Surveying the Regional Need for Land Consolidations from GIS information in Finland

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Key words: Land Consolidation, Spatial Analysis, Parcel Structure

SUMMARY

Finnish agricultural landscape has experienced fragmentation due to long-lasting structural change as well as historical reasons. Land consolidation projects have been completed since 1750s.

The aim of this study was to quantify how the Finnish agricultural parcel structure has changed between 2010–2020. Spatial analysis methods were utilized over two datasets of all agricultural parcels in Finland. Individual parcels were considered, as well as larger parcels that combined the adjacent holdings of a single farmer.

Average parcel size increased by 5 %. There was no significant difference in the growth rate between individual parcels and the combined holdings. Average distance from the homestead to the parcel has increased by 19 %. In land consolidation areas have been the parcel size increased on average by 27 %, while the average distance grew only by 11 %. Around 37 % of fields were under lease in 2020.

The average size of Finnish agricultural parcels is slowly growing, but the growing distance to parcels fragmentates the structure further. Rental markets do not seem to offer much flexibility in increasing parcel size. Land consolidation appears to be effective in combating fragmentation. Materials created can be used in land consolidation planning and execution in the National Land Survey of Finland.

SUMMARY (in Finnish)

Suomen peltotilusrakenne on pirstoutunut pitkään jatkuneen maatalouden rakennemuutoksen ja historiallisten syiden johdosta. Uusjakoja Suomessa on tehty jo 1750-luvulta lähtien.

Tutkimuksen tavoitteena oli selvittää, kuinka Suomen peltotilusrakenne on kehittynyt 2010–2020 välisenä aikana. Kahta kaikki Suomen peltolohkot sisältävää aineistoa analysoitiin erinäisin spatiaalisen analytiikan menetelmin. Analyyseissa huomioitiin paitsi yksittäiset lohkot, myös saman viljelijän vierekkäiset omistukset eli niin kutsutut viljelijälohkot.

Tulokset osoittavat keskimääräisen lohkokoon kasvaneen noin 5 % sekä yksittäisillä että viljelijälohkoilla. Keskimääräinen talouskeskusetäisyys on kasvanut noin 19 %.

Tilusjärjestelyalueilla muutokset olivat 27 % lohkokoossa ja 11 % etäisyydessä. Noin 37 % peltopinta-alasta oli vuokrattuna 2020.

Keskimääräinen peltolohkon koko kasvaa hitaasti, mutta kasvanut talouskeskusetäisyys pirstoo tilusrakennetta. Viljelijät eivät kykene vaikuttamaan peltolohkokoon kasvunopeuteen esimerkiksi vuokrauksen avulla. Tilusjärjestely vaikuttaisivat olevan tehokas keino maatalousmaiden pirstaloitumisen vähentämiseen. Maanmittauslaitos voi hyödyntää tutkimuksen tuloksia tilusjärjestelytoimintansa suunnittelussa ja kohdistamisessa.

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1. DEVELOPMENT OF FINNISH PARCEL STRUCTURE AND LAND CONSOLIDATION

Finnish Land consolidation has its origin in the Swedish Basic Land Consolidation. In the year 1757 the Swedish Crown ordered basic land consolidation (isojako in Finnish) procedures to be performed in the whole kingdom. During that time Finland was a part of the Kingdom of Sweden. Basic land consolidations started in the coastal regions of Finland although officials often faced strong resistance from local villagers and farmers. The main reason for the basic land consolidations was the establishment of independent farms that were capable of paying taxes. Another benefit of basic land consolidations was the mapping of all farmland. During the centuries basic land consolidations advanced through Finland and in 1960 the last basic land consolidation procedure was completed in Kuusamo, North-Eastern Finland.

After Finland was separated from Sweden in 1809 some differences in land consolidation procedures started to appear between these two nations. During the 1800s there was a widespread understanding in professional circles in Finland that the first basic land consolidations had not been done as well as they should have been done. Often a scattered parcel structure remained. Old Swedish legislation that was in many cases still valid in Finland allowed arrangement of basic land consolidation to be done and the late 1800s saw a boost in these arrangements. By 1918 the total area arranged by this type of projects was 1 547 590 hectares in the whole of Finland.

From beginning of the year 1917 new purely national legislation was in force and now emerged new name to this kind of Land Rearrangement. New name was in Finnish uusjako. Translation of this term is not without problems. Literally uusjako can be translated as New Land Consolidation meaning land consolidation that is done after the Basic Land Consolidation. After a hundred or more years had passed following Basic Land Consolidations and restrictions of farm parcelling were lifted, the term uusjako started to mean more or less the same thing as Land Consolidation. The meaning of the term has evolved during the nearly one hundred years that it has been used in Finnish legislation. All this time there was also the Finnish term tilusjärjestely. This term means land consolidation in broader sense and it includes all types of Land Consolidations and for example arrangements done in conjunction with other cadastral surveys, such as parcelling.

During the early 1900s Land Consolidations were concentrated in southern and southwestern agricultural areas of Finland. Projects were large and ambitious. Often projects included whole villages with fields and forests often covering a total area of more than 10,000 hectares. Hearings of landowners were formal and projects did not have to have approval of land owners. During the period 1918–1980 the total area arranged in land consolidations was 891 000 hectares. As did basic land consolidations, land consolidations advanced through the agricultural heartlands of Finland. This time Eastern and Northern Finland were excluded because the settlements were of a different type. In Eastern and Northern Finland farms were and still are often alone in the forest, far apart from each other, so that a scattered parcel structure was a rarity.

In the 1990s land consolidations were concentrated in Western Finland, in an area roughly between the cities of Vaasa and Oulu. The reason for this concentration was the strong agriculture in the region and the scattered parcel structure in these areas. In other areas of Finland, the last land consolidations were completed during the 1980s and land consolidation activity died down despite some efforts to start new projects. At the beginning of the millennium there was pressure to reform the Land Consolidation process. The strong opposition of landowners and the inefficiency of the old Land Consolidation procedure were evident. Development led to a process that was more customer driven and project areas that were smaller than earlier although there were no legislative changes.

From 1757 to the present day, Land Consolidation in Finland has been cadastral surveyor driven process. The land surveyor was and is chairman and the key decision maker in the project. The role of the land surveyor is similar to that of a court judge in the European (Roman) court system. Since the year 1972, land surveyors have been civil servants at National Land Survey of Finland (NLS). Decisive legal decisions are made by a land surveyor and two trustees appointed by the municipal council. Often trustees are from another municipality to avoid improper connections between trustees and landowners. The new process that was implemented in the first years of the new millennium emphasized landowner opinion and one-on-one negotiations between the landowner and land surveyor.

The new process has led to a new boom of land consolidations in Finland. New projects have started and now land consolidation activity has expanded to the regions of Satakunta, Pirkanmaa, Kymenlaakso, Northern Savonia, North Karelia and Uusimaa. The Average project area is 1000 hectares and the average project time has been reduced to five years. Projects include building operations such as ditching, building of underground drainage and agricultural roads. Projects were subsidised by the Ministry of Agriculture and Forestry. During the period 2002 - 2014 roughly 50–70 per cent of project costs were paid by the Finnish government.

Concurrently with the developments in land consolidation, the agricultural sector in Finland has been under constant change. During the 20th century, the number of farms first rose rapidly from 200 000 to more than 320 000, first due to land acquisition by tenant farmers, and later due to settling refugees from the land area lost in the second world war. After peaking in the 1960s, the number of farms began to decline rapidly. The number dropped below 100 000 in

the turn of the millennium, and currently there are less than 50 000 farms in Finland. Amount of total cultivated area rose with the number of farms but has not decreased as rapidly. Since the early 2000s, the development has plateaued, and currently there are some 2,2 million hectares of cultivated area in Finland.

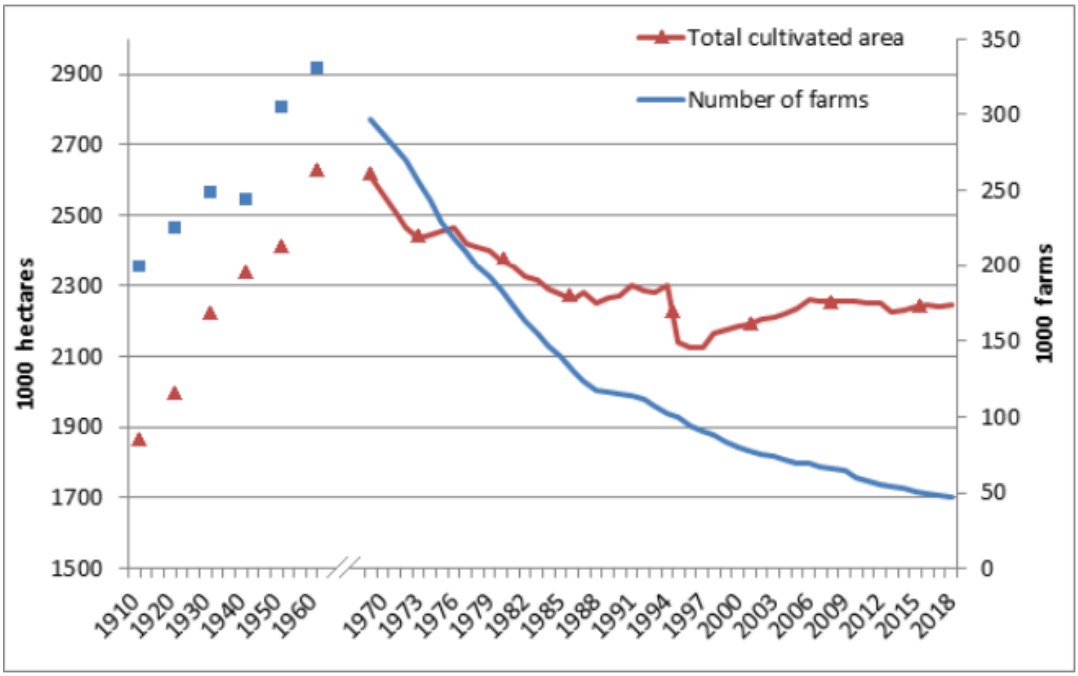

Figure 1. The number of farms and total cultivated area in Finland, 2010-2019 (Niskanen 2020).

This study aimed to quantify how the parcel structure has changed between the years 2010 and 2020. The Finnish agricultural parcel structure and need for land consolidations have been examined by land consolidation professionals since at least the 1980s (Tenkanen 1980). Since the year 2000, it has been studied by Ylikangas (2002), who sampled representative municipalities in every region in Finland and analyzed their parcel structure. Hiironen & Ettanen (2012) analyzed the whole country both on regional and municipal level. Most recently, Kankare (2020) surveyed the structure and its development, especially focusing on the economical harms of a disadvantageous parcel structure. While these studies were successful in depicting the current state of parcel structure and need for land consolidations, they drew comparisons from each other while being not fully comparable, and therefore no accurate depiction of developments could be made.

2. MATERIALS AND METHODS

The European Union mandates that every country should have and Integrated Administration and Control System (IACS) for administrating and controlling the EU support given to farmers. In Finland this IACS system is put in to place by the Finnish Food Authority. The main material for this study were all the parcels registered in the IACS registry in the years 2010 and 2020.

As well as parcels, the database also contains the location of most farms in the country. Information on whether the parcel was under a lease or not was included for 2020 parcels. In the 2010 database only the tenure holder was mentioned, with no regard whether he owned or leased the parcel.

The registry as a whole can contain fields that are not in use anymore. To get an accurate and comparable representation of the parcel structure for each year, the database was narrowed down by removing all parcels that were not used in applications for farmer's support in the respective year. The number of parcels and farms before and after the removal are presented in table 1.

	Whole registry		**After removing inactive**	
Year	**2010**	**2020**	**2010**	**2020**
Number of Farms	76 107	84 215	62 643	47 340
Number of Parcels	1 018 466	1 122 068	942 283	905 489
Parcels under lease	-		-	406 008

Table 1. Number of parcels and farms in the IACS registry, and the numbers after removing the inactive parcels.

The Finnish Geospatial Research Institute FGI calculated the distance from the homestead to each parcel using the Finnish Topographic database's road vectors. Each road class was assigned an average speed, which was then used to calculate travel time between the homestead and parcel. Medians and means as well as change parameters were calculated for parcel size and distance and travel times for the whole of Finland as well as each of the 21 regions.

While the IACS registry contains single parcels, it is often the case that farmers combine multiple adjacent parcels and cultivate them as one. These so-called farming parcels depict the parcel structure more accurately than the single parcels registered in the registry. Farming parcels were created by combining any parcels farmed by the same farm, be it owned or leased, which borders are within 0,7 meters from each other.

To get a local view, the results were aggregated to a grid of 5 km X 5 km, covering the whole of Finland. Only cells that contain at least 100 hectares of agricultural land were considered. Averages of travel time, distance and size were calculated for each cell, as well as changes over time, using map algebra tools (Tomlin 2012). A parcel is counted towards the cell in which its geographic center, also known as centroid, is.

To survey possible areas in need of an land consolidation, a multiple criteria decision analysis (MCDA) (Greene et. al. 2011) map was created. In MCDA, map layers containing different information are overlayed and combined together to create new information on the studied issue. The layer selection con often be based on an experts substance knowledge on the issue at hand. Three different map layers were combined to produce a representation of areas with

possibilities. The layers combined were *1*. the change in parcel size in every cell between 2010-2020, *2*. rental percentage in every cell and *3*. farm development potential in every cell.

Farm development potential in it self is a result of MCDA, created by National Land Survey Finland and FGI to represent the parcel structure from the point of view of the farmer. Instead of parcels, the farms are aggregated in to a grid. It combines five different aspects of land fragmentation in to one. Each layer is scaled between 1–10 and they are combined with and equal weights. The five layers used are :

1. How many different parcels the farmer visits
2. The average size of the farm's farming parcel
3. The average distance to a farming parcel
4. How many of the farming parcels are part of a larger field and could be made larger
5. How much cultivated land there is within 10 km of the farm

Each layer is scaled between 1–10 and they are combined with and equal weights.

The idea behind the data selection is that *1*. The change in parcel size could be indicative of past agreeability towards changes in parcel structure in the area, *2*. lower rental percentage is advantageous for a successful project, as active farmers who farm their own fields are usually more favourable towards land consolidation, and *3*. the farm development potential indicates the need and possibilities for improvements in parcel structure in the area. Every one of the layers is scaled between 0–2, and the layers are combined with equal weights.

3. RESULTS

3.1 Changes in parcel structure

During the study period, total number of parcels decreased in every region as well as the whole of the country. The amount of cultivated land increased in some regions, whilst decreasing elsewhere. The mean parcel size increased everywhere, averaging a total of 4,7 % of growth in the whole of Finland. The median is considerably smaller than the mean, and its' growth has been slower at 2,1 %. Mean parcel size in whole of Finland was 2,52 hectares in 2020, the median size being 1,5 hectares. Results for every region are presented in figure 2. Largest parcels can be found in the south of the country. The fastest growth, however, is found along the western coast in the Ostrobothnian regions, with Northern Ostrobothia topping the charts with an 8 % change in the mean value.

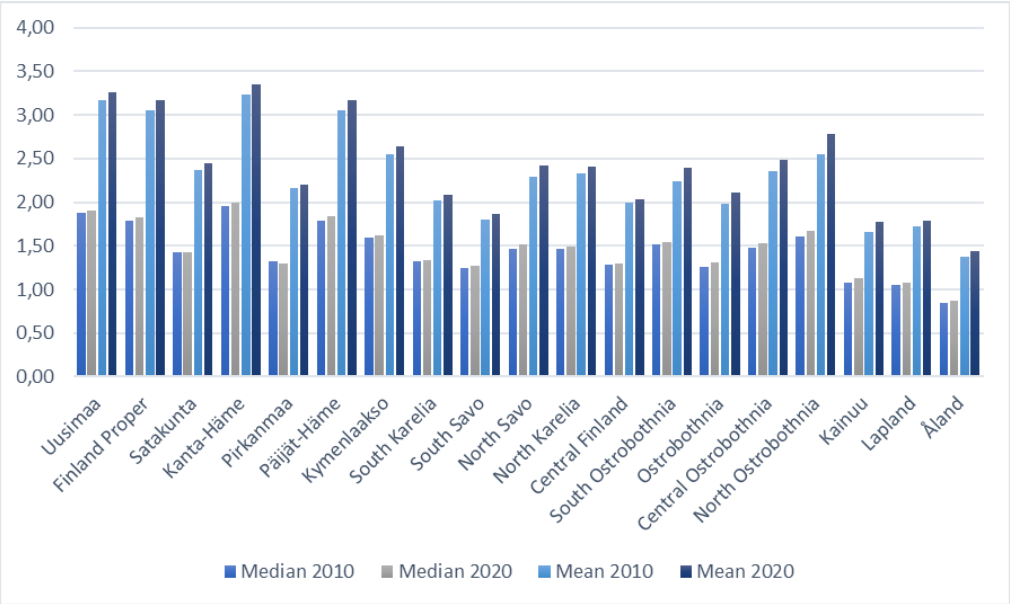

Figure 2. Mean and median parcel sizes in Finnish regions, 2010 and 2020.

The farming parcels, that combine the adjacent holdings of the same farmer, have grown similarly, with a mean of 3,18 in 2020 and a growth rate of 4,6 %. The median size was 1,74, up by 3 % from 1,74 in 2010. Around 37 % of all cultivated land area was under lease. If number of parcels is considered instead of land area, the share rises to 45 %. This indicates that rented parcels are smaller than those owned by the farmer.

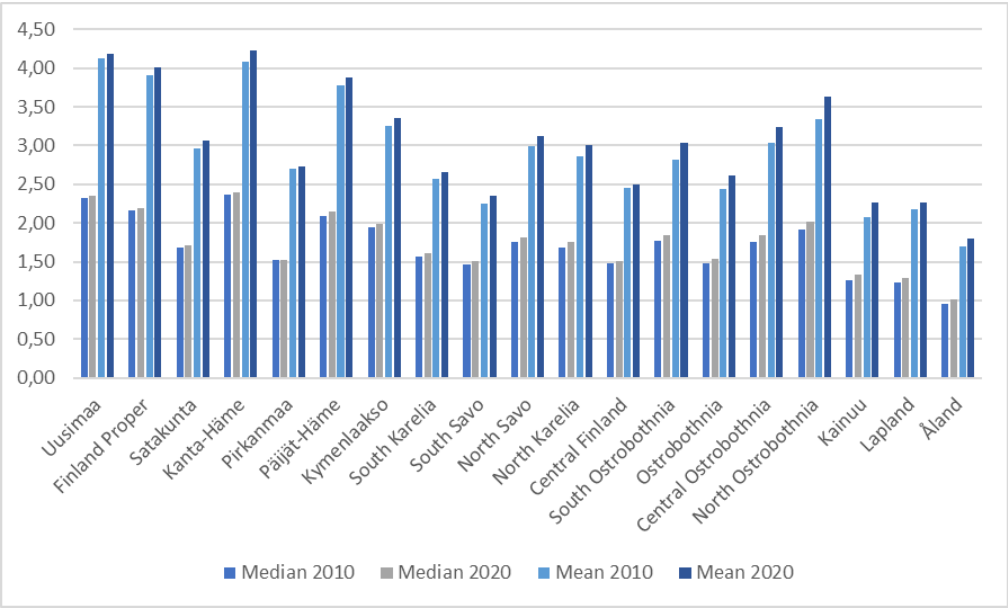

Figure 3. Mean and median farming parcel size in Finnish regions, 2010 and 2020.

The mean distance from the homestead in 2020 was 4,30 km, up by 19 % from 2010.The change in the median was even more drastic, increasing from 1,58 km to 2,04 km, or by 29,5 %. The changes in travel time are smaller, 16,9 % and 23,8 % for mean and median respectively. As the distance has increased more than the time used for travel, it would indicate that, based on routing method used, with different speeds assigned for different road classes, that agricultural traffic is moving to bigger roads as the fields are further away than before. Therefore, the implications for the growing distance are not only, for example, economical with more fuel and time consumed, but it also affects traffic flows and road safety. This is due to the large and slow farming machinery moving to the larger, busier roads.

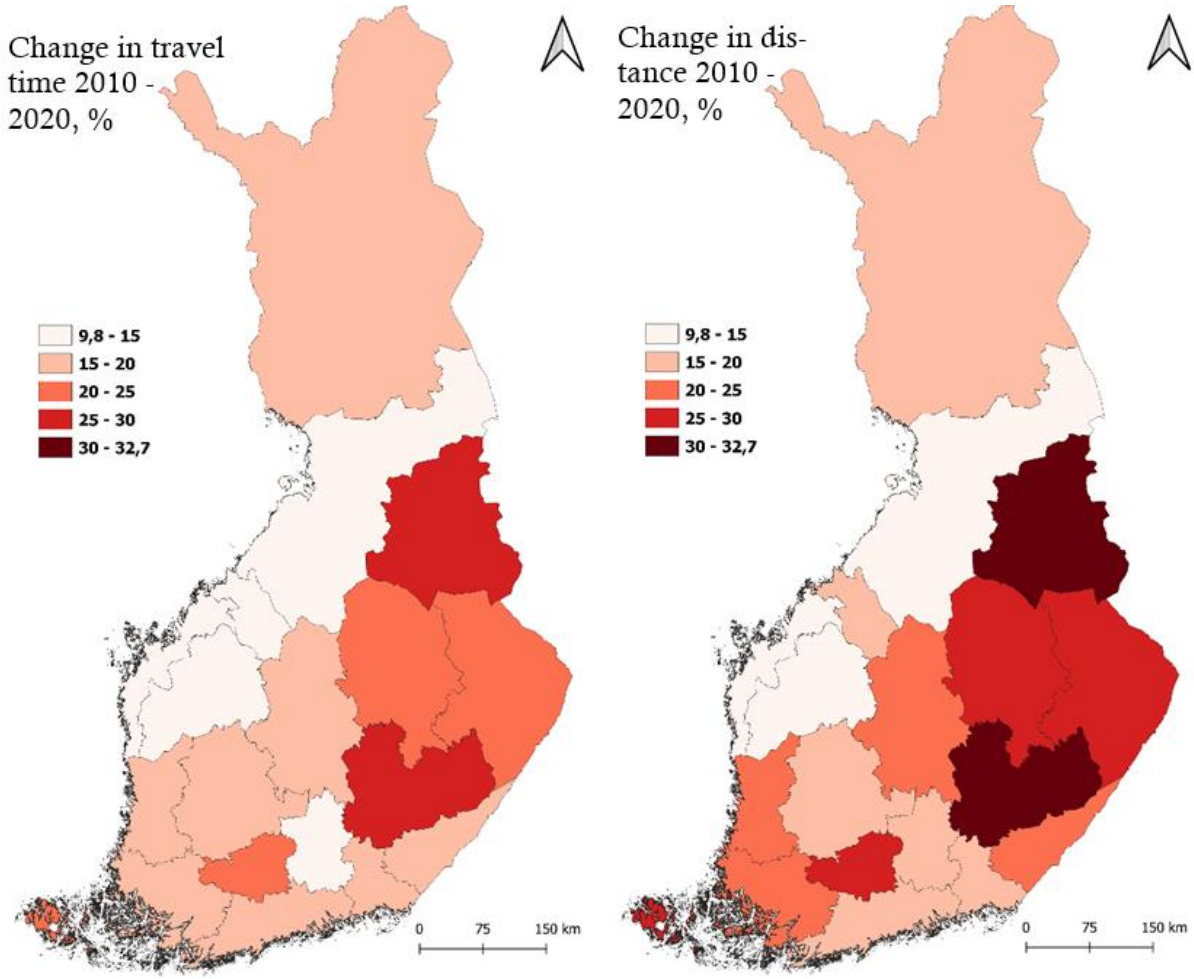

Figure 3. Changes in travel time and distance between 2010-2020 in each region of Finland.

If the changes within land consolidation project areas are examined, it can be seen that the growth in parcel size has been greater, with an average increase of 27 % and growth in every single project area. The change in distance has been slower in the project area, if compared to the average change of the respective region. The average increase of distance over all project areas was 11 %. In 2020, all project areas had a lower rental percentage than the region the area was located in. It seems that the areas, where the land consolidation projects are completed,

often have already bigger parcel size and shorter distance in the beginning of the project than the regional average. This shows that the projects often are not necessarily located in areas where the parcel structure is the worst on absolute terms, but rather in areas where there are possibilities for and successful and effective land consolidations.

3.2 Gridded maps

While the regional maps and figures give an overview of the changes in parcel structure, the grid maps can be used, for example, to spot focus areas for land consolidation, or to analyze the structure in a more detailed, local manner. In figure 4 are represented the mean parcel size in a grid cell in 2010, 2020 and the relative change between them.

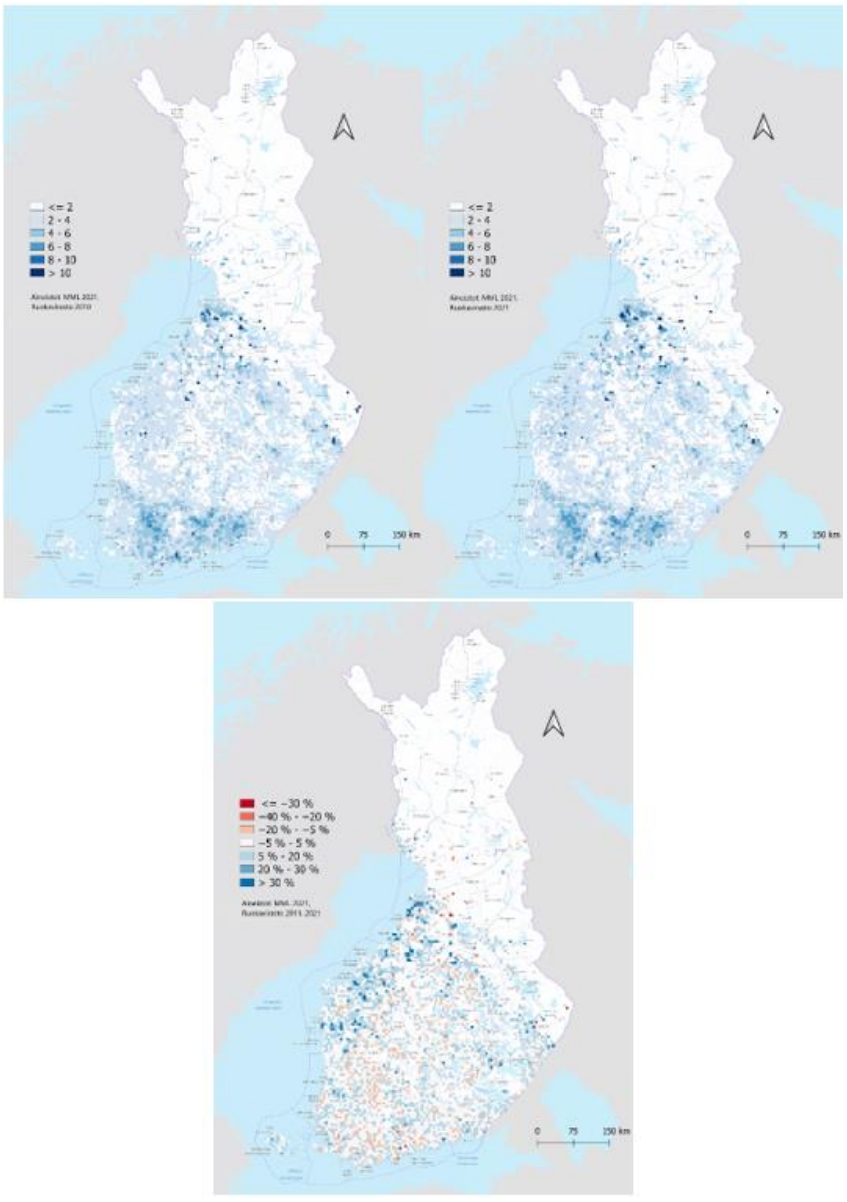

Figure 4. Mean parcel size in a 5 km X 5 km grid in 2010 (top left), 2020 (top right) and the relative change between the years (bottom).

The maps show that the largest parcels are concentrated in southern part of country, whereas in other parts the average size is smaller. Moving north, some single cells with very large average size can be identified. These are often either newly cleared areas, or old peat extraction areas that have been taken into agricultural use. The biggest increases in parcel size can be found in the coastal regions of Bothnian bay. These areas also the most active areas for land consolidations and land clearings in Finland. In other parts of the country, the parcel size has often actually decreased.

A grid representing rental percentage was also created. The grid cells with the highest percentage are often located in coastal areas, be it a lake or the sea, as well as surrounding larger cities. This could perhaps be attributed to willingness to hold on to properties in these areas in case of an increase in land value due to proximity to water or a city.

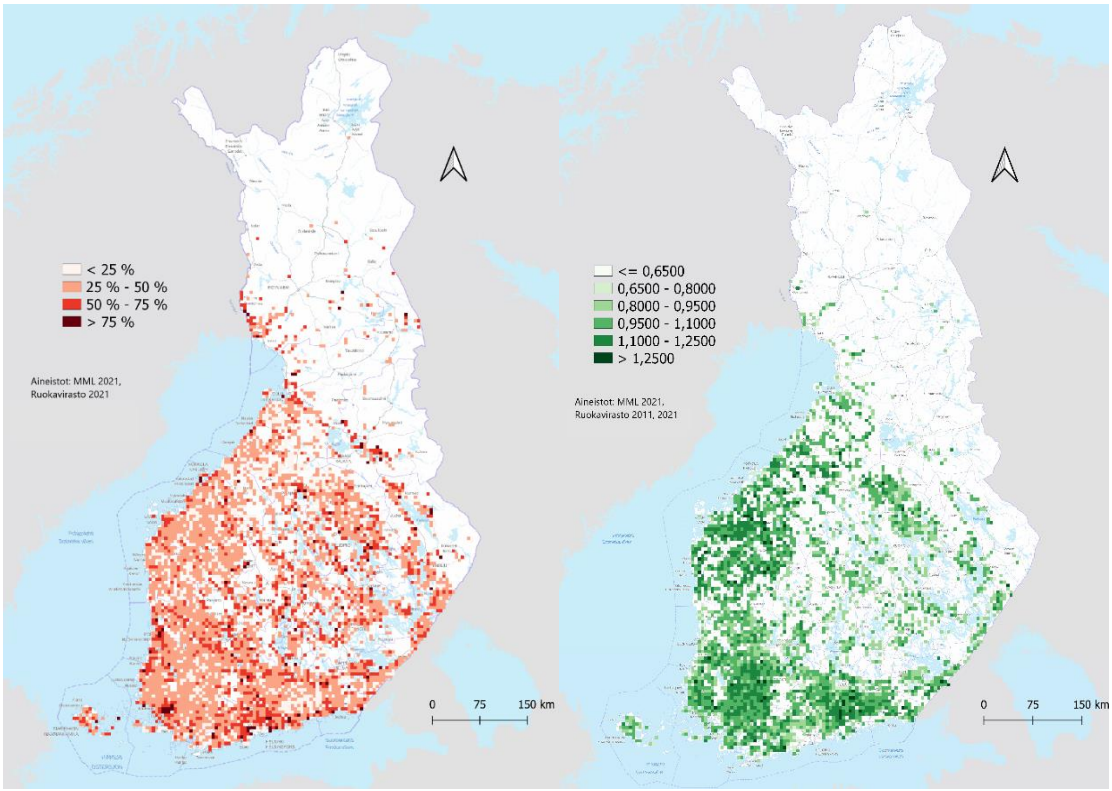

Figure 5. Left: Rental percentage. Right: Possibilities for changes in parcel structure.

Finally, the possibility for changes was analyzed. There is a lot of cells with moderate possibilities, but the darkest cells are areas where the parcel structure should be examined more closely and the needs and willingness for land consolidation should be surveyed. It should be noted that possibilities for changes does not represent land consolidation potential per se, as the original starting parcel size should be taken into account. With limited resources for land

consolidations, an area where the parcel size could be increased from 2 to 6 hectares is much more important than an area where it would grow from 10 ha to 14 ha.

4. DISCUSSION

The mean parcel size in Finland is slowly growing. The median is quite a bit smaller, saying that very large parcels are skewing the distribution. This should be taken into consideration when examining parcel sizes. As the farming parcel size is growing at a pace nearly equal to the 'normal' parcel, it seems that, for example, rental markets are not as flexible a tool, as sometimes suggested, for farmers in easily adjusting their need for land.

This is shown also by the increase in the mean homestead distance. With a limited land market, the farmers need to buy or lease land where they can, rather than from a close proximity of their current holdings. The longer distances also have implication for traffic flow and road safety, affecting them both negatively.

It seems that land consolidations are an effective tool in mitigating land fragmentation. Land consolidations seem to increase growth rate of parcels and decrease the growth rate of distance. To ensure this effectiveness also in the future, tools are needed to focus land consolidation efforts to areas where they are not only most needed, but also where they have good chances for succeeding. This can be ensured with good planning and successful communications with landowners and other stakeholders, such as farmer's associations and the local community. In this the grid maps could be a competent tool. First, the NLS can use the maps, such as the land consolidation possibilities grid, in screening and identifying potential project areas. Then informing the public and landowners in the area about the benefits of land consolidations can be focused on these areas. Finally, maps such as in figure 4 can be used to demonstrate both the need and the effects of land consolidation, when marketing the possible project to the stakeholders and landowners.

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