2012).

In spite of twice refusing EU membership at referenda (major arguments against EU membership being losing control over agricultural, rural and fisheries policies, however also the fact that Norway is a young nation, having been in union with respectively Denmark and Sweden for 500 years ending in 1905), the recent development of multifunctionality in Norway mirrors that of the EU. It should be stressed that most Norwegian farmers always were pluriactive due to small scale farms and limited inbyeland. Combinations with forestry, fisheries and various handicrafts and trade were common. The agricultural modernization project has been linked to visions of an efficient, rational full-time farmer (Jones and Rønningen, 2008), and during the productivist period, fulltime farmers were strongly encouraged, by the state as well by agricultural organisations. This however never became a full reality due to the small scale structure of most of the country's agriculture, restricted by a difficult topography, long distances and harsh climate, as well as farmers own interest in pluriactivity, meaning several sources of income, also off farm income (Bjørkhaug, 2007).

This contribution will give an overview over Norwegian agricultural policy regimes in the period 1999-2014. As white papers are important and are actually defining Norwegian policies, ideologies and policy implementation, the presentation will be structured linked to white papers in this period. This should be useful for AGRISPACE WP4 Thematic areas for empirical analysis and WP7 Dissemination and policy recommendations and partly also WP6 Stakeholder involvement and network building.

Recent white papers on agricultural policies were published in 1993, 1999, 2011, in addition to the white paper on climate and agriculture in 2007. Concentrating on the last 15 year period, we will here include the following white papers:

- St.meld. no. 19 (1999-2000) On Norwegian agriculture and food production (Om norsk landbruk og matproduksjon)
- St.meld. no. 39 (2008-2009): The Climate challenges – agriculture a part of the solution (Klimautfordringene – landbruket en del av løsningen)

- Meld. St. 9 (2011-2012): Agriculture and food policies – Enjoy your food (Landbruks- og matpolitikken. Velkommen til bords).

Background - The Norwegian model of agriculture – active farming all over the country

The 'Norwegian model of agriculture' (Almås, 2004; Rønningen et al., 2012) is strongly regulated, low exporting, and agricultural policy legitimacy has been closely linked to a notion of multifunctionality. The model has been presented with what can be summarized in five main objectives after the World War II:

- 1) Increasing food production, productivity **and food security**,
- 2) Rural settlement and employment
- 3) **Preparedness** in relation to risk. This was part of the post-World War II legitimacy of agricultural objectives, also with an eye to the Soviet neighbour in the east.

During the 1970s objectives of

- 4) Farmers' **income equal to industrial workers**, partly sparked off by the Hitra action, in which farmers refused to pay taxes as a protest to the income crisis in agriculture, and
- 5) **Environmental objectives**, were included, as environmental damage increasingly was recognized as a problem associated with intensive agricultural production from the mid-1970s (Almås, 2004; Blekesaune, 1999).

A number of legislative and regulatory measures concerned with subsidies, trade tariffs, border controls, veterinary issues, as well as policies designed to avoid farmland concentration and to avoid farmed land to be used for other purposes than food production were developed. However, udal legislation principles go back probably 1000 years, aiming at maintaining farmland within the family and also as a mean to prevent land ownership concentration on few hands (see Flømsæter, 2009; Shucksmith and Rønningen, 2011; Rygg et al., 2011; Gjerdåker, 2001). These have come under considerable pressure to be liberalised (Bjørkhaug and Rønningen, 2014).

Dairy production has been the most important agricultural production in Norwegian rural areas, and has, partly attributable to it being a labour intensive sector, been extensively supported in family farm policies since the 1970s. The success of the dairy sector has to a large extent been based on the development and widespread use of the Norwegian Red Cattle (NRF), a breed combining good dairy and meat production characteristics. The breed has been a symbol of good resource utilization, including grazing systems (Veie and Værdal, 2013). Yet, it did replace regional breeds that were less productive, but better adapted to rough terrain and grazing – in other words utilizing local resources. Imported feed concentrates now make out a substantial part of the diet of the NRF cow. Developments within dairy are crucial to understand in order to analyse agricultural and land use developments internationally (see e.g. Muirhead and Almås, 2012) as well as in Norway (Almås, 2004; Bjørkhaug and Rønningen, 2014).

At the core of the Norwegian agricultural policy mechanisms has been a policy of regional specialization (geographical “canalization”) of productions based on “relative comparative advantages”. This meant that areas with suitable natural conditions should mainly concentrate upon grain production while the uplands, the coast and Northern Norway ought to do what they are best suited for; grass feed based dairy and beef productions. Rich outfield pastures were important feed resources, but also a certain share of nationally produced grain for feed was an important element in this delicate balance of regional specialization and zoning of differentiated payments in order to achieve this.

Post-productivism? Well, at least policy-driven multifunctionality

Oversupply, water and soil pollution, environmental degradation, landscape losses and constantly worsening farm economy, along with the budgetary costs, lead to the questioning of the sustainability of the productivist policies of the post-WWII period. Environmental scandals and the high budgetary costs of EU's Common Agricultural Policies (CAP) contributed to a new counter-productivist agenda being raised, which later has been conceptualised as post-productivist, focusing on the need for maintaining agriculture's reproduction of common, or collective goods, related to environment, landscape, rural community sustainability, cultural heritage and values, as well as animal welfare and health (Marsden et al., 1993; Ward, 1993; Lowe et al., 1993; Blekesaune, 1999; Rønningen and Olsson, 1999; Bjørkhaug and Rønningen, 2014).

The end of the 1980s saw a major restructuring of agricultural subsidies in Europe; namely, the partly replacement of existing production-orientated payments with agri-environmental payments. By its overseas critiques in eg the US and Oceania this has been referred to as "protection in disguise" (Potter and Tilzey, 2007). These reforms can be seen to represent an important principal break in policies and echoing wider global changes as reflected in the WTO negotiations on liberalizing agricultural trade, specifically the idea of "green", "amber" and "blue" boxes.

In Norway, this shift was mainly implemented through the introduction of general Acreage and Cultural Landscape Payments (AK) in 1989, replacing previous production-oriented schemes. All farmers adhering to very general environmental rules qualified for AK, with the main criterion being to avoid landscape and environmental damage from agricultural activities. These payments comprised approximately one fourth of agricultural payments, and were therefore a crucial component of the policy instruments aimed at achieving the overarching objective of Norwegian agricultural policies, namely ensuring "a viable agriculture and living cultural landscapes throughout the country".

White paper On Norwegian agriculture and food production St.meld no. 19 (1999-2000) (*Om norsk landbruk og matproduksjon*)

Norway's notion of multifunctionality has changed over the years. During the 1990s and early 2000s, agricultural policy rhetoric from both the Ministry of Agriculture and the National Farmers Union leaders was heavily related to agriculture as a producer and maintainer of well-kept cultural landscapes and carrier of cultural heritage (Daugstad et al., 2006). Norway developed a variety of multifunctionality that was strongly associated with the notion of "active farming" – maintaining these qualities through maintaining farming all over the country. The concept of multifunctionality has been gradually re-interpreted and transformed into an issue of diversification and rural entrepreneurship, not least as a way of taking the focus away from increasing economic and structural pressures (Rønningen et al., 2012).

This white paper stressed a stronger focus on consumers and the «societal use» of agriculture (p.10). The main objectives of agricultural policies were defined as 1) to produce healthy food of high quality based on consumers' preferences, 2) to produce other goods and services based on the total resources of the sector, and 3) to produce collective goods such as viable rural areas, and a broad spectrum of environmental and cultural goods, and a long term supply of food.

In other words, multifunctionality of agriculture, as well as increasing consumer orientation and economic robustness were major signals.

The White paper no. 19 (1999-2000) further stressed the need to develop a more robust farm economy based on "taking all the resources of the agricultural properties into use". These signals have been followed up, and activities such as farm tourism, nature based tourism, game and fishing/angling tourism, as well as green care have had a substantial growth in

Norway (Vik and Farstad, 2009; Magnus and Kvam, 2011; Flø, 2011). This does in other words represent modern pluriactivity and “multifunctionality”.

The then minister of Agriculture, Lars Sponheim, used the concept “Agriculture Plus”, defined as the modernization and new strategies in agricultural policies (Miljøverndepartementet og Landbruksdepartementet, 2005). This must be seen as the equivalent to the international concept of multifunctionality. While the concept of multifunctionality itself never really gained foothold in the agricultural community in Norway, its content certainly did (Heggem, 2014; Rønningen et al., 2012).

In spite of the many positive developments linked to this approach, and also an increasing market potential for some of these products and attractions, skeptics have pointed out the poor economic performance of many of these business developments in a high cost country that features a scattered population and long distances to major markets. Further, while agricultural subsidies are legitimized by the image of small farms producing attractive landscapes and biodiversity, these are increasingly being closed down and/or are not entitled to payments any longer (Shucksmith and Rønningen, 2011).

Norway has witnessed high levels of land abandonment, a strong regrowth of scrub, and a consequent reduction in the attractiveness of landscapes for both tourists and locals (see Soliva et al., 2008; NRK, 2011; Bryn et al., 2013; 2014). Representatives of agricultural management and bureaucracy both at regional and local levels state in interviews and the media that agriculture is no longer delivering “an attractive cultural landscape all over the country”, despite the Acreage and Cultural landscape payments as well as the more targeted cultural landscape management payments (Øian and Rønningen, 2013; Veie and Værdal, 2013).

No doubt this is a result of structural changes, the reduction of active farms and farmers, the decline of mixed farming systems, reduced grazing and hay cutting, and the decrease and changes in dairy, but there has also been insufficient targeting and monitoring to achieve multifunctional aims. In their assessment of goal achievement of agricultural policies, the national audit (Riksrevisjonen, 2010) state very clearly that the overall objectives are not being met. Whether production of collective goods may be organized differently, is an issue raised in recent research (Burton and Rønningen, 2014).

Restructuring processes have been strong, and during the past fifteen year period, the number of active farming units decreased from 70,100 in 1999 to 42 900 in 2014 (SSB, 2014). In particular, the dairy industry — the so-called backbone of the Norwegian agricultural system — has witnessed a dramatic reduction in the number of active farms (SSB, 2010; Tine Nord et al., 2011).

Neo-productivism?

At the beginning of this century the concept of “neo-productivism” was used to describe policies that responded to environmental degradation and that encapsulated considerations of sustainability (Bjørkhaug et al., 2012). Neo-productivism included integrated and organic farming systems that were productivist in mode because of their focus on food production, but were also more sensitive towards the environment (Evans et al., 2002). After the global agricultural crisis a more critical understanding of neo-productivism has been raised by Anderson (2009) who states that neo-productivism is simply a disguised form of productivism that exploits environmental problems and consumer consciousness for purely marketing purposes. Further, Hurlings and Marsden (2010:3) claim neo-productivism to be part of a battleground of rival paradigms on sustainable forms of ecological modernization”.

Within the context of climate change an increasing world population; changed global consumption and dietary preferences; speculation in food and agricultural commodities; and a focus on food security all created a renewed impetus for what we have termed “neo-productivist” approaches to agriculture (Rønningen et al., 2012). Burton and Wilson (2012)

outline four distinct “types” of neo-productivism — two of which are occurring within neoliberal agricultural regimes (cooperative productivism and competitive productivism) and two within multifunctional regimes (market productivism and repositioned productivism). Norwegian agricultural policy responded quickly to global shocks — particularly food security and climate change. A climate report was commissioned into the contribution of Norwegian agriculture to climate change and the potential for the industry to respond to new environmental, food production and economic conditions (St.meld. no. 39 (2008-2009)).

White paper no 39, 2009 “Climate change – agriculture a part of the solution” - A climate turn in Norwegian agricultural policies?

In 2006, the agricultural sector as a whole - which includes forestry - represented 60% of Norwegian climate emissions, although agriculture itself only represented 9% of Norway’s emissions of climate gases in general, including CO₂. The main climate strategy of the Norwegian governments has been investments overseas, such as e.g. rainforest conservation payments. The white paper on “Climate change - agriculture is part of the solution” (Ministry of Food and Agriculture, 2009) represents the first Norwegian sector-based attempt to address and formulate the challenges related to climate change. In particular, it emphasises FAO estimates that, by 2030, the world will need almost 50% more food production than today, and the need that will be doubled again within 2050.

High food prices have effectively highlighted a potential tension between, on the one hand, increasing production to ensure supplies and affordable prices, and, on the other, securing public goods (e.g. Brobakk and Almås, 2011). Although environmental protection and increased food production are not necessarily mutually exclusive — indeed, it is common for stakeholders to refer to dual objectives of “food and environmental security” — the recent concentration on food production has the potential to relegate the environment to a back seat.

Climate change adaptation and possible food security issues have introduced a new aspect into the multifunctionality argument, reigniting discussion in support of agriculture’s production of food and fibre. Norway sees potential benefits emerging from climate change, in particular in terms of increasing the area of arable land and/or introducing more productive crops in Northern Norway and in Upland areas in Southern/Mid-Norway. According to the then Norwegian Minister of Agriculture and Food, Lars Peder Brekk, increased attention has been brought to maintaining a protectionist, supportive agricultural system in which the aim is to produce more food in a sustainable and climate-friendly way (Brek, 2010) — as seen, for example, in the FAO (2009) report on “How to Feed the World in 2050”. With this change, the Minister argued, Norway no longer has to struggle to justify its protectionist agricultural system:

“In my view, the main instrument for global food security is the national food production. Every country has an obligation to provide food for its own population. Trade alone cannot solve the fundamental challenges regarding the rising hunger. In the future we have to use all land resources to produce food” (Brek, 2010).

White paper No 9. (2011-2012) on agricultural policies (*Velkommen til bordet*) and signals forward stated four objectives for agricultural policies: 1) Food security, 2) agriculture all over the country, 3) strengthened business development, and 4) sustainable agriculture.

It further stated that food self-sufficiency should be maintained at the current level. Within 2030, the population is expected to increase by 20%, and an increase in production is thus necessary. This has perhaps somewhat exaggerated been interpreted as a need for 20% increase in food production. The previous emphasis on cultural landscape dimensions and multifunctionality in former white papers is weakened significantly. The focus and rhetoric is turning towards food production and food security.

Where, how and at what scale can such an increase in Norway's food production be achieved?

The signals of the white paper, as well as recent signals by the new conservative/blue coalition government and its minister of agriculture, Sylvi Listhaug, are a weakening of the regional profile of agricultural policies, a liberalisation of legislation and regulations, especially that linked to transfer and sale of farm properties as well as quotas.

The concept of sustainable intensification is referred to in this white paper, and it has become a central term and objective within agricultural policy documents and research policy documents, such as the Research Council of Norway's major research programme "Sustainable innovation in the food and bio-based industries" (BIONÆR 2012) as the solution to these challenges. The basic idea is to increase production, productivity and efficiency of the farmed land and units. Farm land protection has become an important issue within land use planning and the public debate.

Research results from the BIONÆR programme financed project, Agropro, are that Norwegian land is actually used more extensively than previously, with lower crops, towards less intensive plant crops, producing less energy and proteins per area unit. Farmers are investing in machinery and equipment to reduce the labour per produced unit which actually leads to reduced productivity. As most Norwegian farmers historically and still predominantly are pluriactive, the households total work and income situation is decisive for how farmers and their families make farm business decision. As long as the profitability of farming is very limited, the extensification strategies and effects will be carried on (Forbord and Vik, 2014).

The development of a future bioeconomy has become a defined goal for policy-makers nationally, across Europe, and worldwide. The need for sustainable resource use, the growing demand for both food and energy, and the need to decouple economic growth from environmental degradation are urgent reasons (Sheppard et al., 2011). This bioeconomic transition from systems of mining non-renewable resources to farming renewable ones (Zilberman et al., 2013) will be driven by the application of new biotechnological processes and use "renewable biomass and efficient bioprocesses to support sustainable production" (OECD, 2009: 8).

Finally, we will mention that in the report from the agricultural agreement between the state and the farmers' organisations, the majority of the parliament's industry committee demand a new white paper concerning agricultural policies, only two years after the previous one (Bondeblad, 20.6.2014). Normally, these white papers come about every ten years. One reaction is that this will only create even more insecurity and unpredictability for the farming sector. However, the committee points to the objective of increasing domestic food production and increased concern regarding farm land protection.

We think this is all indicating the need for developing some scenarios for national and regional implications of global/national megatrends and national pathways.

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6. POLICY INSTRUMENTS AND SPATIAL DISTRIBUTION OF AGRICULTURE

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Introduction

Within the theme of bioeconomy, this chapter is limited to agriculture. The topic of the chapter is how policy might affect spatial distribution of agriculture. The chapter is therefore of special importance to Work Package 4-4 in AGRISPACE.

Use of land is the basis for agriculture. This type of bioeconomy has therefore a direct and very concrete spatial foundation. Throughout the world, natural conditions for agriculture vary geographically depending on latitude, altitude, other climatic parameters, topography and soil conditions. In Norway, the natural conditions vary from the lowland in the southeast to mountain areas and the northernmost areas. However, there is no unitary connection between natural conditions and observed production. Also other factors affect localization of agriculture, such as available workforce, technology, proximity to markets, and local business culture (Gertler et al., 2003; Storper and Scott, 1995).

Another important factor is policy. Policy can affect localization of agriculture through differentiation of policy or because farmers in different regions respond differently to the same policy (Lange et al., 2013; Matthews et al., 2013). In Norway one has since the 1950s had a goal to influence the overall localization of farming through political measures (Almås, 2004). For example, one has made efforts to *level the possibilities* for gaining an income from farming between favourable and less favourable farming areas. This goal has been tried met via the so-called 'canalization policy', through e.g. the marketing arrangement for grain ("Markedsordningen for korn"), which stimulates farmers in the best agricultural regions to produce grain, "reserving" grass based productions for regions with fewer options. The most recent White Paper on agriculture and food (Meld. St. 9, 2011-2012) sets up four major goals for Norwegian agriculture. One of them concerns spatial distribution in agriculture: "Agriculture in the whole of the country" ("Landbruk over hele landet").¹ This goal is specified in three sub goals: 1. Securing use of agricultural land, 2. Strengthen and contribute to employment and settlement, and 3. Policy adapted to regional opportunities and challenges.² The literature on policy and spatial distribution in agriculture is relatively sparse.

Research questions

Relevant questions to pose concerning policy and spatial distribution in agriculture may include: In what ways does policy influence spatial distribution in agriculture? What goals do eventually exist on spatial distribution, and what values lie behind them? What policy instruments exist, and what instruments are used? What effects can be observed?

Analytical framework

An analytical framework is necessary in order to gain perspective and obtain a structured analysis. Firstly, politics can influence spatial aspects of agriculture in two ways. One is *redistribution* (Matthews et al., 2013) of, more or less given, agricultural production

¹ The other goals concern food security, value creation and sustainable agriculture. Moreover, the Norwegian term "landbruk" not only includes agriculture, but also other types of land-based bio-productions, such as forestry.

² Ideally, to facilitate the policy analysis, we should have analyzed these goals, the values lying behind them and actors' experiences of effects (Weimer and Vining, 2005).

opportunities between different geographical locations. The other is *development* of agriculture, e.g. through diversification (Lange et al., 2013). There are connections between these two aspects. Secondly, there are many types of policy instruments, also called governing resources. These can be grouped in four categories: “Organization”, “treasure”, “authority” and “nodality” (Howlett and Ramesh, 2003). “Organization” is government performing the actual task “itself” through direct provision of goods and services, or indirectly through e.g. voluntary organizations or market creation. “Treasure” refers to all forms of public financial transfers to individuals, firms, and organizations. Such transfers can serve as incentives or disincentives for behavior. Examples are subsidies, user charges, and taxes. “Authority” refers to regulation based on laws, rules, standards, permits, prohibitions and the like. Regulation can be delegated. Authority also includes advisory committees and consultations. “Nodality” refers to the use of information resources by governments. It ranges from passive instruments such as dissemination, via campaigns, advice and exhortation to the creation of specialized research bodies. This type of instrument also includes selection and withholding of information. Moreover, publicly conducted and/or financed research and development (R&D) must be regarded a form of “nodality”. This grouping of policy instruments is applicable to the agricultural sector, however with some renaming. Instead of “treasure” we use the term “economic”, and for “nodality” we apply the term “information”. Combining the four types of instruments with the two aspects of agriculture mentioned above, we obtain a model illustrated in Table 7-1. The stars in the cells are a way to indicate the strength of the influence.

Table 6-1. Policy instruments and influence on spatial distribution of agriculture.

		Type of instrument			
		Organization	Economic	Authority	Information
Spatial aspect of agriculture	Redistribution	**	***	**	*
	Development	**	***	*	***

Discussion

With respect to *redistribution* we find many examples of the instrument “organization” in Norwegian agriculture. However, few of these have an obvious effect on spatial redistribution. The best example is probably the role the state has given Norske Felleskjøp as a market regulator in the grain sector (Norske Felleskjøp, 2008). The market regulation of grain has a profound effect of the distribution of agricultural production.³ In fact, the market regulation of grain contains all of the four types of policy instruments. Economic instruments influence very directly and extensively the spatial redistribution of agriculture. This concerns direct payments as well as price support (Budsjettnemnda for jordbruket, 2014; Utenriksdepartementet, 2008). Among direct payments, support to agricultural land (“Arealtilskudd”) is clearly spatially differentiated. Norway is divided into seven zones⁴ reflecting variations in conditions for agriculture. The subsidy rate per unit land of various crops differs with zone. The rates for 2013 in Table 7-2 provides an example.

The geographical differentiation in direct payments to animals is less comprehensive. For animals based on concentrated fodder (pigs and hens), the rates are highest in northern Norway, and lower in southern Norway. For support to cow milk production (“driftstilskudd”) the rates are slightly higher in Northern Norway. When it comes to price support, this is

³ A good illustration of this is the significant shift from grain production to grass based production in Norway during the era of liberal policy 1850-ca. 1900 (Gjerdåker, 2002).

⁴ The zones are approximately: 1. Lowland in Eastern Norway, 2. Jæren, 3. Other communes in Eastern Norway, 4. Lowland in Trøndelag, 5. The rest of southern and mid Norway, 6. Nordland and Troms south-west of Kåfjord, 7. The rest of Troms and Finnmark. Source: Arnoldussen et al. (2014).

heavily geographically differentiated as 80-90 per cent of this subsidy is given to grass fed animals (cattle, sheep, goats) in the districts (Arnoldussen et al., 2014). Freight subsidies for grain are other examples of economic instruments directly affecting spatial distribution of agricultural production.

Table 6-2. Rates for agricultural land support (“Arealtilskudd”) in 2013. Norwegian kroner per 0.1ha

Crop	Interval ha	Zone						
		1	2	3	4	5	6	7
Coarse fodder	0-25	90	0	124		233	261	291
	Over 25	65	0	75				291
Grain	0-80	123	175		246	246		
	Over 80	102	152		221	221		
Potatoes	All land	80					930	
Vegetables	0-8	550					1650	
Fruit	0-4	1000				1450		
Berries	0-4	1000				1450		

Source: Statens landbruksforvaltning (2013)

Concerning “Authority” certain legal instruments affect spatial redistribution in agriculture. Important ones are the market regulation for grain (“Markedsordningen for korn”) and milk quotas. The former arrangement makes it economically possible for farmers in Norway to produce grain. In the milk quota system, sales of quotas is allowed only within the borders of a county. We contend that this affects the spatial distribution of milk production in Norway. The effect of instruments in the category “Information” on spatial redistribution is less clear. One might hypothesize that the high concentration of publicly financed agricultural research and administrative bodies in Eastern Norway stimulates farmers in this region more than in other regions.

Regarding *development*, we assert that especially “Information” plays a big role for developing agriculture in all parts of the country. The regional departments of significant research institutions such as Bioforsk impact the development of agriculture in the regions. One example is government money provided to develop new plant breeds for a particular climatic zone (Hole, 2000). Another example is publicly funded projects to develop agriculture in a particular region (Sørum, 2014). Moreover, this shows that the instruments in themselves not necessarily affect spatial distribution, but rather that the design of an instrument makes a difference. Investment grants have a regional effect to the extent that they lead to profitable agricultural projects being realized that otherwise would not have come into being. Another example of economic instruments is those improving conditions for farming through land levelling and drainage. The former had a big impact on agriculture in grain areas in the 1960s and 1970s. The latter is an investment subsidy reintroduced in 2013 after being abandoned since the 1980s. An example of an “Authority” instrument potentially affecting spatial development of agriculture is local decision-making power on cases under the Agricultural Act and the Concession Act (Forbord and Holm, 2007). In general, various state and state funded organizations play an important role in developing agriculture and agriculture based activities in various regions. Examples are the agricultural department at the county governor and the partly state funded Norsk landbruksrådgivning (“Norwegian agricultural advisory service”), which is present all over Norway.

Implications

If we expand the perspective to the bioeconomy sector as a whole, all four types of policy instruments are still relevant. This is no surprise since the classification of instruments is general. However, the importance of *various types* of instruments will vary with type of bioeconomy. Instruments in the category “Economy” play a prominent role in traditional agriculture. In forestry certain “Authority” instruments may be of crucial importance, for example standards. “Information” is especially important for the development of new sectors of bioeconomy. Moreover, new bioeconomic activity seems to be unevenly spatially distributed with concentrations in certain regions (Birch, 2009). For new firms in the bioenergy sector “Organization” in the form of market creation may be a very interesting type of instrument, such as public institutions buying heating produced from forest residues (Forbord et al., 2012).

Conclusion

All the four main types of policy instruments are used in Norwegian agricultural policy, and all need to be included in studies aiming at explaining the connection between policy and spatial distribution in agriculture. However, the effectiveness of a policy instrument will depend on which aspect of spatial distribution one want to influence. Some types of instruments may be effective in redistributing agricultural production, while others will be more effective in developing new productions.

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7. NORWEGIAN IMPORT REGULATION FOR LIVE ANIMALS AND ANIMAL PRODUCTS

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The import of live animals and animal products poses a significant risk of importing infectious diseases. In this chapter, we present the history of import regulation in Norway and the current Norwegian negotiation space, the scope of livestock imports since 1990, the importance of national monitoring programs, and The Norwegian Livestock Industry's Biosecurity Unit, KOORIMP.

General history

THE NORWEGIAN VETERINARY CARE (1890)

The establishment of a Norwegian veterinary care institution and the Veterinary Institute in 1890-1891 was the start of a 100-year period of animal diseases control and improved animal welfare (Sandvik and Naess, 1992). It resulted in a very good animal health status by international standards. In this system, the national chief Veterinary Officer in the Department of Agriculture had great authority. There was a general import ban for live animals and animal products, but exemptions were made. Based on assessing formal applications, the authorities could grant import licenses. This infection protection regime, similar to that of many other countries, acted as a protection barrier for the agricultural sector. There was a broad understanding of the risks posed by imports among stakeholders in the agricultural sector.

EEA (1994) AND THE REVISED EEA-AGREEMENT (1998)

When Norway signed the EEA (European Economic Area) agreement 1 January 1994, we accepted the principle of free movement of goods across national borders. By signing this agreement, we also had to accept EU standards for cross-the-border trade with live animals and animal products (including fish), and EU standards for controlling and reporting diseases (MAF, 1998). These changes significantly reduced the powers of the chief Veterinary Officer, and removed the opportunity to uphold a *general* import ban of live animals that had existed for more than 100 years. Concerns were raised and lively debated among veterinarians (Skjerve, 2014). However, the EEA Agreement did not prevent Norway from exercising veterinary border control, including requirements of origin and health certificates, and allowing for health control through additional samplings. A majority vote in Stortinget in 1992 underlined the importance of maintaining a strict border control regime due to the risk of importing animals or animal products that might contain infectious agents, and Norway chose to keep the same rights as third countries regarding this point (Skjerve, 2014).

This challenged exports (particularly of fish) to the EU, as these had to follow the EU-regulations applied to imports from third countries. Moreover, Norway had previously an open trade relationship with Sweden and Finland, and both became EU-members in 1995. Therefore, Norway and EU entered negotiations to revise the EEA Agreement, and in 1998 Stortinget legislated the new agreement.

The revised EEA Agreement provided Norway with the same rights and duties as EU countries regarding imports and exports, removing the specific veterinary border control between the EU and Norway (MAF, 1997). Due to domestic controversies related to the risk of importing diseases with live animals and animal products, several "compensatory measures" were established. These included the establishments of The Norwegian Livestock Industry's Biosecurity Unit (KOORIMP), and national surveillance and control programs for exotic diseases not sufficiently safeguarded by EU legislation. These programs, alongside the SPS Agreement signed in 1995, reinstated some possibilities for border

control. However, live animals or animal products from countries with similar health status documentation as Norway were exempt, allowing for example easy import of sheep from Denmark, Sweden, Finland and Austria (Melkild and Tollersrud, 2007).

Trade within the EEA Agreement is continuously revised and renegotiated, to include specific national interests. In the early 1990s for instance, a salmonellosis epidemic in the EU caused by the consumption of eggs, resulted in a significant number of long-term illnesses and several deaths. Norway, Sweden and Finland escaped the epidemic, and negotiated special guarantees when importing eggs from other EU countries, after documenting significantly lower risk, thanks to monitoring programs for *Salmonella* in these countries. Such monitoring programs are nevertheless expensive, limiting the number of diseases for which we can require special guarantees. Moreover, concessions may become the subject of political critique due to its potentially trade-distorting effect.

WTO AND SPS (1995)

From 1. January 1995, the new WTO Agreement replaced the former GATT agreement. Due to the ongoing discussion and referendum on Norwegian EU membership, the WTO agreement got little attention when presented for Stortinget (St. Prp. 65 (1993-1994)) (Skjerve, 2014). The previous import system for agricultural goods based on quotas and licenses were replaced with a tariff-based system allowing Norway to protect the agricultural sector. Food imports are today largely regulated to meet Norwegian interests through modulations of tariffs. Included in the WTO framework is also a system of tariff exempts for LDCs (Least Developed Countries), enjoying low or no tariffs.

The SPS Agreement (Sanitary and Phytosanitary Measures) under the WTO allows countries to restrict imports to protect human, animal or plant life or health (WTO 2014). Regulations must be based on a scientific assessment of the actual risks involved. Countries are encouraged to use the standards developed by the relevant international bodies whenever they exist, such as the Codex Alimentarius, Office International des Epizooties (OIE), and the European and Mediterranean Plant Protection Organization (EPPO). Single countries have the opportunity to decide upon their own acceptable level of risk. Therefore, they may apply stricter standards than those recommended by international bodies, as long as they're scientifically justified and applied similarly to all countries.

LIVESTOCK INDUSTRY

Live animal import has remained small due to a combination of high tariffs, risk awareness and loyalty within the industry – a position supported by KOORIMP. Epidemics of paratuberculosis and BVD (bovine virus diarrhoea) in Norway related to cattle imports in the early 90s, the spread of BSE (bovine spongiform encephalopathy) from UK to most EU countries through live cattle and cattle products, and the foot-and mouth outbreak in 2001 in UK and few other countries, causing the slaughtering of 10 million sheep and cattle, has raised awareness and skepticism towards animal imports in Norway. Paratuberculosis and BVD are cattle diseases prevalent in Europe, against which the present EEA agreement provides insufficient protection. The livestock's industry own initiative represents an important element in Norway's protection against exotic disease agents.

Current negotiation space

Import regulation of live animals and animal products, can result from following principles:

Customs based regulation, particularly of food imported from LDC countries.

Import procedures recommended by KOORIMP. Information may be spread through journals, meetings, and the internet. Follow-up of these recommendations are motivated by loyalty and economic gains (higher slaughter price).

Legislation administered by the Norwegian Food Safety Authority (NFSA). These must comply with international obligations, and legal options for regulating trade are:

- The SPS Agreement (WTO)
- Negotiations within the EEA Agreement
 - readjustments of tariffs
 - additional import guarantees, based on the health status in Norway compared to exporting countries
- Safety Clause of the EEA Agreement

Imports of livestock and animal products

Livestock imports are of greatest concern, because live animals represent ideal reservoirs for specific infectious agents, may excrete these for long periods, and are generally introduced into herds with native animals which may easily be infected. The consequences of importing one single infected animal can therefore be a massive disease spread in the country. Table 7-1 shows the extent of import of livestock in Norway.

Animal products imports are usually less risky. When used as food for human beings, they are often treated in a way that inactivates infectious agents, for example heat treatment (cooking or frying). Spread of zoonoses, that is diseases that can spread between humans or animals, are still of concern. Human food is less likely to lead to exposure of native animals, but imported fodder may easily spread diseases.

National monitoring programs

National monitoring programs provide a basis for assessing disease incidence in Norway, to:

Fulfill our international obligations and facilitate the export of animals and animal products

- Be granted additional guarantees in international trade
- Contribute to domestic food safety and animal health

The NFSA decides annually of which monitoring programs should be done, and is involved in sampling and reporting. The Veterinary Institute is involved in planning, laboratory analyses, and reporting. Summary of the results from monitoring programs are sent to the NFAS on a monthly basis, and is made public on their webpage (http://www.mattilsynet.no/om_mattilsynet/#overvaking_og_kartlegging)

Annual reports are published at the Veterinary Institute webpage (<http://www.vetinst.no/Helseovervaaking>)

Table 7-1. Livestock import to Norway, 1991 to 2013. Poultry are day-old chicks. (Source: KOORIMP and KIF Annual Report 2013)

Year	Cattle	Pig	Sheep	Goat	Poultry
2013	30	0	12	0	20 611
2012	0	24	17	0	21 596
2011	1	0	39	0	45 029
2010	0	0	49	0	24 590
2009	0	0	18	0	28 225
2008	7	0	0	46	106 958
2007	31	0	4	5	170 866
2006	8	1	71	20	106 891
2005	0	49	39	53	143 175
2004	0	0	11	26	172 523
2003	19	8	0	90	69 666
2002	0	0	0	33	130 000
2001	14	0	0	0	90 000
2000	48	0	2	16	138 800
1999	13	3			176 347
1998	13	8		1	105 009
1997	101	30			135 458
1996	129	24			194 046
1995	276	55		38	110 492
1994	375	41			129 570
1993	197	2	3		19 319
1992	141	21		12	
1991	89	10		8	

KOORIMP

The purpose of The Norwegian Livestock Industry's Biosecurity Unit, KOORIMP, is to maintain and promote the health of Norwegian production animals and the safety of foodstuffs derived from domestic animals.

It was founded in 1995 by the Norwegian abattoirs, dairies, farm animal breeding organizations, feed industry and insurance companies. It includes TINE SA, Nortura (Gilde and PRIOR), The Meat and Poultry Association (KLF), Q-Dairies, Geno (Norwegian Livestock Breeding Stock), TYR (Norwegian Kjøttfeavlsag), Norsvin, The Norwegian Poultry association, The Norwegian Sheep and Goat Association, The Farmers Union, The Norwegian Smallholders Union, and the Gjensidige Insurance Company.

KOORIMP's main task is to advise importers about precautions and tests that should be performed and documented prior to an import of production animals, semen and embryos. KOORIMP may recommend import procedures stricter than those required through legislation. These requirements are included in KSL – Quality in Agriculture. The individual importer is responsible for compliance with the KSL additional requirements, and their documentation.

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8. PRODUCTION AND POLICY RESPONSES TO CLIMATE CHANGE

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When it comes to climate change, climate policies and their effects, the agricultural sector faces a particularly challenging future. First, as underlined in successive report from the Intergovernmental Panel on Climate Change (IPCC, 2014), the net outlook for agricultural production on a global scale is one of declining productivity and reduced yields. While the areas closer to the equator will be hit the hardest, more elevated areas to the north - among them Norway - is expected to get improved conditions for agricultural production (Parry et al., 2007). However, these areas will not be evenly distributed throughout Norway, as there will be pockets experiencing more or less floods, storms and drought than today (NOU 2010:10, 2010; Neby et al., 2012). Second, being a major contributor of GHG emissions both directly (from production) and indirectly (via input factors) (Headey and Fan, 2010), agriculture need to mitigate alongside other societal sectors for reasons such as the environment, economy and sector legitimacy (St.Meld. 39, 2008-2009; Vermont and De Cara, 2010). One of the big questions of our time, then, is how to meet a growing demand for food and biomass from an increasing population, while at the same time mitigating climate change and adapting to weather variability and new climate policies (Smith and Olesen, 2010). Research have shown that over the last ten year period, global production has increased more than demand, and global grain production hit a new all-time high in 2013/2014 (FAO, 2014). On the other hand, as long as the main energy input is fossil (Pfeiffer, 2006), and the consumption of particularly red meat continues to grow, GHG emissions also continue to grow (Bonesmo and Harstad, 2013; Westhoek et al., 2014).

In a Norwegian context, the issues describes above have very distinct geographical, or spatial, implications. The double challenge of mitigating and adapting to climate change, and increasing food production to meet future demands, come together in the concept of sustainable intensification. In the Agriculture and Food Policy White Paper from 2012 (Meld.St. 9, 2011-2012), sustainable intensification, or increased sustainable food production, is hailed as a cornerstone of domestic food security. The White Paper states the importance of maintaining a strong focus on sustainability and utilization of Norwegian resources, research in agronomy, improvement of farmer skills, as well as maintaining the geographical distribution of production types. The White Paper on Climate Change for the agricultural sector from 2009 (St. Meld. 39, 2008-2009) states that the agricultural sector must be part of the solution when addressing climate change in Norway, including GHG emission-cuts, carbon sequestration and adaptation.

Studies on climate change response in Norwegian agriculture show, in addition to central policy documents such as the White Paper, at least three major trends. First, there is a high degree of concern over future climate change, and its effects for agricultural production (Aasprang, 2013; Brobakk, 2014; Brobakk, 2015). Concern is relatively evenly spread throughout the nation, and across productions. However, farmers are mainly concerned about the sector per se, and the overall production potential, not their own production (ibid.). On the other hand, studies also show a correlation between climate change concern and proximity to climate related events such as storms and floods (Brobakk, 2015). This corresponds with the Psychological Distance of Climate Change hypothesis: personal risks of climate change are judged to be lower than societal risk (Leiserowitz et al. 2010; Spence et al., 2011), and people's perception of global climate change changes when experiencing local extreme weather-events (Spence et al., 2012). We might therefore expect a wider geographic spread in climate change perception in the future, if and when real climate change effects hit with different gradient in different parts of the country.

Second, when it comes to climate change policy implementation, things change slowly. Despite economic support for measures such as subsurface drainage of agricultural soils, research on biofuel production from manure and forest plantation (Haugland et al., 2013), real progress towards the national goal of cutting GHG emissions from agriculture with 1.0 - 1.5 mill. tons CO₂-equivalents by 2020 is still awaiting in the future. The white paper (St. Meld. 39, 2008-2009) states that climate mitigation or adaptation policy measures must be cost-effective without altering the main domestic agricultural policy goals, including food production level and farm structure. Further, the farmers themselves emphasize other goals than GHG reduction as important when asked, reflecting loyalty to and support for the current agricultural policy (Aasprang, 2013; Brobakk, 2014; Brobakk, 2015).

Third, the farmers further underlines that new challenges from Norwegian climate policies is as important as the challenge from climate related changes affecting the production potential (Skarbø and Vinge, 2012; Flemsæter and Bjørkhaug, 2014). Based on these findings, future farmer responses might be a mix of climate mitigation policy adaptation, as well as locally based climate change adaptation of production, in other words policy driven and spatially based adaptations.

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9. SPACE AND AGRICULTURE

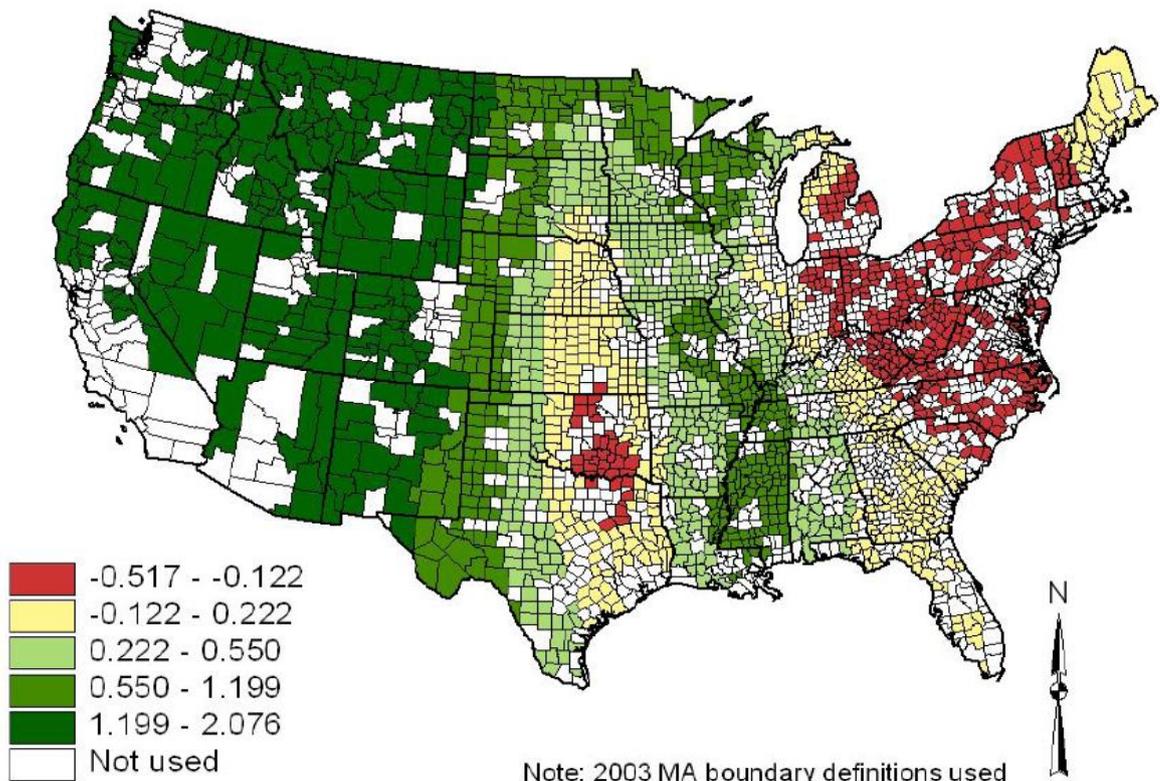
Øyvind Hoveid, Norwegian Agricultural Economics Research Institute

Why bother?

One does not need to bother about what happens where when spatial patterns are permanent. However, in a dynamic society such spatial coordination is unlikely.

At all times:

- Each locality has an economic structure of its own which may give rise to locality specific responses to time and policies --- not even signs need to be identical. An illustration: the local effect of % college graduates (resident 1985-90) on subsequent employment change (1995-2000). Partridge, Rickman, Ali and Olfert (2008)



- The union of all local responses forms the nation-wide response
- Economists and statisticians have the responsibility of revealing spatial variations and to provide local predictions

The starting point of spatial economics (von Thünen 1826)

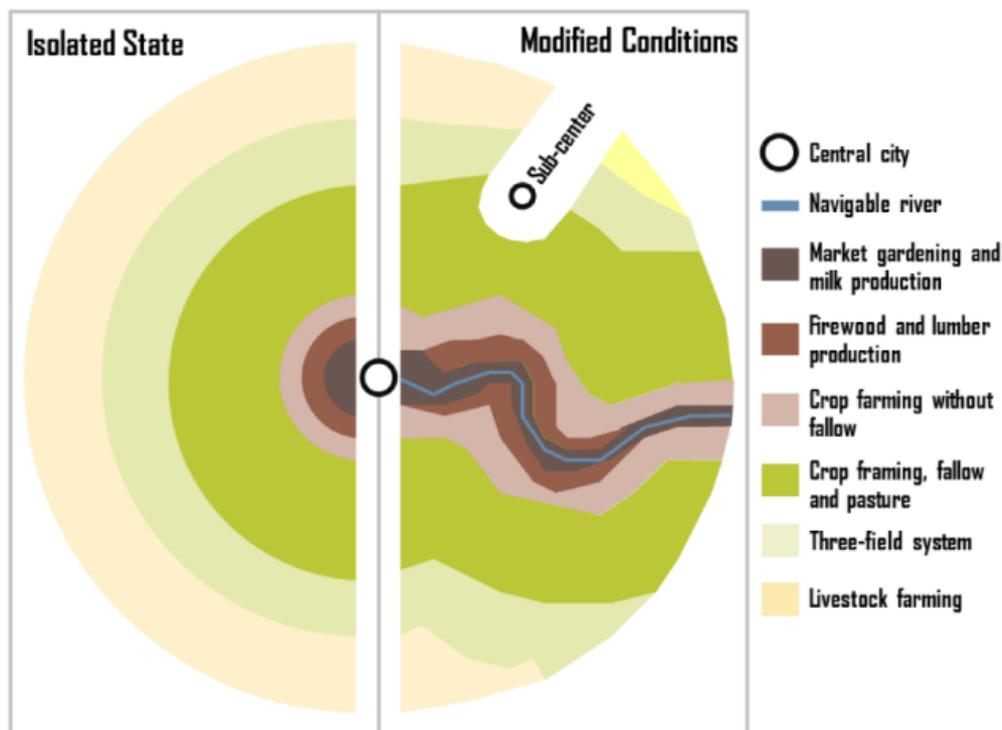


Figure 9-1. Graphical illustration of an isolated state and modified conditions. Source: http://www.lewishistoricalsociety.com/wiki/tiki-read_article.php?articleId=12

The “isolated-state” model illustrates — with a background of early 19th century transportation technology — that

- locations with different distance to centre choose different production
- locations of agriculture are tightly linked with the location of population

The modified model brings in more realism by pointing out that:

- Costs of transportation depend on infrastructure
- More than one centre of attraction may be involved

Economic growth and developments of technology, institutions and eventual policies have weakened the spatial links between agriculture and population. Nowadays,

- Freight terminals and airports are additional centres of attraction, while highways and railroads are additional infrastructures for the population at large
- Agriculture is land based and can to a limited extent follow the mobile population
- However, farmers do have spatial relations to the other rural population through local centres and direct contacts
- And close to urban areas land-use and farming are highly influenced by urban growth. There is a large literature on these issues under the label of “rural-urban fringe”

Space matters for agriculture because:

- The key productive resources of farmland and hours of sunshine are not evenly distributed and cannot be moved
- The transport of other farm inputs and farm outputs is costly
- There are economies of scale: in order to produce at competitive unit costs a certain scale of operation is required

Any unregulated activity under such conditions will create spatial patterns with the trade-off between economies of scale and transportation

- When transport is expensive relative to economies of scale, production occur at small scale wherever immobile resources are located (von Thünen's case)
- When transport is cheap relative to economies of scale, production occur at large scale in a few locations that are best endowed with the immobile resources

Norway is a diverse country with respect to agriculture

- Not only land and sunshine resources (growing conditions) are varied and unevenly distributed geographically, but also the policies
- Subsidies that vary by zone attempt to compensate for varying growing conditions
- The combination of spatially varied growing conditions and policies constitute a large "policy experiment" which can be evaluated along zone borders

A problem: the local determinants of farming are only partly observable

Each farmer is in contact with numerous agents at some distance: Neighbours, the local community, the processors of products, the suppliers of inputs, employers (if part-time farmer) and potential employers (if not). The costs of making transactions with the various agents are part of the local economic conditions. Likewise, a wide range of natural conditions with regard to soil and climate are also parts. The conditions can be measured to some extent, however many aspects have escaped measurement. With respect to unmeasured conditions, we will assume:

- Closeness in terms of travelling costs between farmers means also closeness in economic conditions
- Closeness in terms of shortest distance means closeness in natural conditions

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10. SPATIAL DIFFUSION OF INNOVATION

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Introduction

Within geography, as well as neighbouring fields within the social sciences, the spatial diffusion of innovation received considerable attention in the 1960's and 1970's (Tonts et al., 2010). Everett M. Rogers (1962) argues in his theory of diffusion of innovation that individuals obtain information from those around them, especially those who have gone through the same processes and made new decisions. As a result, innovations diffuse. Rogers (1962) defines an innovation as an idea, practice, or object that is perceived as new by an individual or other unit of adoption. Diffusion processes are important in agriculture because farmers tend to rely on information from their colleagues (Berger, 2001) and neighbours (Buttel et al., 1990). Spatial diffusion processes in agriculture are especially good to study on a local level because they can be highly visible to others; anyone who passes the farm and other farmers (Burton, 2004; Schmit and Rounswell, 2006).

While studies of diffusion of innovations have been numerous, few have picked up the opportunity to statistically analyse the geographical dimensions of the diffusion processes. In 1953 (Swedish edition), the Swedish geographer Torstein Hägerstrand developed analyses of spatial diffusion of innovations (Hägerstrand, 1967). The most significant contributions to this field were carried out the 1960s and 1970s (Tonts et al., 2010). Hägerstrand developed a theory on farmers' adoption of new farming practices based on the idea that farmers adopt new ideas from the surrounding milieu, personal contacts and mass media. Even if these ideas were developed in relation to diffusion processes among Swedish farmers, Tonts et al. (op. cit.) suggest that these processes can operate on a wider geographical scale, perhaps even globally.

The theoretical and methodical work of Torstein Hägerstrand (1967) on neighbourhood effects in the study of diffusion processes were pioneering. However after some decades of less attention to this work, new methodological and theoretical tools enable new and sophisticated statistical analyses of spatial effects in line with Hägerstrand's ideas. These analyses can provide development of knowledge on challenges and opportunities for sustainable growth in production and innovation in land-based bio-production across spaces - of which is the overarching objective of AGRISPACE.

Empirical analysis

In the empirical analysis in AGRISPACE, we will examine how different statistical techniques within spatial regression analysis can help us analyse the spatial distribution of innovations in relation to questions raised in WP4 Types of production:

1. How **types of production** vary with **spatial localization** (what is being produced, where and how is it conducted).
2. What opportunities and challenges might be created under different forms of **bio-economic transitions** in land-based productions, and how can these be exploited and mitigated at the farm level across space.

In AGRISPACE, we are interested in farm structural and agricultural change in Norway, how and why changes can develop in sustainable ways, and in particular how these develop in different geographic regions. Spatial error and spatial lag models can identify the spatial proximity of the units of analysis. If correlations between neighbouring units occur, we can claim a spatial effect in how agriculture is structured in Norway. A model incorporating spatial lag and error effects can capture the spatial autocorrelation among the errors and the autocorrelation within the dependent variable identified in an ordinary OLS regression model. Comparison between ordinary least square models (OLS) and spatial models allows for the identification of the potential causes of the autocorrelations (Brasier, 2005, p.554).

While an important part of social science knowledge-building on farmers' motivations and farm adaptations build on studies of individual characteristics of the farmers and their values and concept of knowledge (see e.g. Burton 2004; Burton and Schwarz 2008), focus on the spatial patterns in localisation of farms in relation to transitions to new innovation are less explored (examples exist e.g. in studies of diffusion of organic agriculture e.g. Bjørkhaug and Blekesaune 2013). The AGRISPACE project will assess the spatial dependence between geographical defined areas with particularly interesting features in relation to particular productions and potentials for bioeconomic innovations. Spatial analysis can be used to explore observed data that enable us to explore hypotheses on the spatial processes behind localisation innovations.

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11. HOW TO MEASURE AND VISUALISE SPATIAL VARIATION

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Introduction

It is a common property of geographic data that they vary across space, both variation due to spatial heterogeneity (depends on definition, but in general similar to: first order property of a spatial process, large scale trends, regional trends, non-stationary process) and spatial dependency (depend on definition, but in general similar to: second order property of a spatial process, small scale trends, local effects, spatial autocorrelation).

“Spatial data analysis uses statistical theory and software to analyze data with locations coordinates” (Krivoruchko, 2011). In spatial data analysis the key aspect is to understand the spatial variation of the event in question, described by spatial context (e.g. neighbor events) or spatial covariates (e.g. elevation, soil or distance to centers of attraction). Common steps in spatial data analysis are: (i) Visualizing the data: visual display of data using plots or maps, a basis for generating hypothesis, etc., (ii) Exploratory data analysis: descriptive statistics, maps and scatter plots that display/illustrate the spatial variation and show important features (including extreme data values), and (iii) Development of statistical models and hypothesis, i.e. models that capture the spatial variation of the data. A red line in this chapter is that “it is generally helpful to look at the data set before any models are fitted or hypotheses formally tested” (Fotheringham, 2000). Do we see unusually high or low values or spatial patterns (e.g. groups or associations between variables)?

Spatial variations of agriculture-related data are interesting because they possibly display results of different driving forces (spatial covariates), such as nature (terrain, climate) and policy (vary by region). This chapter concerns why we should visualize spatial data, and how to do it (focus on heterogeneity, not dependency). The exploration of spatial data is relevant in many WPs in the AGRISPACE project, and the same techniques will apply for displaying results (e.g. model results, predictions, confidence intervals). This is more a presentation of general ideas and techniques than “state of the art”, but some recent examples of measuring and visualizing spatial variation in agriculture and bio-economy are given.

Spatial data

Spatial/geographical data can be divided into (Krivoruchko, 2011) (i) continuous data (geostatistics data, possible value everywhere), (ii) regional data (aggregated to polygonal, lattice), e.g. aggregated municipality data, and (iii) discrete point data (locations of events), e.g. direct payment farm unit locations. The type depends on how the data was collected/sampled, which again is dependent on research question and practicalities like time, cost and availability. It is possible to convert from one data type to another, e.g. from polygon (area) data to point data (e.g. using centroid), or from point data to polygon data (e.g. using Voronoi tessellation).

Both input data and output data of an analysis must consider the geographic space (spatial unit), i.e. polygon (municipality, county or regular grid), lines, points or pixels (cells), in addition to the data values (continuous (here data value, not data locations), ordinal, interval, categorical or binary).

Spatial variation

Spatial heterogeneity is the effect that the means (intensity) varies from place to place, that there is an uneven distribution of an event or attribute values across the study area. This is a non-stationary process with the data mean and the variance varying in space instead of being constant (Pfeiffer 1996).

Spatial dependence is the effect that outcomes at different locations may be dependent, that “observed values closer together usually should be more alike than values further apart” (Krivoruchko, 2011). The extent of spatial dependency can be modelled, usually by removing the heterogeneity before analysis (e.g. removing trends) so the data is stationary (data variability is the same everywhere in the data domain) (Pfeiffer 1996).

When we see a pattern in spatial data, it can usually be described as heterogeneity or dependence, or both. There might for instance be spatial heterogeneity and not spatial dependency, or vice versa. What we study, or find, depends among other things on the purpose of the analysis and prior knowledge. The purpose of the analysis is for us to map data on a chosen scale, and prior knowledge is how we expect the data to behave.

SCALE

Scale can influence whether we see spatial dependency or spatial heterogeneity, or both, as the variation may differ between spatial scales. Spatial dependency and spatial heterogeneity can e.g. both exist at a given scale, but when looking at a coarser scale it may be more interesting to describe the underlying regional trends only.

In the project AGRISPACE the regional trends have a high focus. We will also work on dependency between e.g. neighbouring farm units (neighbouring effects, Chapter 10), but a start for many of the analysis is the regional aspect. With regional trends we mean variation across Norway. We will mostly operate on a national scale, to visualize and understand differences between regions.

EXPECTED REGIONAL PATTERNS

We expect to see regional variation regarding agricultural data in Norway. This is due to the possible uneven distribution of driving forces or agents of the phenomenon in question, such as growing conditions (terrain, climate, soil), policy instruments (subsidies vary by zone), transport and demography and contact with numerous agents such as processors of products, suppliers of product and access to employees (Chapter 8). These might explain the spatial patterns. The visualizations presented in this chapter thereby concentrate on spatial heterogeneity, i.e. how the mean (intensity) of location or attribute value varies across Norway.

Visualize

A starting point in spatial data exploration is to visualize the data. Tools to do this are graphs/diagrams and maps. They both need a geographic space/entity/unit to hold the corresponding value or aggregation of that geographic location (e.g. sum, mean, maximum, range or presence/non-presence).

For national scale maps (e.g. display Norway on A4 paper) simplifications are needed. One can display e.g. points of farm units (Figure 1), but as there are a total 43010 points in 2013, it is better to aggregate and present a large scale smoothed surface. Of course we can “zoom in” to a local scale.

MAPS

“Considering the spatial dimension is essential when the data are geographical” (Fotheringham, 2000), as the location of events are of interest. The fundamental tool of spatial data exploration is to map the data (Figure 2-9). We should also remember to display the data of the phenomenon with other geographic data, to look for patterns, generating

hypotheses, etc. There are many map options, from simple schematics to 3D maps showing the data in so to say every detail. By varying symbols by size, shape and colour there are vast opportunities. And not to mention the big visual influence the classification scheme makes (by manual delineating or by methods such as equal interval, standard deviation, quantiles or geometrical intervals) (Figures 3 and 4). One can visualize the data values or the variation from the mean (Figure 9). In addition, one can group the data into categorical classes before displaying them on a map (e.g. farm units of different productions).

GRAPHS

Contrary to maps, it is more important for graphs that visualize geographical data that they relate the values to defined regions that people are familiar with (e.g. municipality or county). A map in itself, if the shape is known (e.g. Norway) will make people know where they are, even if the values are presented on a grid with a cell name that is not known. Examples of graphs are bar plots, spider/web/rose diagrams, scatterplots, box plots and histograms, displaying values for different regions. One can also establish a link between e.g. a scatterplot of two groups and where these groups of points are located on a map.

Measure spatial variation

An important question is if the pattern we seem to see, in fact is a pattern? Is there a variation in intensity (mean of events or attribute values) across the study area? There are several ways to quantify and describe the spatial heterogeneity (spatial data variability), depending on research question and data (semivariogram model, landscape ecology heterogeneous indexes, geographically weighted regression, quadrat analysis, nearest neighbour analysis, trend analysis, cluster tests, etc.), and beyond the scope of this introduction.

Examples of studies presenting spatial variation

Some recent, state of the art (?), visualization of spatial variation related to the “agricultural sector” and/or “bioeconomy” are shown in Table 10-1.

Table 10.1. Mapping of spatial variation examples.

Paper	Geographical input data/unit	Agriculture/bioeconomy	Scale	Modelling	Visualization (map)
Debolini et al. 2013	service = polygon, headquarter = point, and Mapping scale: 35 ha, 0.2 x 0.2 cm on paper.	local knowledge in assessing the spatial organization of agricultural services at a provincial scale	Provincial (county?), 28 municipalities (Germany)	overlap, spatial distribution of "services mapped as polygons)	map of polygons, not complete tessellation (ca. 60 x 60 km)
Ungaro et al. 2014	point (presence/absence), 2 random points per 1 km ²	mapping landscape services, e.g. crop production	Study area: 576.4 km ²		100 x 100 m, Result from Kriging, and spider map for regions vs. services
Toth et al. 2014	NUTS classification 1, 2 and 3 (different sizes)	Economic spatial structure of Europe	Europe	Gravity model	Gravity centre, polygon ellipses on Europe map
Thomas et al. 2013	Land use (supply), districts/polygons (demand)	Spatial supply and demand (variation in benefits of bioenergy) relationships for biomass energy potential	National scale (England)	40 km buffer,	Buffer circles with information inside, on national map. Different colours on buffer circles, and different size of buffer centroids
Gutzler et al. 2015	Administrative unit (districts in Germany), ca. fylkeskommune	Agricultural intensification scenarios	Regional (in Germany)	Difference in indicators based on scenario results	14 administrative districts, values relative to mean

Examples of maps based on information from PTR discrete point data

“The Norwegian Direct Payment Register (PTR) is a database covering all units that claim direct payments on the basis of eligible animals and acreage”, “almost all farms apply for payments and as almost all animal and crop production activities are eligible for various kinds of direct payments” (Mittenzwei, 2012). Application for subsidies is a yearly event. The farms that applied 2013 are defined here as the Norwegian farms (although the register does not hold every farm). A total of 43010 farms applied for subsidies in 2013. Farms locations are represented as discrete points. The dairy production farms are further defined as having “dairy cows > 0”, resulting in 9503 dairy farms (Table 10.2). Although farms are represented as point data, the presented mapping techniques apply for different data types.

Table 10.2. Descriptive statistics of the dairy production location data (2013).

Dairy production	Farms	Cows				
	N	Min	Max	Sum	Mean	Standard Deviation
	9503	1	143	228954	24.09	16.0

One can argue that the points (Figure 10.1) are too fine scaled to be represented on a national scale. The same would be the case for e.g. land use data, where all the small polygons of different land use give too much detail on a regional scale. We then have to either generalize to a coarser scale or aggregate the values.

The following maps display the variation in density/intensity of dairy farms, or number of cows on dairy farms, across the study area (Norway), using different techniques (Table 10.3).

Table 10.3. Discussion of the presented maps.

Technique	Figure	Discussion
Discrete point data	10.1	This is the actual location of farms. We see where things are, but overlapping features make it difficult to see trends.
Grid count	10.2-10.4	Dividing the study area into regular grids of different sizes and count the number of events in each square. This is sensitive to size of grid squares being used (Fig. 10.2 vs. Figs. 10.3 and 10.4). And classification scheme. In Fig. 10.4 it looks like there are only milk farms in one area of Norway, while Fig. 10.3 give a more nuanced picture.
Cartogram	10.5	"If you have data with disparate values between areas, making an area cartogram is an effective way to map out those values". This highlights a region in south-western Norway. Maybe to much.
Kernel density	10.6	This is dependent on choice of resolution, and type and size of kernel, i.e. how smoothed the data gets. Can make contour maps from density maps. Only one point inside radius would give spots like in Fig. 10.6.
Administrative units, choropleth map	10.7-10.9	Dividing the study area into e.g. municipalities and count the number of events in each unit. The possible different size of units may emphasize some areas more than other, even if the values are the same.
Symbols on geographic unit (on map)	10.10	E.g. Pie chart or bar/column chart. Display multiple statistical information in map, but dependent on choice of region, as Figs. 10.7-10.9.
Random dot map	Not relevant	This fills the geographic unit with dots rather than e.g. colour. The number of dots is relative to the value of the unit. This would only confuse regarding farm location units, where we are used to think of one point as one farm.

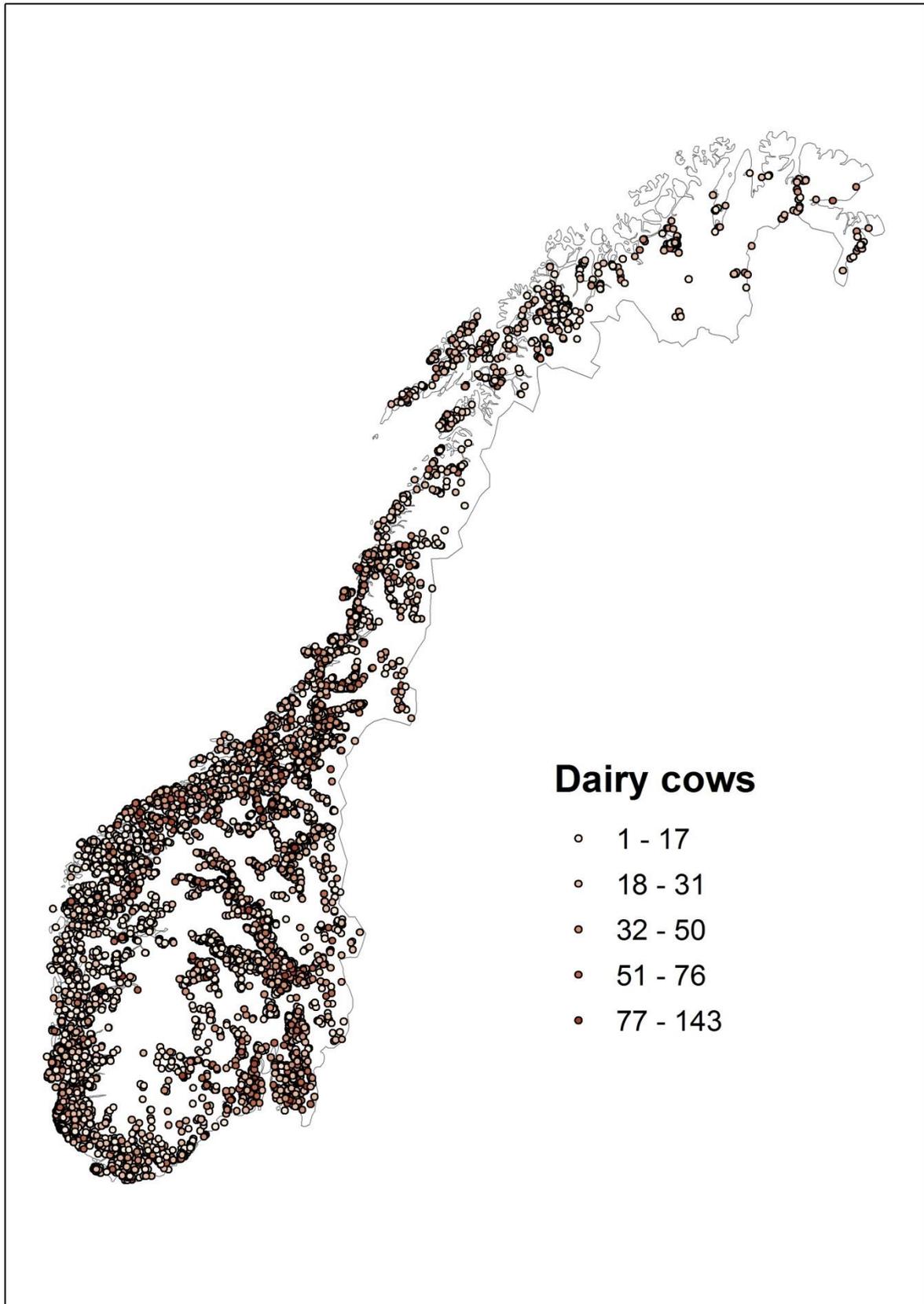


Figure 10.1. Discrete point data, classified according to Natural Breaks using colour to differentiate between classes.

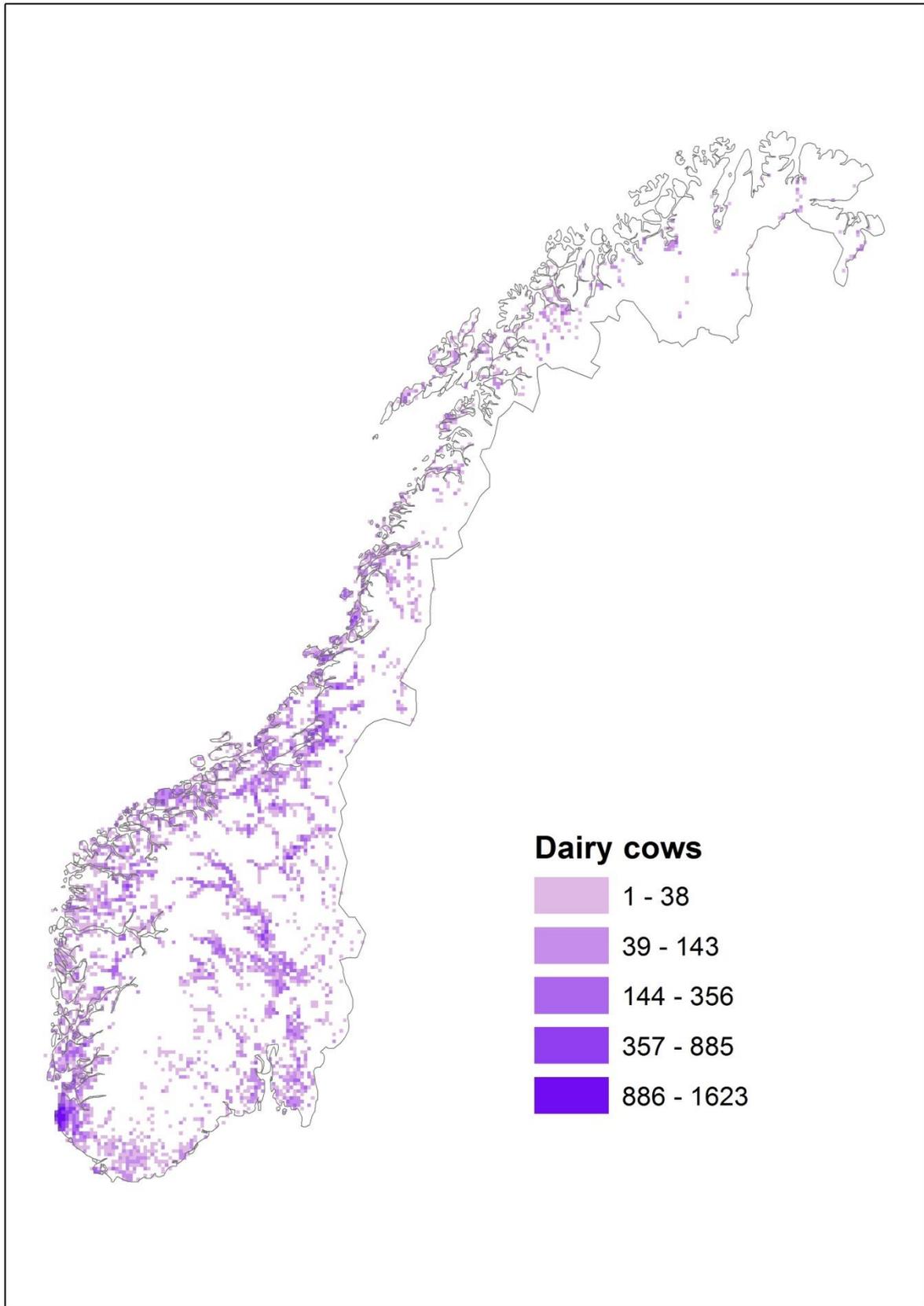


Figure 10.2. Grid 5 x 5 km, number of cows in each grid-cell, classified according to Natural Breaks using colour to differentiate between classes.

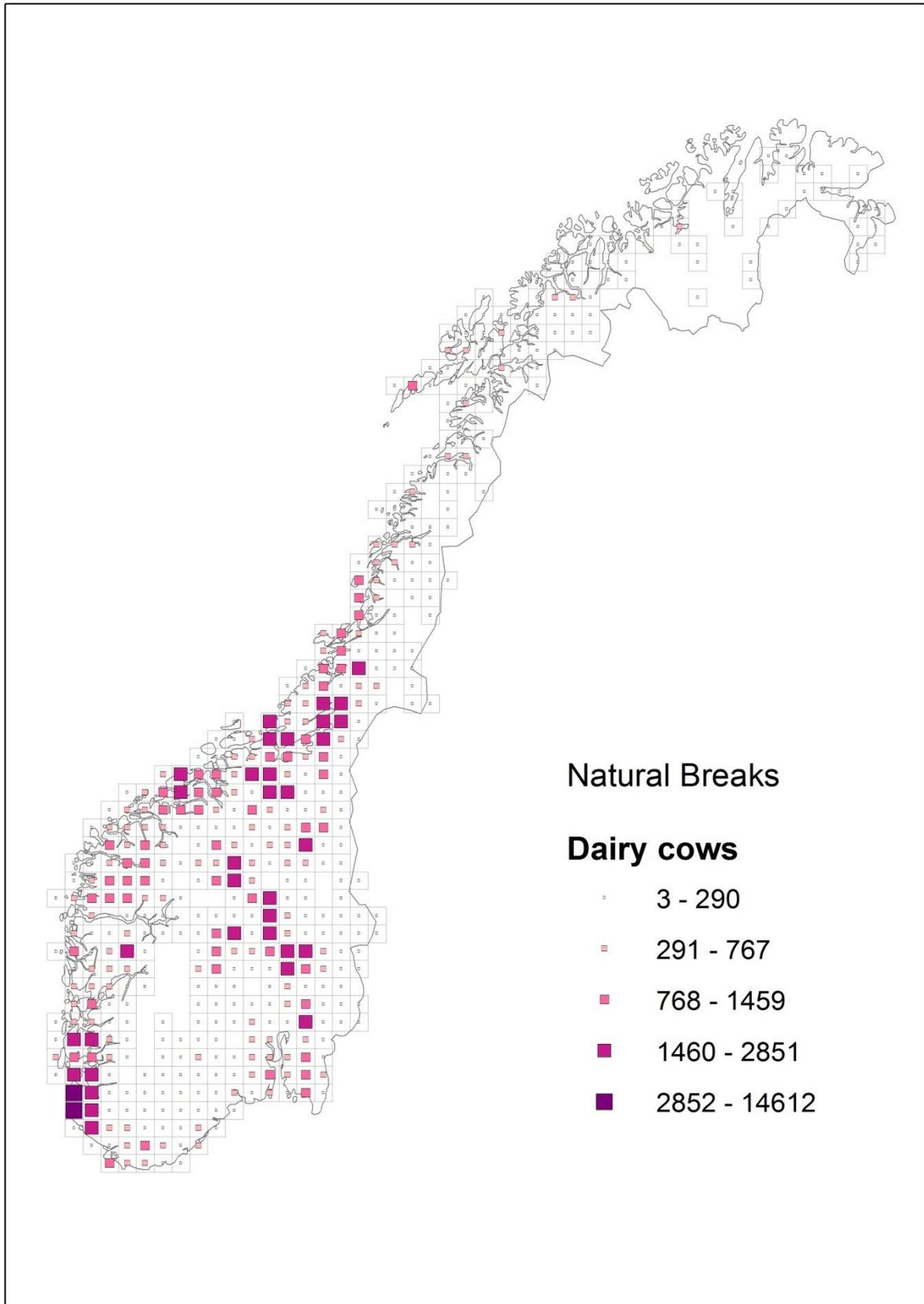


Figure 10.3. Grid 25 x 25 km, number of cows in each grid-cell, classified according to Natural Breaks using both colour and size to differentiate between classes.

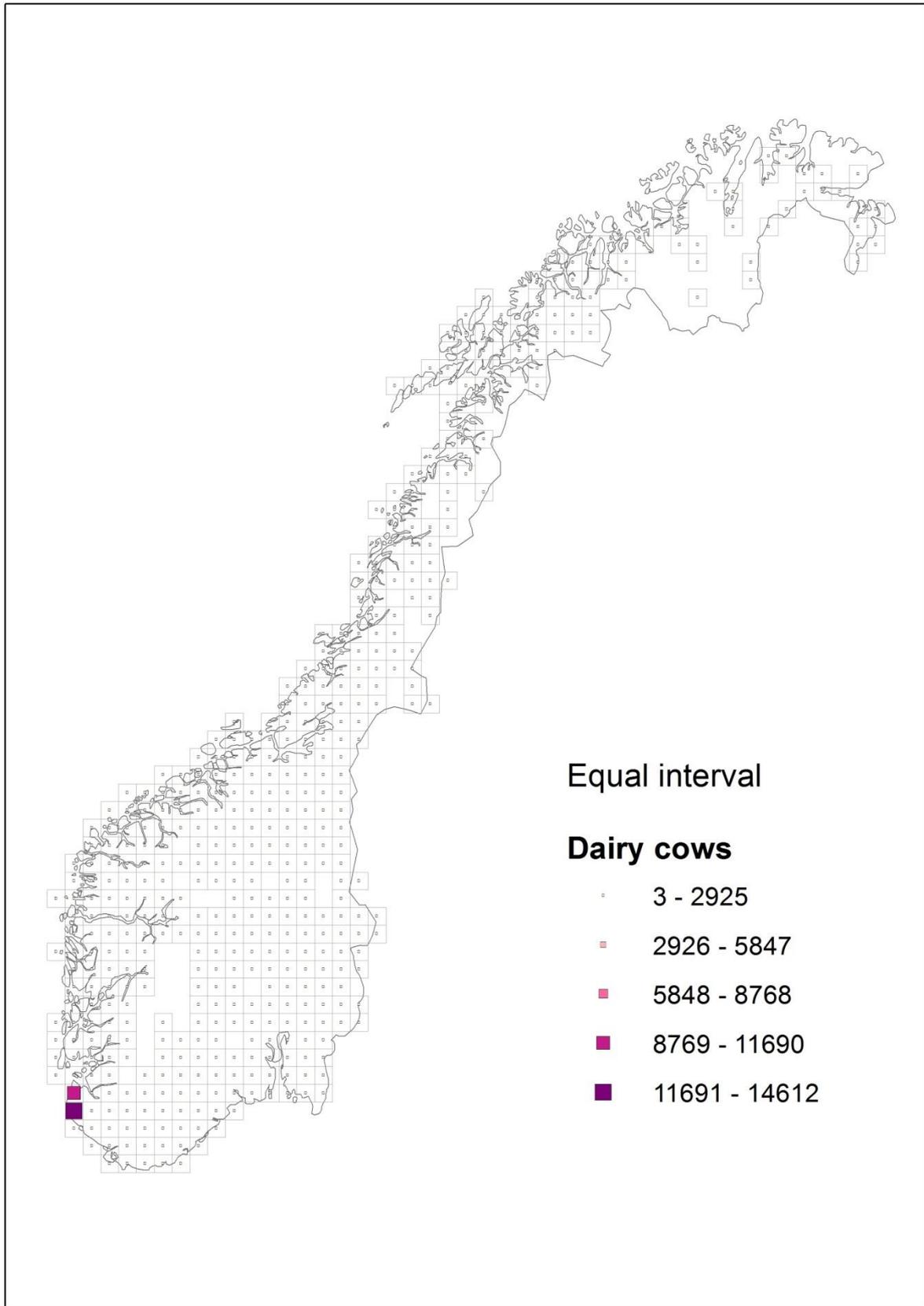


Figure 10.4. Grid 25 x 25 km, number of cows in each grid-cell, classified according to Equal interval using both colour and size to differentiate between classes.

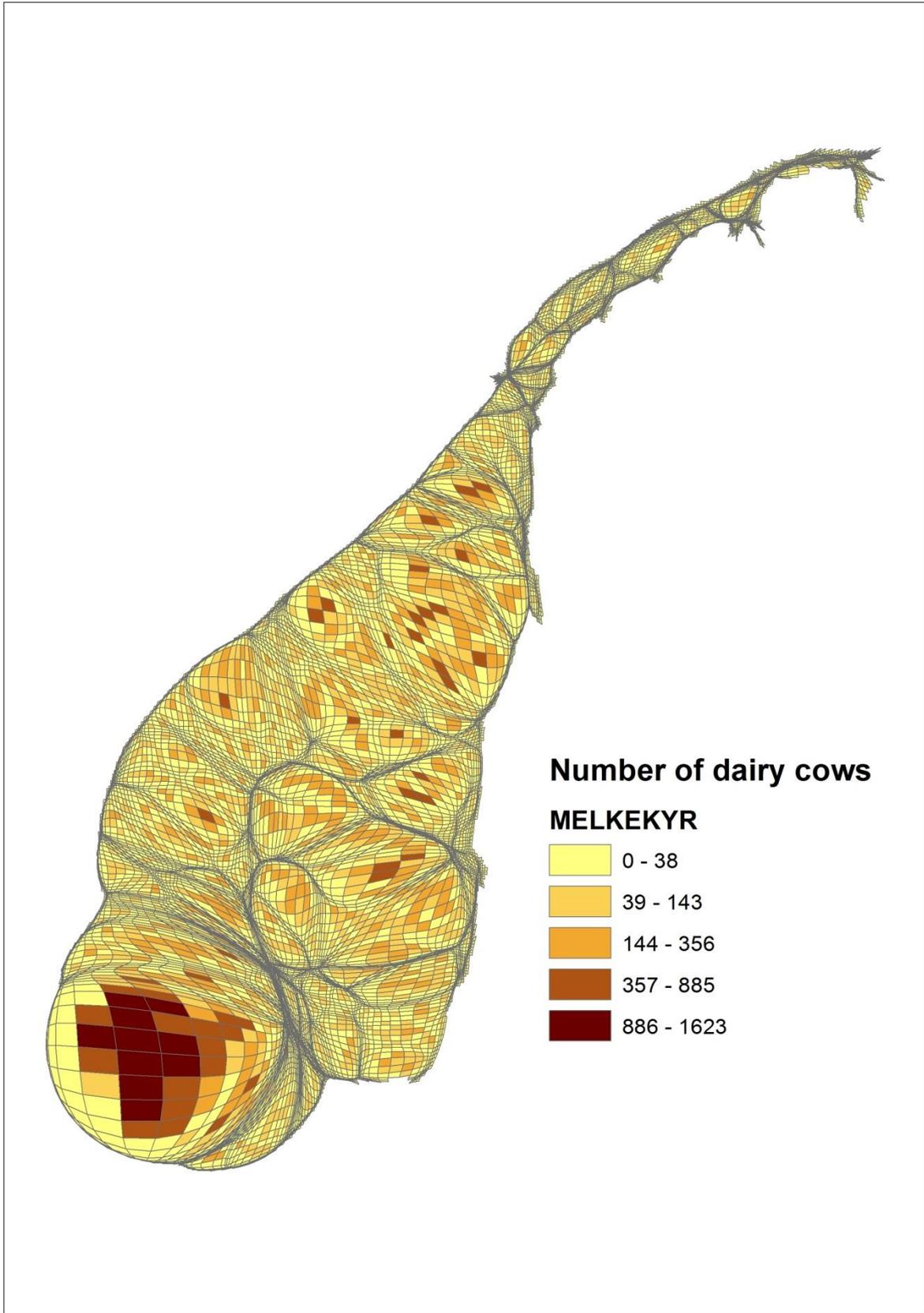


Figure10.5. Cartogram of 5 x 5 km grid. number of cows in each grid-cell, classified according to Natural Breaks using both shape and colour to differentiate between classes.

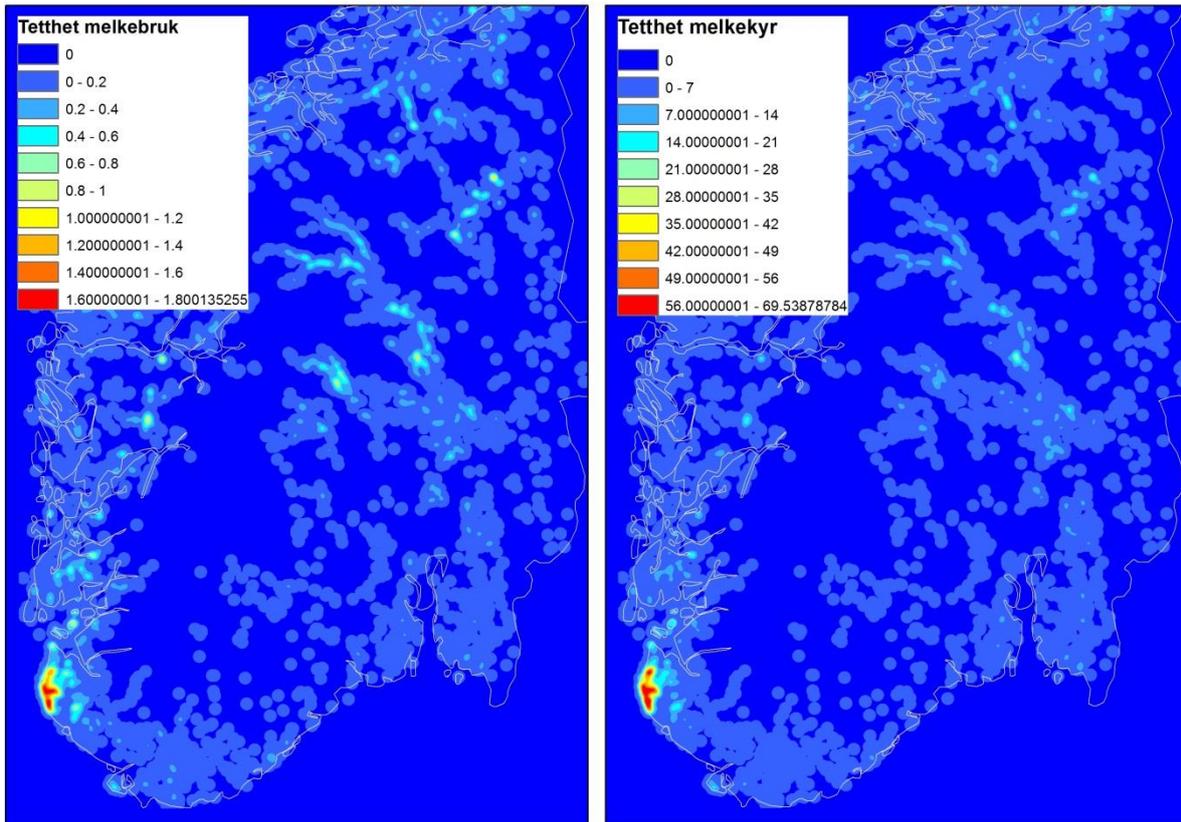
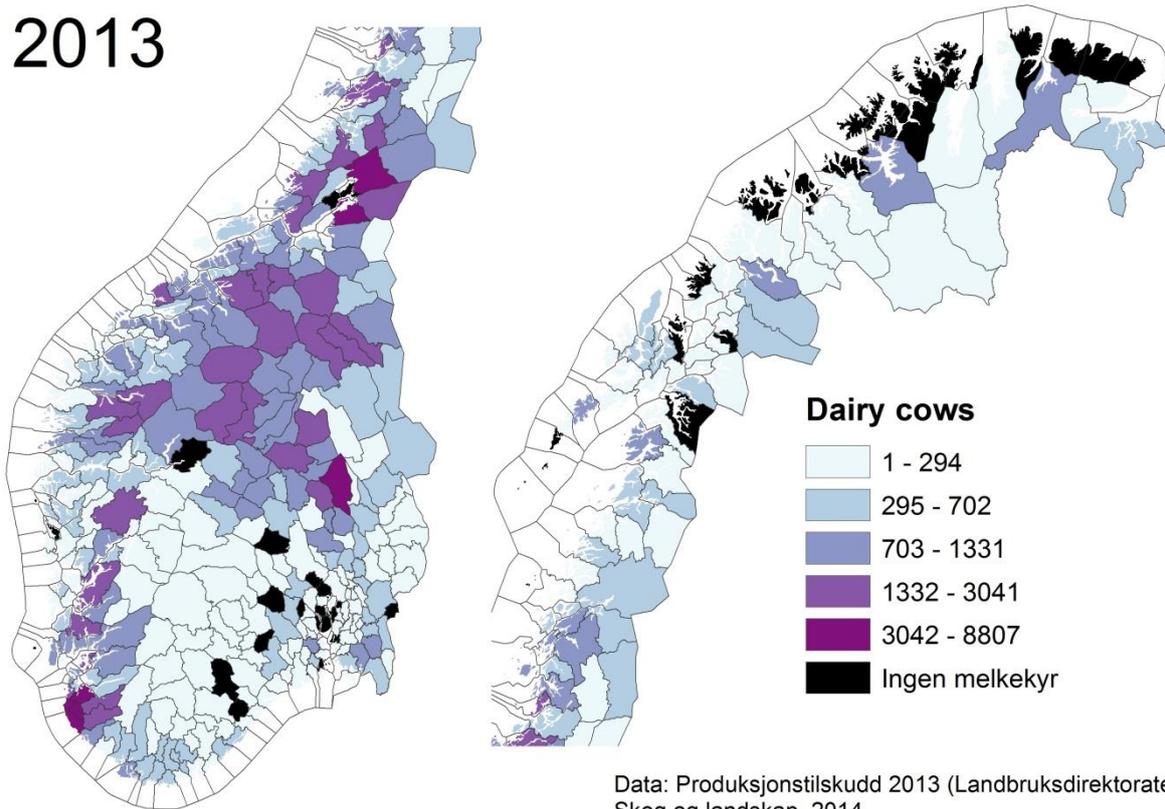


Figure 10.6. Kernel density estimate ("mean"). 5 km radius. It describes the overall variation in the mean value of the phenomenon.

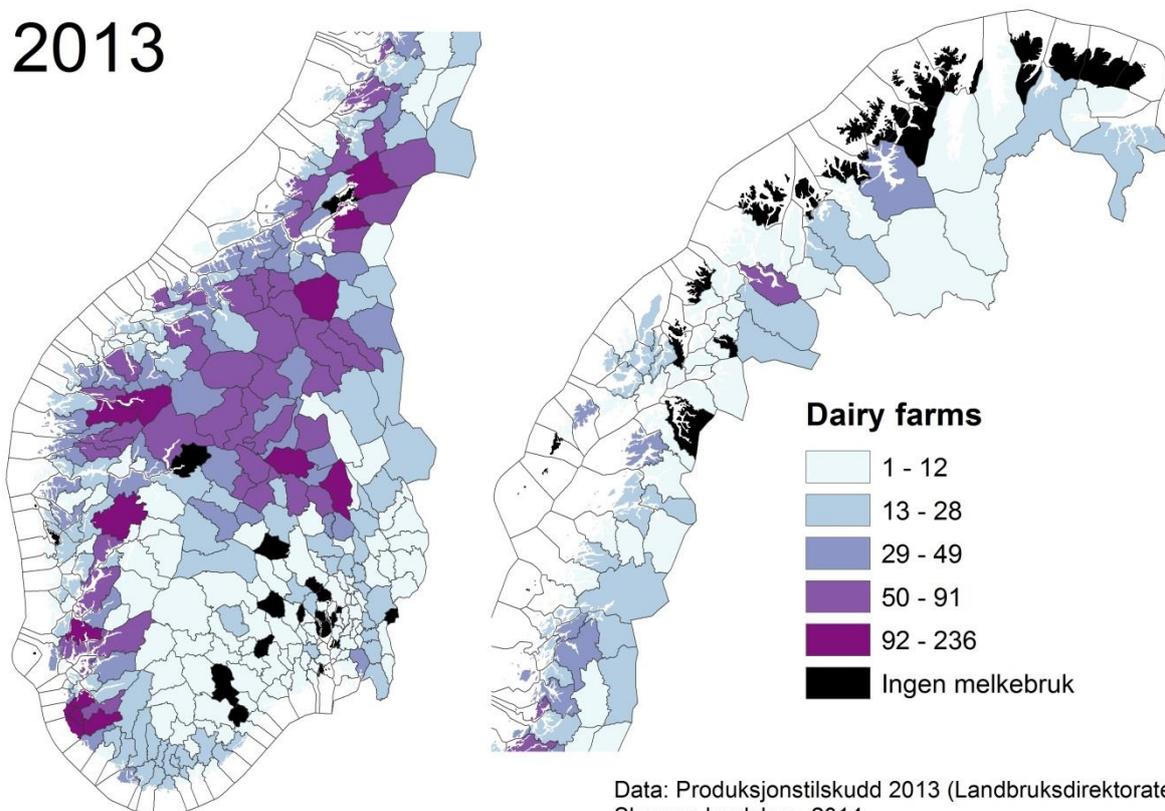
2013



Data: Produksjonstilskudd 2013 (Landbruksdirektoratet)
Skog og landskap, 2014

Figure 10.7. Amount of dairy cows by municipality.

2013



Data: Produksjonstilskudd 2013 (Landbruksdirektoratet)
Skog og landskap, 2014

Figure 10.8. Amount of dairy production units by municipality.

2013

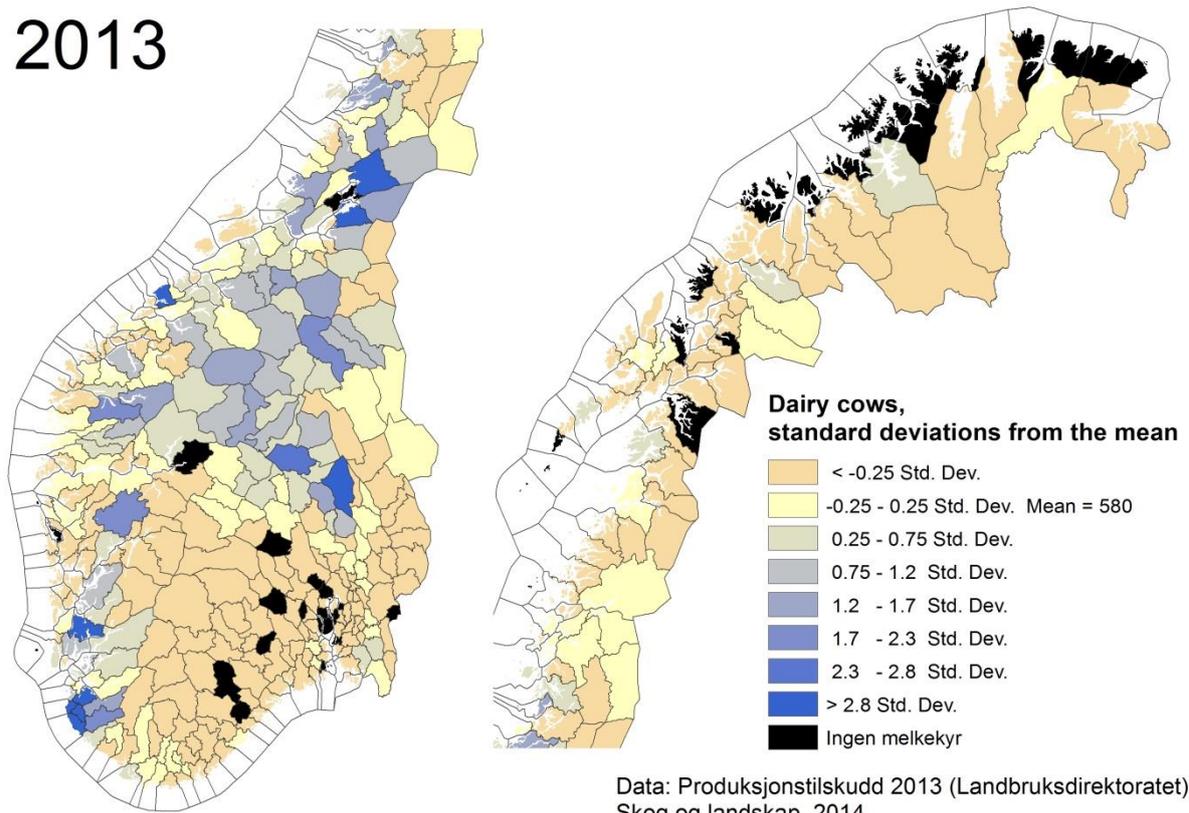


Figure 10.9. Amount of dairy cows by municipality. Standard deviations from the mean.

2013

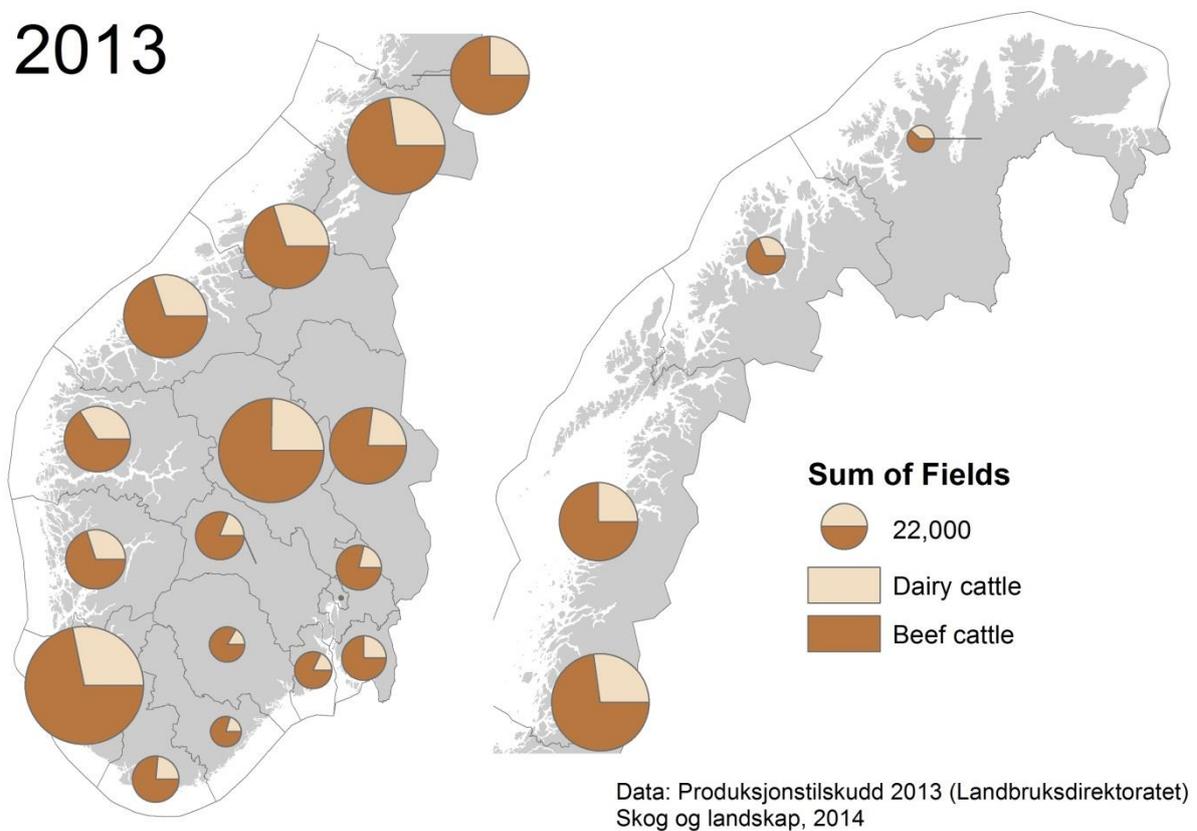


Figure 10.10. Proportion of dairy cattle (dairy cow) and beef cattle in county.

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12. PREFERENCES FOR LANDSCAPES

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Introduction

Land based bio-economy uses annual and perennial crops including trees as the source of economic activity. Growth and harvesting of crops influences the landscape, both with respect to biodiversity in this landscape as well as perceived aesthetic value of the landscape. Thus the aesthetic value is influenced by the choice made by the landowners. Changes in the land based bio-economy are likely to change the appearance of the cultivated landscape. Tourism and recreation possibilities will also depend on how land is used and its aesthetic qualities. Thus an understating of the preferences for the cultural landscape is important in order to evaluate the desirability of such changes from a human perspective as well as its impact on bio-diversity and other ecosystem services. Being aware of the impact of change may also help us choose better ways to implement or regulate alternative land use that changes in the land based bio-economy may result in. An integrated view of the landscape, where cultural, social qualities, ecological functions as well as visual quality is suggested in the European Landscape Convention. Norway signed this agreement in 2001 (RA & DN, 2007), thus we should explore ways to evaluate potential changes.

Several studies address the relationship between landscape characteristics as cover, elements and composition of land cover as factors important for biodiversity. However, the main issue in this chapter is human preferences or the aesthetic satisfaction derived from a landscape, which is one of the issues dealt with in WP 2 of the project AGRISPACE.

Theoretical background

In order to explain landscape aesthetics preferences several theories exists. Fry et al. (2009) divide them into three:

- Cultural preference theories: Preferences are explained as shaped by cultural and personal experience, with beauty essentially being in the eye of the beholder (Meining, 1976 in Fry et al. 2009.)
- Evolutionary theories: Preferences are shaped by our common evolutionary history. Thus we respond positively to features that enhance survival and well-being.
- An integrated theoretical framework – where both evolution and cultural preferences may influence the preferences.

These first two theoretical backgrounds have resulted in the two contrasting paradigms:

- The Subjective approach based on the cultural preference theory. Preferences are “in the eyes of the beholder” (as a human construct). Here the significance of personal factor as knowledge, experience, familiarity, demographic factors and cultural background has been investigated (this is examples listed in in Frank et al. (2013)).
- The objective approach: The beauty lies in the object (intrinsic attribute of the landscape). Objective studies focus on the composition of a landscape as well as the form and configuration of its elements.

Newer studies represent usually a mixed methods approach as advocated by Fry et al. (2009) as well as De la Fuente de Val et al. (2006). Studies which focus on composition of landscape and elements in it also include demographic variables and discuss differences

between types of respondents. Further, Carvalhi-Ribeiro et al. (2013) found that land cover, which is a typical factor used in objective studies also is an asset for addressing the subjective landscape dimension. Consequently separating most studies in either objective or subjective studies is not possible or fruitful.

Predicting landscape value of an element may also be difficult: According to Antrop (2000), what we perceive can be described as “the whole is more than the sum of its composing parts”, alternatively he describes it as: “Each element only gets its meaning, significance or value according to the context or the surrounding elements”.

Theoretically based concepts for landscape preferences

Tveit et al. (2006) identified nine key concepts based on theory of landscape preferences and experience, which together characterize the visual landscape. Ode et al. (2008) presented visual indicators identified for these the nine concepts, and provide references to studies where they are used and suggest how such data can be found. Below is a short summary based on the more detailed description in Ode et al. (2008):

Complexity refers to the diversity and richness of landscape elements and features and the interspersion of pattern in the landscape. Three types of indicators are proposed:

- i) Distribution of landscape attributes (or number of elements), examples are both diversity of attributes and density of landscape elements.
- ii) Spatial organization of landscape attributes – with emphasis on complex or simple. Suggested indicators are edge density, heterogeneity and aggregation.
- ii) Variation and contrasts between landscape elements. Indicators are degree of contrasts, shape variation and size variation.

Coherence refers to the unity of scene, and the indicators refer to the spatial arrangement of landscape elements. Such as; ii) the spatial arrangement of water, is measured by the presence of water, and the correspondence of land form and location of water and ii) the spatial arrangement of vegetation.

Disturbance, the lack of contextual fit and coherence in the landscape. Suggested indicators are i) presence of disturbing elements, ii) area visually affected by disturbance. However it is important to identify which landscape elements that are perceived as disturbing.

Stewardship, the sense of order and care in the landscape reflecting active and careful management. Indicators used describe i) level of management of the vegetation and ii) status and conditions of man-made structures.

Imageability, the ability to create a strong visual image. Indicators are i) spectacular, unique and iconic elements (landmarks, building, water) and ii) viewpoints.

Visual scale, describe landscape rooms/perceptual units in relation to size, shape and diversity, and degree of openness in the landscape. Suggested indicators deals with i) open area, ii) obstruction of view.

Naturalness describes the perceived closeness to preconceived natural state. Three types of indicators: i) Naturalness of vegetation (share of natural vegetation, stage of succession, shape of vegetation). ii) Pattern in the landscape perceived as natural or not fractal or fragmentation indices, iii) water in the landscape

Historicity describes the degree of historical continuity and richness in the landscape. Indicators are: ii) vegetation with continuity over time, ii) organization of landscape attributes (as fields and spatial arrangement of vegetation) iii) landscape elements (density of cultural elements, shape of line features).

Ephemera refer to landscape changes with season, weather or other temporal effects. Indicators describe seasonal and weather changes. i) Season bound activities (farming activities with seasonal patterns, presence of animals). ii) Landscape attributes with seasonal

change. This include natural vegetation with seasonal variation, seasonal variation in crops and fields and water with seasonal change. Iii) Landscape attributes with weather characteristics (water).

This summary suggests that the same type of information can be chosen as an indicator for preferences of several theoretical reasons. Such examples from an agrarian landscape are presence of water and field size.

Substitutes for the real landscape in landscape studies

Great attention has been devoted to finding factors determining aesthetic preferences. In this research field, a photo of the landscape is established as a substitute for the real landscape, (already used in the seventies). Preferences are collected with use of questionnaires/surveys where one is asked to rank landscape visualized with pictures. This may be unaltered photos or manipulated photos. Thus some studies also investigate the impact of the composition of the photos (Slobodova, 2014). Later, also computer generated pictures are used. This method make it possible to better control the content of the image, one example is Ode et al. 2009. However, also satellite images and maps are used in Frank et al. (2013) and “building blocks” are used to capture the preferences for landscape composition in Pinto-Correia et al. (2013).

Consensus in landscape preferences

A very high consensus is seldom found in preference studies (one example of this is Howley, 2011). Kolivoda et al. (2014) found however that the higher the visual aesthetic quality, the better consensus. Some factors are found to be more important than other factors. Van Zanten et al. (2014) performed a meta-analysis on preferences studies involving European agrarian landscapes. In these studies, north – western European studies dominates. They found that historic buildings, mosaic land cover and presence of livestock in the landscape had high mean preference score. Further they found that mosaic landscapes and, to a lesser extent, landscapes by forest/natural land cover obtained higher mean preference scores than landscape dominated by agriculture. Van Zanten et al. (2014) also point out that several studies in order to explain observed preference heterogeneity have explored relations between beneficiary characteristics and landscape preferences. In their meta study, they confirmed that often local residents stated higher preferences for attributes associated with agricultural land cover, while visitors state higher preferences for attributes associated with forest and natural land cover. This is also illustrated in Natori and Chenoweth (2008) who compared preferences for rice paddies between farmers and naturalists. Van Zanten et al. (2014) also found that preferences for agricultural land in general are higher in more remote marginal agricultural areas.

There are few factors that are directly comparable between studies, which limit the possibility to perform a meta-analysis. Thus van Zanten et al. (2014) suggested that further agrarian landscape preference case studies should examine preferences for a number of general attributes types to enable further cross-case comparison of relative preferences.

However, some other factors are found to be more important than others in influencing the value or ranking of a landscape. For example, water tend to enhance the value of a landscape whether it is observed in a photo of the landscape or whether it is landscape elements as vegetation that suggest that there is water in the landscape (Dramstad et al. 2006, Howley 2011).

Final remarks

Both in order to understand preference ranking, and to predict the impact of changes in the landscape due to changes in use of the land, our aim is to find factors that have an influence on aesthetic preferences. However there is a large amount of possible indicators to be used

based on theory, and collinearity between potential indicators within a study area is to be expected. Thus choosing the appropriate set of indicators is important and a challenge. However useful are only indicators that varies significantly within our data-sample, this may favour computer generated images. Further, we should aim at choosing indicators that are used in previous studies to facilitate for comparison.

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13. FARM-LEVEL PRODUCTIVITY IN A SPATIAL CONTEXT

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Introduction

Norway is committed to enhance its agricultural performance and develop the efficiency of land-based bio-production. An important aspect in this endeavour is a better understanding of farm-level productivity in general. Our main interest is to analyse the effects of farm-level changes (induced by either policy reforms or market challenges) on productivity (measured in efficiency) and infer specific policy options in order to successfully enhance further the knowledge basis for a more efficient domestic food production.

Through analysing the Norwegian dairy sector which is one of the most regulated agricultural fields, the efficiency is expected to be heavily influenced by policies and regulations. In particular the milk quota regime has made that farms could not exploit economies of scale. Although, there are a number of empirical approaches for measuring farm level efficiency, we apply a parametric estimation of the structural dynamic efficiency measures proposed in 2009 by Silva and Oude Lansink. Furthermore, we aim to contribute to the literature by detecting spatial interactions between individual farms or several clustered farms to improve the understanding how a single farmer's decision(s) affect the neighbouring farmers' decisions. As an example, the increasing number of farm exits is a particular issue, which affect agricultural productivity in many ways (e.g. increasing scale effect). There is no common understanding between the decision-makers and researchers regarding the long-term economic effect of farm exits. We surmise that the increasing number of average land sizes due to decreasing number of farms could lead to more professional and more efficient production. We make an attempt to address this emerging issue and put the Norwegian dairy sector into an intertemporal (dynamic interpretation) and interregional (spatial interpretation) context.

With this short preliminary work we motivate the importance of productivity, delineate a basic analytical tool (TFP) and provide some thoughts regarding potential spatial extensions.

Motivation

Norway has experienced acceleration in economic growth since the '70s and '80s. The newfound oil stocks substantially contributed to restructuring the national economy from a labour intensive to capital intensive economy as a whole (such as chemical plants, mining, telecommunication, oil production and refining). The relative capital intensive feature of the Norwegian agricultural sector denotes that the available agricultural investments have been allocated for the most part on technological progress rather than promoting labour capacity. Labour has become steadily substituted with capital and other inputs (e.g. intermediate import products) (Nygård, 2013). The Norwegian government intends to broaden the agricultural production by twenty percent over the next twenty years in order to develop food security and ensure food safety (LMD, 2011). However, the geographical location, natural environmental endowments and northern climatic conditions do not lend Norway a comparative advantage in land-based bio-production. Agricultural production can be increased by either the extension of arable land or enhancing productivity through technological investments. The total amount of agricultural land in Norway has not changed significantly in recent decades which may indicate that the reasonable amount of the arable land has been reached although there is a potential to increase arable land somewhat (Arnoldussen et al. 2014). For this reason, we overlook the consideration of arable land expansion. Thereinafter, we will focus on farm-level technological efficiency and productivity

differences of domestic food production. We will measure productivity as an important performance indicator of the agricultural sector. Government agencies and academics have maintained a strong interest in measuring and analysing growth in agricultural productivity and its determinants. Productivity depends on numerous factors such as investments, scale effects, innovation, technology availability, human capital as well as farmers' production choices etc. Productivity, by definition, measures how much output is produced with a given set of inputs or how much input is used for a given set of outputs (Gollop and Swinand, 1998). This referred in the literature as the output and input based Malmquist productivity indices assuming constant returns to scale which means that the output and input efficiency measures for the same output and input combination are equal (Bjurek, 1996).

The above mentioned factors' influences on productivity constitute an important area of research. Important issues such as increasing number of farm exits, knowledge spill-overs associated with technology adoption, effects of spatial externalities on farmers' production choices and land use choices need to be addressed. Spatial externalities in agriculture have the potential to shape the land use decisions of farmers which lead to improved productivity, local economic welfare and broader environmental stability (Parker and Munroe, 2007). There is a need for providing enhanced knowledge basis for the design of better policy options in order to make domestic food production more efficient.

Discussion

The comprehensive investigation calls for using a number of varieties of econometric and statistical techniques to quantify relationships. For analysing productivity differences in agriculture, the measure of total factor productivity (TFP) has become the most frequently used productivity index-number. TFP is the proportion of output not explained by the amount of inputs used in production (Comin, 2006). It refers both to technological progress and improvement in efficiency of production with which farmers combine inputs to produce outputs by the variation of time. In most studies, TFP was estimated at aggregate level (national or regional level) (e.g. Wiebe et al., 2000; Chavas, 2001; Suhariyanto and Thirtle, 2001; Trueblood and Coggins, 2003; Nin et al., 2003), where the data were derived from national accounts which revealed efficiency differences between countries. However, we intend to calculate TFP at lower aggregation level (e.g. sector level or farm-level) in order to analyse the changes of farm-level productivity. Furthermore, we aim to reveal how resource allocation differences lead to diverse productivity growth. To detect the source of productivity growth, information could be collected from disaggregated panel datasets. Farm-level data can be obtained from either the agricultural census or from farm surveys. Although due to the large number of farms the datasets may not be perfectly reliable or could have immanent bias (e.g. missing data or uptake bias) and not necessarily all the desired determinants are included, which arises accessibility problems. Panel estimation technique would allow detecting technical inefficiency as fixed effects of specific farms/regions of the production frontier, which is accountable for technology differences and spill-overs between clustered farms. By sorting the spatially clustered farms, we intend to improve understanding of the characteristics of the farm-groups. That is, to typify advantages and disadvantages with respect to productivity (spatially disadvantageous location, soil quality, input access, different policy applications, spatial externalities etc.) and also to determine the effect of changes in land tenure induced by farm exit behaviour.

Approximately 5.5% of farms give up production annually in Norway. Storm et al. (2014) argue “*that farm survival is influenced by neighbouring farmers’ characteristics and, in particular, by the direct payments neighbouring farmers receive.*” Their research detected the causes behind the decision of exiting. By proceeding to the course, we are interested in addressing the latter utilization of land. The agricultural land owned by exiting farmers may be rented out, sold on the market or is abandoned. This induces the question regarding the reaction of neighbouring farmers. Theoretically the enduring farmers’ interest is to increase their crop land size which is one of the major factors encourages productivity increase (i.e. scale effect). This progress could lead to substantive changes in the productivity margin. Furthermore, if we decompose the calculated productivity margin into sector specific margins, we can obtain individual responses and are able to differentiate agricultural sectors according to their speed of responses of productivity increase.

Regarding the spatial part of the investigation, when spatial interactions, spill-over effects and effects of spatial externalities will be detected on disaggregated data level or clustered level, we intend to apply the related econometric tools. For instance, spatial lagged model or spatial error model (Anselin, 1988; 2002) by including the previously calculated productivity indices to identify the supposedly increasing returns to spatial concentration.

Summary

Empirical case studies will be developed in detecting farm-level productivity and spatially analysing farm interactions in order to enhance further the knowledge basis for a more efficient domestic food production in Norway. We make attempt to calculate farm-specific intertemporal technological and allocative inefficiencies to reveal production differences between farms. Our primary interests lie on detecting land use change both in tenancy change due to farm exits in the dairy sector, as well as the market influences of policies and regulations.

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14. THE JORDMOD II MARKET MODEL

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Concept and structure

The JORDMOD II market model is a Multi-Commodity model (MCM) which covers the most important agricultural products in Norway. In MCMs, quantities are determined by behavioral equations. Whereas that is the usual approach in general equilibrium models to model final demand, MCMs also use behavioral equations to determine netput quantities, in opposite to Computable General Equilibrium (CGE) models which incorporate production functions. The use of MCMs is widespread for agricultural policy analysis (cf. Britz and Heckelevi 2008); international organization such as the OECD and FAO maintain and apply such models (AGLINK-COSIMO, OECD 2007), but also research institutes respectively universities (e.g. FAPRI, Devadoss et al. 1989; CAPRI, Britz and Witzke 2014; ESIM, Banse et al. 2005). Two strands of MCMs can be broadly distinguished: models where individual equations are econometrically estimated such that the equations describing specific markets differ structurally (e.g. in FAPRI and AGLINK-COSIMO), and template models where equations are structurally identically (e.g. in ESIM and CAPRI), and differences are expressed by parameters, an approach pioneered by Roningen et al. 1991. Our approach falls in the later class, as do most CGEs.

The market model applied in here is only one module in the overall planned JORDMOD II model. Over the next years, an econometrically estimated layer of single farm models will be developed, as planned to be linked with a module describing farm structural change. The supply response of the single farm models together with information on farm structural change will be aggregated to the regional level and used to parameterize the supply side in the market model. As the conceptual and econometric work on these modules has just recently started, we drive the market model during the intermediate period until all modules are fully operational with regional supply responses derived from CAPRI, which comprise regional programming models for Norway at NUTS III level.

Based on the spatial equilibrium (SPE) approach, we consider commodities as homogenous, such that price differences in space depend on transport margins and policy instruments such as import tariffs. The use of the spatial equilibrium approach is relatively seldom in MCM models; it is found in some single commodity models (e.g. Anania 2005, Nolte 2008) and in models which combine Mathematical Programming with price endogeneity (McCarl and Spreen 1980). One reason for the limited application of SPE in international trade analysis is the fact that calibration against observed trade flows remains challenging (e.g. Paris et al. 2011, Wieck et al. 2012), while observed counter-trade cannot be captured at all. However, in Jordmod II, we use that approach only to describe price formation inside of Norway, where these problems are of limited relevance. The more widely used approach to depict bi-lateral trade flows in equilibrium models is based on the Armington assumption (1969), especially in CGEs, but also e.g. in the global market module of CAPRI. Assuming goods differentiated by regional origin inside Norway, as the Armington approach suggests, seems not appropriate. It would also be unclear how to construct a set of interregional flows to calibrate an Armington based model against as observation on such interregional flows are not available. A net-trade approach, on the other hand, would face the challenge how to properly reflect the large transport costs between Norwegian regions.

Furthermore, we assume that markets are competitive, and that producers maximize profits and consumer utility, standard assumptions in MCM models. They are reflected in the choice of functional form and parameterization: we use (semi-)flexible function forms and ensure global adherence to regularity conditions. That approach is still not widely applied in agricultural MCM analysis. Whereas non-templated MCM models basically cannot control for regularity, simply as they do not depict demand and supply systems, most other MCMs based on template (e.g. ESIM) use double-log functions where regularity can only be imposed locally. To the knowledge of the authors, no MCM model mentioned above beside CAPRI controls for curvature.

Specifically, we use a normalized quadratic profit function (Diewert and Wales 1988) to determine **netput quantities** – the difference between production and on-farm use, e.g. for feed and seed - of the agricultural sector at regional level. The parameters of these functions shall later provide a consistent second-order approximation to the aggregate behavior of the individual farms in the supply module. We use a price-index for variable inputs for normalization. As the Hessian of the normalized quadratic function form is fixed, curvature can be imposed globally, while homogeneity is guaranteed by the normalization. We combine the NQ functional form with a partial adjustment approach where last year's netput quantities multiplied with the related normalized prices enter the profit function:

$$\pi_i = (1 - pa) \left[\sum_i \alpha_i p_i + \frac{1}{2} \sum_{i,j} \beta_{ij} p_i p_j \right] + pa \sum_i x_i^{t-1} p_i$$

Where p_i are normalized expected prices in the current year, pa depicts the partial adjustment factor, x_i^{t-1} are lagged netput quantities and α , β are parameters of the long run profit function. The short run profit netput quantities can be derived via the envelop theorem:

$$x_i^t = (1 - pa) \left[\alpha_i + \sum_j \beta_{ij} p_j \right] + pa x_i^{t-1}$$

The equation can be alternatively be interpreted from the partial adjustment perspective: the short run netput is a linear combination of the optimal long-run level – the expression in the bracket, which is the derivative of the long run profit function – and last year's netput quantity. The partial adjustment approach can here interpreted to capture e.g. rigidities in the technology linked to longer production period and sunk costs of past investments.

Equally, we use expected prices which are linear combination of current and last year's prices, acknowledging that some adjustments to observed prices are possible.

A Generalized Leontief (GL) expenditure system drives final demand. The system has again the advantage that curvature can be easily imposed globally; however at the cost of not allowing for Hicksian complementarity between products, a restriction of limited relevance in our setting. The choice of functional forms reflects long-standing experience with the CAPRI system (Britz and Witzke 2014). The GL system used is based on the following family of indirect utility functions (Ryan and Wales 1998):

$$U(p, y) = \frac{-G}{(y - F)}$$

depending on consumer prices p and income y where G and F are functions of degree zero in prices. Using Roy's identity, the following Marshallian demands are derived:

$$x_i = F_i + \frac{G_i}{G} (y - F)$$

F is simply chosen as the sum of commitments, i.e. additive term which describe consumption quantities independent of prices and income, while term G is based on the GL function form, where b is a matrix of parameter describing own and cross-price effects:

$$G = \sum_i \sum_j b_{ij} \sqrt{p_i p_j}$$

While using the spatial arbitrage condition in the model reflects the relation between price difference in space and trade, we refrain from using the Takayama-Judge approach which requires maximizing explicitly the social welfare function. In agricultural PEs, the SPE approach is typically combined with Mathematical Programming as proposed by McCarl and Spreen 1980, i.e. a Leontief presentation of agricultural supply. Such a set-up is applied e.g. by GLOBIOM (Havlik et al. 2011), but also in the original JORDMOD model. Price endogeneity is typically implemented by integrating linear inverse demand functions which only reflect own-price effects in the objective function, which is not line with a regular demand system. These functions are often piecewise linearized to yield a price endogenous LP, which allows for a very high number of endogenous variables.

Given the focus on Norway, the possible advantages for staying completely linear are limited, such that we rather maintain micro-economic stringency. Therefore, instead of using the direct optimization approach used in these models, we incorporate the first order conditions reflecting optimal behavior of the individual agents (producers, demanders, traders) as behavioral equations in our model, as typically done in Multi-Commodity and Computable General Equilibrium models.

Transport and tariff cost minimizing behavior, which is embedded in the spatial equilibrium approach, yields the Kuhn-Tucker-Karush based spatial arbitrage condition which requires capturing properly the complementarities between trade flows and inter-regional price differences. The latter necessitates the MCP (Mixed Complementarity Problem) solution format.

Summarizing, the model has basically four types of (in)equalities: (1) FOC derived from the dual profits function which determine supply quantities at the endogenous prices, (2) the demand equations which define demand quantities at the endogenous prices, (3) market clearing condition which define regional prices, and (4) the spatial arbitrage conditions which simultaneously determines trade flows and differences in regional prices. As Norway is considered a small country, we treat international prices as fixed.

The model covers 20 agricultural netputs: 5 cereals (wheat, barley, rye, maize, other cereals); rape seed, potatoes and pulses as non-cereal typically arable crops; four types of fruits and vegetables, 4 types of meat (beef, pork, poultry, sheep and goat meat), eggs and raw milk. Soy cake is considered as an input. Additionally, the model covers land, labor and capital demand by agriculture; related prices can either be fixed or be depicted by regional market clearing based on linear factor supply functions. Finally, there is a remaining input category used also as the price index in the NQ function of which the price is fixed.

The dairy sector is depicted by seven products: butter, skimmed milk powder, cheese, fresh milk products, cream, concentrated milk and whole milk powder. The model comprises milk fat and protein balances at regional level which drive milk fat and protein prices, which are used to determine the processing margins for dairy products and the raw milk price. The processing margins drive the demand for raw milk and the output of the dairy products, again based on NQ profit function. It is parameterized according to elasticities found in CAPRI.

Baseline, parameterization and technical implementation

In order to derive an ex-ante baseline, we first use statistical data on agricultural netput quantities, processing and final demand to derive the net-trade for reach region in the model for the expost period 2011. Growth rates of regional population and income, along with

estimates about the development of regional agricultural production are then used to estimate the future net-trade position for each region and product. Combined with an estimate about interregional transport costs and international prices, the spatial arbitrage condition can then be used to estimate (future) inter-regional transport flows which equilibrate each regional market. That estimator delivers at the same time (future) regional market prices.

The demand system is parameterized based on elasticities for broader food categories reported by the Economic Research Service of the US department for Agriculture. Following the approach applied in CAPRI (Britz and Witzke 2014), we use substitution elasticities inside the food groups to derive individual own and cross price elasticities. Based on a Bayesian approach, using a Highest Posterior Density estimator (HPD, Heckeley et al. 2005), we find a parameter set for the GL system which reflects the a-priori information on elasticities, while describing a regular demand system (see also Witzke and Britz 1996). For the supply side, netput elasticities derived from the Norwegian regional supply models in CAPRI based on sensitivity experiments (see Britz 2013) are used as priori information. Again, a HPD estimator is used to define parameters of the NQ system. A Cholesky factorization ensures global curvature of the calibration Hessian.

Similar to most other tools in that field (e.g. Britz and Kallrath 2012), we use GAMS (General Algebraic Modelling System, Bisschop and Meeraus 2008) to encode the model and all necessary data and parameter transformation. Coding conventions, e.g. with regard to a modular structure and use of mnemonics, follow guidelines developed for CAPRI (Britz 2010). For the Bayesian based parameter calibrations, we use CONOPT (Drud 1994, version 2014), the market model is solved in PATH (Ferris and Munson 2000) as an MCP. A Graphical User Interface allows steering the model and results exploitation, is it implemented GGIG (GAMS Graphical Interface Generator, Britz 2014).

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15. INTERDISCIPLINARY PERSPECTIVES

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Increasing recognition of complexity and change in real world problem solving (Jackson, 2006), acknowledgement of the need to involve all stakeholders to solve 'real world' land management problems (McCown & Parton 2006), a need for more 'democratic' and open science (Lowe & Phillipson, 2006), and increasing wariness by governments of being "sold simple solutions to complex problems" (Jackson, 2006: 647), have lead to science increasingly turning to interdisciplinarity and transdisciplinarity to resolve 'real world' land management issues such as those addressed in the AGRISPACE project. However, difficulties in developing research with high levels of integration are widely acknowledged in the literature (e.g. Balsiger, 2004; Loibl, 2006; Petts et al., 2008) meaning that careful planning is required to achieve the desired outcome.

A key component of this is the recognition that different levels of integration are required to complete different tasks in integrated research (Blevis et al., 2009) and thus the type and level of integration may vary over the length of a project and the task at hand (Jerneck et al., 2011). We acknowledge the existence of three key levels of integration (see Stock & Burton, 2011) that will be applied in AGRISPACE.

Multi-disciplinary – non-iterative research focused on disciplinary action within a specific research field but with the results shared by other disciplines/work-packages.

Inter-disciplinary – problem focused iterative research coordinated between disciplines/ work packages where effort is made to cross epistemological and ontological boundaries (e.g. qualitative and quantitative research methodologies) but stopping short of the development of new theory or research 'fields'.

Trans-disciplinary – a holistic problem focused approach involving stakeholders and scientists co-developing knowledge with a clear objective of both resolving the problem and synthesising new disciplines and theories.

Stock & Burton (2011) suggest there are two key approaches to integration between disciplines in multi-inter-trans-disciplinary research; the development of a unitary theory or methodological pluralism. Unitary theory involves a single methodological approach agreed on by all disciplines involved, whereas methodological pluralism contends that not all methods (for example, quantitative and qualitative methodologies) are equally valid in all situations. Instead it makes "explicit use of theory to identify the strengths and weaknesses of different methods, and view them as complementary – addressing different kinds of question" (Midgely, 1996: 25 – also see Jackson & Keys, 1984).

Agrispace adopts the methodological pluralism approach to integration, primarily because it enables projects to "focus more directly on the problems, rather than the particular intellectual tools used to solve them" (Haddorn et al., 2006: 120). However, methodological pluralism itself represents a serious intellectual challenge (Midgely, 1996).

Leadership is recognised as a key component of successful interdisciplinary research projects. The ability to motivate researchers (Hollaender, 2003), a willingness to cross disciplines (Jakobsen et al., 2004), and the ability to maintain balance between groups employing different methodologies/epistemologies and deal with conflict (Petts et al., 2008) have all been recognised as key components of leadership. In addition, it is important for interdisciplinarity that researchers remain 'problem oriented' rather than disciplinarily focused as it is this problem orientation that promotes high levels of integration with different disciplinary perspectives required to address different parts of the 'problem' (Bruce et al., 2004; Massey et al., 2006; Petts et al., 2008).

Methods of ensuring good integration include (a) developing an understanding of each others' language/key concepts in the early stages (Stevens et al., 2007), (b) involving all the research team at the early stages of project development (Kooistra & Kooistra, 2003; Mottet et al., 2007), (c) maintaining collaboration activities throughout the project (Deconchat et al., 2007), (d) coordinating access to all emerging results from the work packages (Höll & Nilsson, 1999), and (e) integrating the knowledge of local stakeholders (Höchtel et al., 2006; Deconchat et al., 2007). In addition, work packages should have specific cross-disciplinary iterative linkages embedded in the methodology. Towards the end of the project it is good practice to make an assessment of interdisciplinary success through a 'communal reflection' process and an assessment of the 'significant outcome' (contribution of the research to problem solving) (Wickson et al., 2006).

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