

## **Land consolidation and its effect on climate**

**Juhana HIIRONEN and Kirsikka NIUKKANEN, Finland**

**Key words:** land consolidation, climate change, cost-benefit analysis

### **SUMMARY**

Northern location, cold weather and sparse population put permanent restrictions on the competitiveness of the Finnish agriculture. At the same time the fragmented property division resulting from land divisions and settlement has had a decreasing impact on the profitability of agriculture. Although the number of farms has fallen and the average size of the farms has increased during the past decades the benefits arising from the increase in size have not been realized due to the continually growing fragmentation.

The structural development of farm economy has increased the need to re-arrange land parcels in Finland. This has meant that land consolidation projects are prioritized according to their overall impacts. As environmental effects don't have monetary value they are most times ignored in the social decision making process. One aspect that is not properly taken into consideration when the overall impacts of land consolidation are calculated and the implementation decision made is emissions to climate.

This case study analyzed how much petrol consumption reduced in land consolidation project in Järilä. The study also estimated the monetary value of the reduced emissions. As a result the study presented a generalization of the importance of land consolidation's climate effects in Finland. To define the reduction of petrol consumption production cost calculations were used. To estimate the monetary value of the climate effect substitute cost method was used.

By using production cost calculations, it was calculated that the total reduction of working hours was 1 348 hour/year in land consolidation project in Järilä. By using the information about the petrol consumption and emission rate of petrol, it was calculated that the total reduction of CO<sub>2</sub> was 94 tkgCO<sub>2</sub>/year. By using the information about the marginal cost of CO<sub>2</sub> emission, it was calculated that climate effect's monetary value in land consolidation project in Järilä was 106 000 € or 147 €/hectare.

The total amount of land parcels that are re-arranged in Finland is 10 000 hectares/year which means that the total monetary value of land consolidations' climate effect is 1 470 000 €/year. When this is compared to the total cost (10 000 000 €/year) of Finnish land consolidations it can be stated that land consolidation's climate effect is significant and something that should be taken into consideration in the social decision making process. This article added an environmental perspective to the social decision making process of land consolidation.

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## 1. INTRODUCTION

### 1.1 Background

Climate change is estimated to impact the Finnish nature in various ways. In the current climate conditions we are already experiencing weather and climate variations and extreme events that we need to prepare for. The situation is the same all around the world. Combating climate change is a top priority for the European Union (EU). Europe is working hard to cut its greenhouse gas emissions substantially while encouraging other nations and regions to do likewise. At the same time, the EU is developing a strategy for adapting to the impacts of climate change that can no longer be prevented. Reining in climate change carries a cost, but doing nothing will be far more expensive in the long run. (EC 2011.)

As agriculture is a significant contributor to climate change (agriculture's proportion of the EU's total greenhouse gas emissions is 9 percent) the Ministry of Agriculture and Forestry has published an action plan to address the matter. The action plan defines 14 measures for agriculture that help the adaptation or prevention of climate change. The first measure mentioned states that climate change must be taken into consideration when other agricultural policy objectives are defined. The action plan looks for synergies between different actors and sectors and identifies linkages between climate change and other policy objectives. (MAF 2011, p. 6-8, 47; EC 2011.)

The link between land consolidation and climate change is recognized in Finnish land consolidation strategy. According to the strategy public financing should be allocated so that the measures implemented produce the best possible impact. The focus in 2008-2013 should be on combining different points of view in land consolidation, in which case views related to the environment etc. can be more extensively taken into consideration. The strategy states that land consolidation should broadly support social goals, such as rural viability and environmental protection so that the activities would help to achieve the best possible overall impact to social welfare. (MAF 2007, p. 14-15.)

Traditional effects of land consolidation like reduced production costs can be defined in monetary terms quite easily. But as the objectives of land consolidation have become more complex (see Vitikainen 2004, p. 28-29; MAF 2007) so has the decision making process. This has meant that in addition to direct market based values other benefits and drawbacks e.g. environmental effects should be taken into consideration as well (Virtanen 2006, p. 7-8; Hiironen et al. 2010b). One aspect that is not properly taken into consideration when the overall impacts of land consolidation are calculated and the implementation decision made is emissions to climate. There is a strong hypothesis that reduced agricultural traffic reduces petrol consumption and therefore reduces harmful emission to air (see NLS 2006; Panschin & Vitikainen 2010). But as there are no valuation methods to value either the reduced petrol

consumption or its monetary effect the importance of land consolidation's climate effect might be under- or overestimated.

## **1.2 Objectives and methods**

This case study analyses how much does petrol consumption reduce in land consolidation because of the reduced need for agricultural transportation due the reduction of land parcels and/or distance to compound (Objective 1). The study also estimates the monetary value of the reduced emissions to climate due to the reduction in petrol consumption (Objective 2). As a result the study that is based on inductive reasoning presents a generalization of the importance of land consolidation's climate effect.

To define the reduction of petrol consumption (Objective 1) production cost calculations are used. To estimate the monetary value of the climate effect (Objective 2) substitute cost method is used.

## **1.3 Study material and initial data**

Study material is gathered from land consolidation project (LCP) that was done between 2004 and 2010 and that was located in a village called Järilä (Finland). Detailed information that included size, distance to compound, type of production (grain, potato, animals etc.) was collected from each parcel before and after project utilizing Land Information System and Finnish Land Parcel Identification System (NLS 2009a; NLS 2009 b).

## **1.4 Structure of the study**

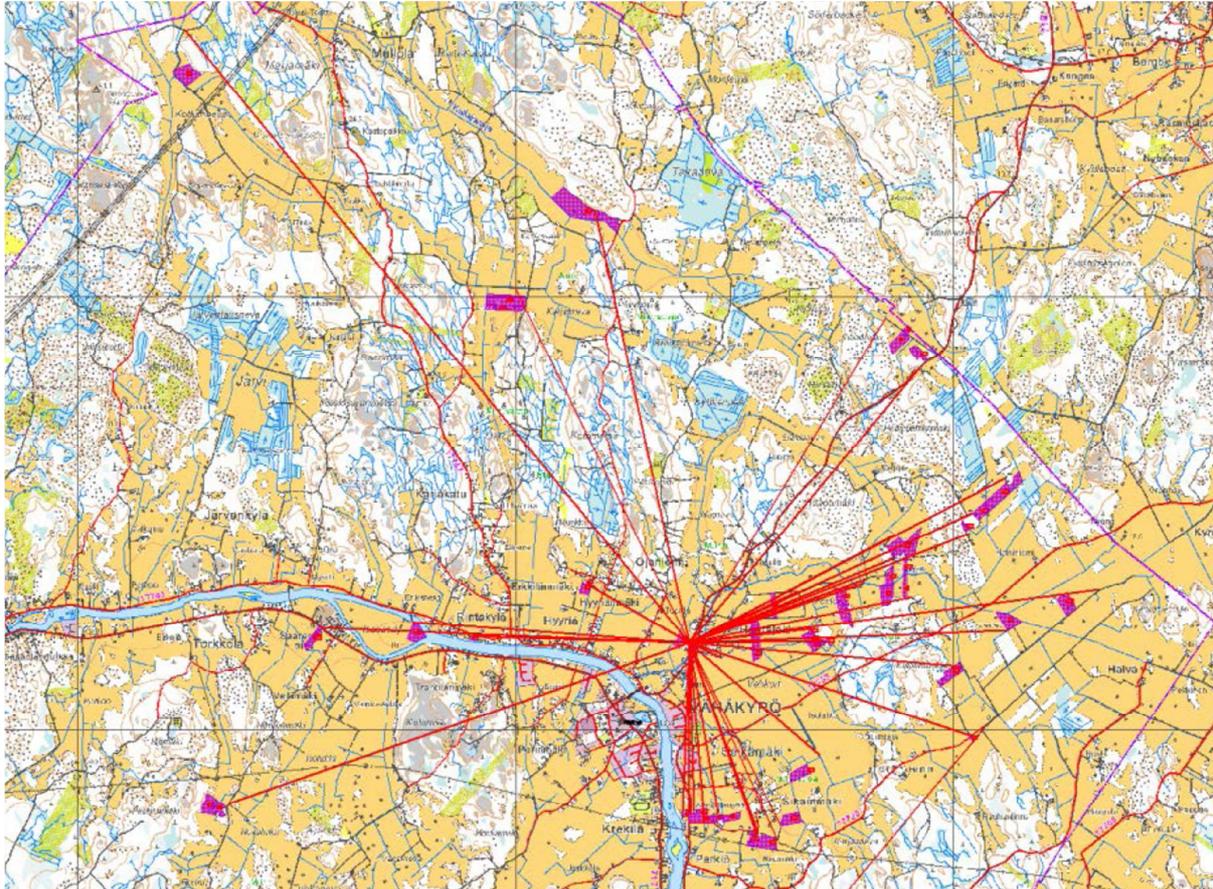
The study is organized as follows. Chapter 1 is an introduction chapter which describes the background, objectives, methods and material of the study. Chapter 2 introduces the reader to Finnish land consolidations. The basic elements (e.g. objectives, preconditions and proceedings) of Finnish land consolidations are presented briefly in this chapter. The third chapter focuses on the study material. The basic information (e.g. location and property structure, proceeding, achieved results) about the studied LCP in Järilä is presented in Chapter 3. Chapter 4 defines the methods to calculate the reduction of petrol consumption and the monetary value of it. Chapter 4 also presents the results of calculations. The discussion and the importance of the results are presented in Chapter 5.

## **2. LAND CONSOLIDATIONS IN FINLAND**

### **2.1 Idea and objective of Finnish land consolidation**

Finland is the most sparsely populated country in the EU. Finland's climate and northern location present special challenges for the profitability and competitiveness of agriculture. At the same time, a fragmented property structure resulting from society-driven land consolidation and settlement activities has had a detrimental effect on Finnish agricultural productivity. (MAF 2007, p. 7, 10.) Despite the fact that the number of farms has dropped 30

percent and that the average size of farms has increased 70 percent during Finland's EU membership, the benefits of rationalization have remained unexploited because the property structure has become increasingly fragmented (CSOF 2010; MEE 2011, p. 8). The structural development of farm economy has increased the need to re-arrange land parcels in Finland. (Hiironen 2012, p. 60; 90-92; MAF 2007, p. 12.)

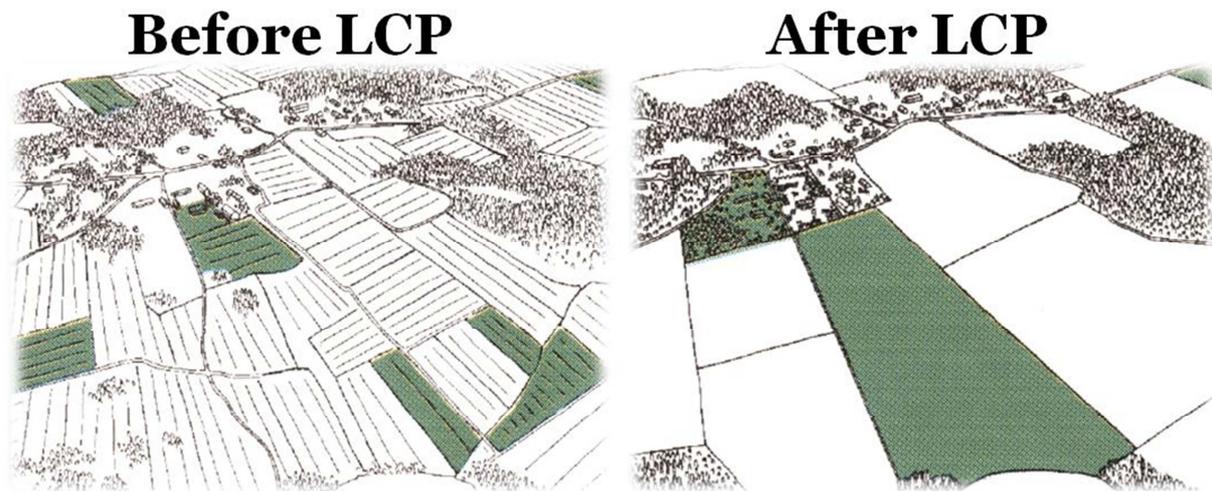


**Figure 1:** An example from Vähäkyrö in Finland. The red lines represent the distance between farm compound and cultivated land parcel. This picture represents a quite typical situation: farmer has more than twenty small land parcels around the village. © National Land Survey of Finland

The aim of the rural policy in Finland is to ensure a viable and functioning countryside. One of the main priorities is to raise the level of competitiveness. In practice this means that farmers are paid farming subsidies for more than two billion euro per year. If competitiveness of a farm is improved, either its incomes must be increased or costs decreased. The farming subsidies concentrate mainly to the first option when land management strategies focus on the latter. (MEE 2011, p. 2; Hiironen et al. 2010a.)

Finnish land consolidations are performed in agricultural areas since it is stated in recent land consolidation strategies (NLS 2007; MAF 2007) that resources shall be focused on improving the feasibility of farms. Land consolidations are performed in areas where property structure

is scattered and improvement possibilities good. This has meant that almost every land consolidation area locates in western part of Finland where there are wide field areas and a lot of farmers. The main objective of land consolidation is to improve the property structure and reduce the production costs (HE 227/1994). Other objectives e.g. environmental protection can be taken into consideration as well (see Vitikainen 2004, p. 28). In recent years a special attention has been paid to reduce nitrogen and phosphorus emissions to the Baltic Sea.



**Figure 2:** Idea of Finnish land consolidation project (LCP). © National Land Survey of Finland

The financing for land consolidation projects comes from national resources although the main principles of subsidization well from *European Union's Council Regulation (EC) No 319/2006 of amending Regulation (EC) No 1782/2003 establishing common rules for direct support schemes under the common agricultural policy and establishing certain support schemes for farmers*, and from the *Commission Regulation (EC) No 1857/2006 of the application articles 87 and 88 of the Treaty to State aid to small and medium-sized enterprises active in the production of agricultural products amending Regulation (EC) No 70/2001*. The subsidize for land consolidations is regulated in the EC No 319/2006 in articles 95 and 96 and in the EC No 1857/2006 in article 13. According to the article 13 in the EC No 1857/2006, the goal for agricultural policy is to restore and improve the competitiveness of rural areas and, furthermore, to restore and to create jobs in those areas. The total amount of money spent in Finnish land consolidations is approximately 10.000.000 €/year (Kontinen 2011).

## 2.2 Legislation and preconditions

As in all European countries land consolidation in Finland is based on legislation. The main land consolidation act in Finland is the Real Property Formation Act. Finnish land consolidation also has connections to the land use legislation, building legislation, environmental protection legislation, nature conservation legislation, and to the agricultural, forest, road, water and expropriation legislation. (Vitikainen 2004, p. 26-27.)

Section 67 in Real Estate Formation Act states “*Land consolidation may be executed if the ensuing benefits exceed the costs and hindrance incurred.*”. This means that in Finnish land consolidations the benefits must always be higher than the costs, and that the profitability of land consolidation must be proven in every case in order to get public finance for the project. There is no statement in Real Estate and Formation Act that the benefits should be monetary but the practice has proven that only monetary effects are compared when the financing and implementation decisions are being made.

## **2.3 Proceedings**

The process of land consolidation consists of four stages: preparation, inventory planning, implementation and reconstruction of the capital improvements. All the stages are not followed by each other and can be done partly at the same time. The preparation stage consists of two main tasks, feasibility studies and cost-benefit analysis. The actual land consolidation starts by inventory planning stage. The surveyor prepares a project plan, invents the rights on the land, values the land and prepares the reallocation plan. This stage is partly done on the same time as preparation stage. The third stage is implementation. It includes registration of the reallocation plan, demarcation of the new parcels, taking into possession of the new parcels, payment of compensation and division of the cadastral survey costs. After that the land consolidation is completed and cadastral survey registered. The fourth stage is reconstruction of the capital improvements. This is a stage that is integrated into the previous two stages and consists on road network and drainage construction. (Vitikainen 2003, p. 72-88.)

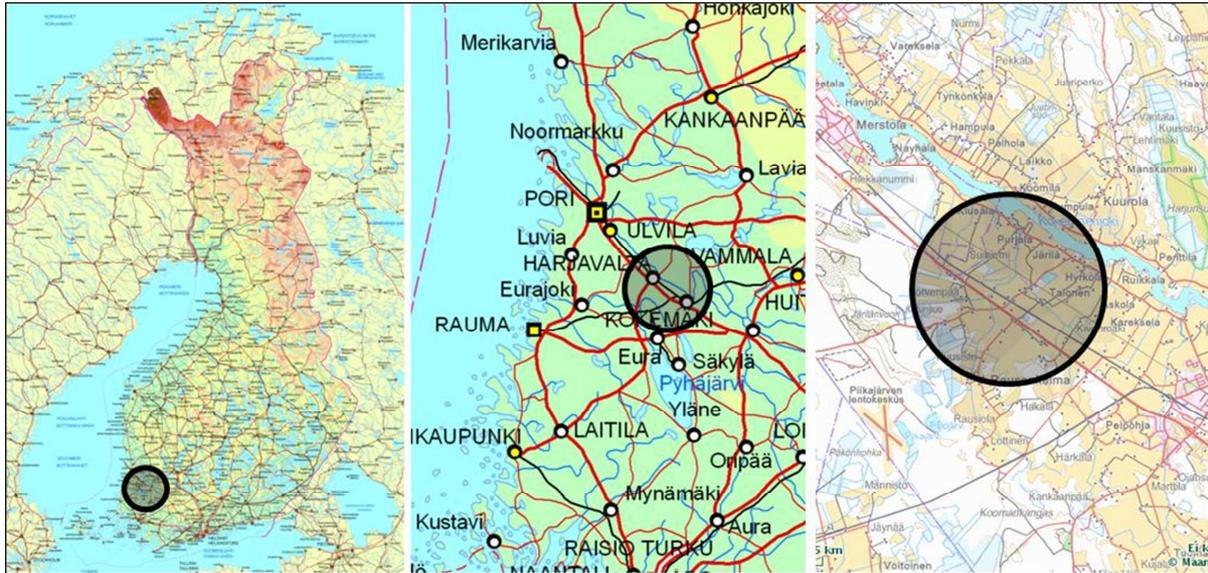
## **2.4 Executive organisation**

The land consolidation procedure is regarded as administrative decision-making, and as in most of the European countries it is entrusted to the administrative authorities. In Finland Ministry of Agriculture and Forestry is the responsible organ for the land consolidations on the governmental level. In Finland land consolidations are executed by using the cadastral survey model, in which cadastral authorities and furthermore a cadastral surveyor is in charge of implementing the projects. (Vitikainen 2004, p. 27.)

# **3. LAND CONSOLIDATION PROJECT IN JÄRILÄ**

## **3.1 Location of the project area**

The field area of Järilä is situated on the border of Kokemäki and Harjavalta in south-west Finland. The distance between Järilä field area and both Kokemäki and Harjavalta centers is approximately six kilometers. The field parcels in the area are divided into several small ones by one highway, local roads, farm roads, one railway and main ditches. Especially problematic are the highway and railway, because they have been built by ignoring the existing landownership and due to that, both of them have dismantled the field parcels. Also the bad condition of main ditches and their location restrict the development of road and drainage system. (Konttinen 2004.)



*Figure 3: The project area locates in Kokemäki and Harjavalta cities in south-west Finland.*

### 3.2 Main phases of the project

In November 2003 seven farmers, from a small village called Järilä, made a request to the District Survey Office that possibility of land consolidation should be evaluated. In the beginning of 2004 surveyor's report revealed the potential of land consolidation in Järilä. In August 2004 farmers decided to apply for the project. In December 2004 the Ministry of Agriculture and Forestry approved the project and decided to support its costs (the amount of support was 85 percent of the survey fees, 60 percent of the costs of improving the main ditches and 40 percent of the drainage costs). In May 2005 the preconditions were found and the area to be consolidated decided. In June 2006 the first arrangement plan was presented to the farmers, and a year later, the third arrangement plan was accepted by the farmers. In February 2008 the possession of the parcels changed. Between 2008 and 2009 the drainage and road network measures were completed. In the beginning of 2010 the project was registered and closed. (Hiironen et al. 2010a.)

### 3.3 Achieved results

Land consolidation declined the number of parcels from 396 to 188, increased the average (median) size of parcels from 1,8 to 5,1 hectares, and decreased the agricultural transportation by 35 percent. It has been calculated that the improvements in property structure lead to 1.053.000 € agricultural benefit. The total cost of the project was 546.000 €. Land owners' share was 203.000 € which means that taxpayers' share was 343.000 €. Land consolidation improved the living conditions and as it improved the feasibility of farms, its effect to migration was positive. It was also stated that land consolidation had beneficial ecological effects (e.g. reduced emissions to air) although these effects were not quantified. (Hiironen et al. 2010a; Hiironen 2012, p. 138.)

#### 4. EVALUATION OF CLIMATE EFFECT

In LCP land parcels are re-arranged closer to compounds and consolidated into bigger units. This reduces working time needed for cultivation and travelling time needed for travelling between compounds and parcels. The reduced working hours mean reduced emissions to climate since petrol consumption reduces along with working hours. To define the reduction of petrol consumption (Objective 1) production cost calculations are used.

There are two main actors, National Land Survey of Finland (NLS) and Work Efficiency Institute (FEI), providing production cost calculations in Finland. Among other things these calculation provide information about cultivation time and travelling time in a function of parcel size and distance to compound. The most recent information about cultivation time in a function of parcel size (see Table 1) and travelling time in a function of distance to compound (see Table 2,3 and 4) are presented by Hiironen (2012).

**Table 1:** Time (hours/hectare) consumed for cultivation in a function of parcel size and in different lines of production (Hiironen 2012, p. 107-110, 116; see NLS 2011a).

Distance (minutes)	Parcel size (hectares)								
	0,5	1,0	1,5	2,0	2,5	3,0	5,0	10,0	20,0
Cattle farm	4,6	3,7	3,4	3,2	3,1	3,0	2,8	2,6	2,5
Vegetable farm	10,4	8,6	7,9	7,5	7,2	7,1	6,7	6,3	6,2
Grain farm	7,9	6,5	5,9	5,6	5,4	5,3	5,0	4,7	4,7

**Table 2:** Time (minutes/hectare) consumed in a cattle farm for travelling (oneway) between farm compound and cultivated land parcel in a function of parcel size (Hiironen 2012, p. 120; see NLS 2011b).

Distance (minutes)	Parcel size (hectares)								
	0,5	1,0	1,5	2,0	2,5	3,0	5,0	10,0	20,0
1	24	14	11	10	9	8	7	7	6
2	47	29	22	19	17	16	15	13	13
3	71	43	34	29	26	24	22	20	19
4	94	58	45	39	34	33	29	27	26
5	118	72	56	48	43	41	37	34	32
6	141	86	67	58	52	49	44	40	39
7	165	101	78	68	60	57	51	47	45
8	188	115	90	78	69	65	59	54	52
9	212	129	101	87	78	73	66	61	58
10	235	144	112	97	86	81	73	67	65
15	353	216	168	145	129	122	110	101	97
20	470	288	224	194	172	163	147	135	129
30	706	431	336	291	258	244	220	202	194
40	941	575	448	388	344	326	293	269	258
60	1411	863	671	582	517	488	440	404	387

**Table 3:** Time (minutes/hectare) consumed in a vegetable farm for travelling (oneway) between farm compound and cultivated land parcel in a function of parcel size (Hiironen 2012, p. 121; see NLS 2011b).

Distance (minutes)	Parcel size (hectares)								
	0,5	1,0	1,5	2,0	2,5	3,0	5,0	10,0	20,0
1	24	14	11	10	9	8	7	7	6
2	47	29	22	19	17	16	15	13	13
3	71	43	34	29	26	24	22	20	19
4	94	58	45	39	34	33	29	27	26
5	118	72	56	48	43	41	37	34	32
6	141	86	67	58	52	49	44	40	39
7	165	101	78	68	60	57	51	47	45
8	188	115	90	78	69	65	59	54	52
9	212	129	101	87	78	73	66	61	58
10	235	144	112	97	86	81	73	67	65
15	353	216	168	145	129	122	110	101	97
20	470	288	224	194	172	163	147	135	129
30	706	431	336	291	258	244	220	202	194
40	941	575	448	388	344	326	293	269	258
60	1411	863	671	582	517	488	440	404	387

**Table 4:** Time (minutes/hectare) consumed in a grain farm for travelling (oneway) between farm compound and cultivated land parcel in a function of parcel size (Hiironen 2012, p. 120; see NLS 2011b).

Distance (minutes)	Parcel size (hectares)								
	0,5	1,0	1,5	2,0	2,5	3,0	5,0	10,0	20,0
1	24	14	11	10	9	8	7	7	6
2	47	29	22	19	17	16	15	13	13
3	71	43	34	29	26	24	22	20	19
4	94	58	45	39	34	33	29	27	26
5	118	72	56	48	43	41	37	34	32
6	141	86	67	58	52	49	44	40	39
7	165	101	78	68	60	57	51	47	45
8	188	115	90	78	69	65	59	54	52
9	212	129	101	87	78	73	66	61	58
10	235	144	112	97	86	81	73	67	65
15	353	216	168	145	129	122	110	101	97
20	470	288	224	194	172	163	147	135	129
30	706	431	336	291	258	244	220	202	194
40	941	575	448	388	344	326	293	269	258
60	1411	863	671	582	517	488	440	404	387

The studied material includes information about parcel size (hectares), distance between

parcel and compound (kilometers) and line of production (cattle farm/vegetable farm/grain farm) of each parcel before and after LCP. Using this information and the information presented in tables 1, 2, 3 and 4, the total time consumed for cultivation and travelling is calculated before and after LCP.

*There has been used an assumption in the calculation that if the distance is less than half a kilometer, the travel to cultivated parcel will be done only by using farming roads. If the distance is between 0,5 and 1,0 kilometer, there has been used an assumption that 67 percent of the travel is done by using farming roads, 33 percent by using rather wide, pavement roads. If the distance is between 1,0 and 3,0 kilometers, there has been used an assumption that 50 percent of the travel is done by using farming roads, 50 percent by using rather wide, pavement roads. If the distance is between 3,0 and 5,0 kilometers, there has been used an assumption that 33 percent of the travel is done by using farming roads, 67 percent by using rather wide, pavement roads. If the distance is more than five kilometers, there has been used an assumption that 10 percent of the travel is done by using farming roads, 90 percent by using rather wide, pavement roads. The average speed on farming roads is 20 km/h and on other roads 40 km/h. (Hiironen 2012, p. 119.)*

The study also estimates the monetary value of the reduced emissions to climate due to the reduction in petrol consumption (Objective 2). To estimate the monetary value of the climate effect, substitute cost method is used. In this case, when the benefit is non-marketed, it is easier to measure the costs of producing benefits than the benefits themselves. The substitute cost method provides surrogate measures of value that are as consistent as possible for services that might be difficult to value by using other valuation methods. By using substitute cost method it is possible to estimate a rough indicator of LCP's climate effect's economic value.

Applying the substitute cost method includes three steps. The first one is to assign the environmental service or benefit by specifying the relevant good (CO<sub>2</sub>) and the levels of the good (reduction of CO<sub>2</sub>). The second step is to find and identify alternative cost to provide the same benefit, good or service. The third step is to calculate the cost of the substituting service.

*The first step: By using production cost calculations and the information specified in tables 1, 2, 3 and 4, it can be calculated that the total reduction of working hours is 1 348 hour/year in Järilä LCP. By using the information about the petrol consumption (25,82 l/h) and emission rate of petrol (2,7 kg/l), it can be calculated that the total reduction of CO<sub>2</sub> is 94 tkgCO<sub>2</sub>/year (Grisso et al. 2010).*

*The second step: There are over 200 estimates of the marginal damage cost of carbon dioxide emissions. The mean estimate in these studies is a marginal cost of carbon of 75 €/tCO<sub>2</sub>. The uncertainty about the cost of carbon is large and right-skewed (the estimated cost at the 95th percentile is 256 €/tCO<sub>2</sub> and the estimate at the 99th percentile is 1 067 €/tCO<sub>2</sub>). (Richard 2009.)*

*The third step: By using the information about the level of reduction of CO<sub>2</sub> (94 tkgCO<sub>2</sub>/year) and the marginal cost of CO<sub>2</sub> emission (75 €/tCO<sub>2</sub>), it can be calculated that climate effects monetary value in Järilä LCP is 7 050 €/year. When this is capitalized like other effects (see Hiironen et al. 2010) to 30 years with 5 percent interest rate, the total value of the climate effect is 106 000 €.*

As this study is based on inductive reasoning a generalization of the importance of land consolidation's climate effect in the whole country is presented. Climate effect in Järilä LCP is 106 000 € in total which means that it is 147 €/hectare. The total amount of land parcels that are re-arranged in Finland is 10 000 hectares/year (see NLS 2011c, p. 18). This means that the total monetary value of land consolidations' climate effect is 1 470 000 €/year in Finland.

## 5. DISCUSSION

Land consolidations are financed according to their overall impacts. Public financing should be allocated so that the measures implemented in LCPs produce the best possible impact. Traditional effects of land consolidation like reduced production costs are defined in monetary terms. But as the objectives of land consolidations have become more complex so has the decision making process. As most of the environmental impacts do not have market values and due to that are not at least comparably included in decision making process, the best possible allocation of public funds may be jeopardized.

In LCP land parcels are re-arranged closer to compounds and consolidated into bigger units. This reduces working time needed for cultivation and travelling which reduces petrol consumption. This case study analyzed how much petrol consumption reduced in LCP in Järilä (Objective 1). The study also estimated the monetary value of the reduced emissions (Objective 2). As a result the study presented a generalization of the importance of land consolidations' climate effects in Finland. To define the reduction of petrol consumption production cost calculations were used. To estimate the monetary value of the climate effect substitute cost method was used.

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The total amount of land parcels that are re-arranged in Finland is 10 000 hectares/year which means that the total monetary value of land consolidations climate effect is 1 470 000 €/year. When this is compared to the total cost (10 000 000 €/year) of Finnish land consolidations it can be stated that land consolidation's climate effect is significant and something that should be taken into consideration in a social decision making process.

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## **BIOGRAPHICAL NOTES**

Mr. Juhana Hiironen, Master of Science (Engineering) 2006, Department of Surveying at Helsinki University of Technology. Since 2008 Chief Expert, National Land Survey of Finland, Development Centre. Mr. Hiironen is finalizing his Doctoral Dissertation on “Impacts of farmland consolidation in agriculture and rural areas”. The permit for publication will be decided on 14. November 2011.

Ms. Kirsikka Niukkanen, Master of Science (Engineering) 2009, Helsinki University of Technology. Since 2010 Doctoral Student, Aalto University, Department of Surveying. Ms. Niukkanen is preparing her Doctoral Dissertation on “Special Interests in Finland”.

## **CONTACTS**

Chief Expert Juhana Hiironen (M.Sc)  
National Land Survey of Finland  
Opastinsilta 12  
FI-00520 Helsinki  
FINLAND  
Tel. +358 50 347 7562  
Email: [juhana.hiironen@nls.fi](mailto:juhana.hiironen@nls.fi)  
Web site: <http://www.maanmittauslaitos.fi/en>

Doctoral Student Kirsikka Niukkanen (M.Sc)  
Aalto University  
School of Engineering  
Department of Surveying  
P.O. Box 15800  
00076 Aalto  
FINLAND  
Tel. +358 50 338 7111  
Email: kirsikka.niukkanen@aalto.fi  
Web site: <http://maa.tkk.fi/en/>