# Possibilities to reduce nutrient loads to water system in land consolidations

**Juhana HIIRONEN and Kirsikka NIUKKANEN, Finland**

**Key words**: land consolidation, water system, nitrogen, phosphorus, monetary valuation, substitute cost method, cost-benefit analysis

## SUMMARY

The Finnish Government approved Water Protection Policy Outlines which defined needs and objectives, aiming especially to reduce the nutrient loads, especially from agriculture. The link between land consolidation and environmental protection activities 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 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. The potential of land consolidations in water protection activities has only recently been recognized in the National Land Survey of Finland (NLS). Therefore activities aiming to reduce nutrient loads from agricultural fields have not been put in practice in Finnish land consolidations. At this moment it is not evident if reducing nutrient loads in land consolidations is something that would be cost-effective and therefore should be one of the objectives that land consolidations have.

This case study analyzed how much phosphorus and nitrogen loads would have reduced if land consolidation project (LCP) that was implemented in Järilä had included water protection activities. To define the reduction of nutrient loads a model (named VIHMA) for the management of runoff waters was used. With VIHMA nutrient loads and their variations due to tillage practices and crop covers in a function of field characteristics (e.g. slope, area) were estimated. To estimate the monetary value of the reduction of nutrient loads substitute cost method was used. With substitute cost method an alternative cost to provide the same benefit was estimated in order to define the monetary value of water protection activities. By using the data collected from LCP the nutrient loads to water system were calculated before LCP. By assuming that grass fields had been re-arranged to risk areas phosphorus loads had been reduced 2,4 % and nitrogen loads increased 0,1 %. The monetary value of the changes in nutrient loads in the assumed situation had been 94 000 euro in total. This can be seen as a significant benefit since the total cost of the project were 546 000 euro.

Based on the results of this study it can be stated that water protection activities should be taken into consideration when the objectives of land consolidation are defined and the re-allocation plan drawn. However, as the topography of the landscape differs significantly between different project areas, similar results might not occur in all LCPs.

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## 1. INTRODUCTION

### 1.1 Background

The Finnish Government approved November 2006 a new set of national Water Protection Policy Outlines to 2015. The new outlines defined needs and objectives for the period until 2015, aiming especially to reduce the nutrient loads that cause eutrophication which is considered to be the primary problem for Finland's surface waters. According to the outlines the greatest need for reductions concerns diffuse loads, especially from agriculture. Agricultural nutrient releases still account for more than half of all the nutrient discharges into water bodies. The key objective is that nutrient loads entering water bodies from agriculture should be reduced by a third by 2015 compared to their levels over the period 2001-2005, and halved over a longer timescale. In planning the measures needed to reach these targets, consideration must be given to the productivity and economic viability of agriculture. Water protection measures carried out by farmers on a voluntary basis should be favored where possible which is why the new agri-environmental subsidies programme promotes e.g. the establishment of buffer zones and wetlands. (ME 2007, p. 9)

The link between land consolidation and environmental protection activities 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.)

The potential of land consolidations in water protection activities has just been recognized in the National Land Survey of Finland (NLS) (see Kolis 2012; Kattainen 2012). Therefore activities aiming to reduce nutrient loads from agricultural fields have not been put in practice in Finnish land consolidations, at least systematically or in a bigger scale. At this moment it is not evident if reducing nutrient loads is something that should be one of the objectives that land consolidations have. Therefore measures aiming to reduce nutrient loads are not systematically considered when the re-allocation plan is drawn (Kolis 2012, p. 28).

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 taken into consideration when the overall

impacts of land consolidation are calculated and the implementation decision made is nutrient loads to water system. There is a hypothesis that it would be beneficial to re-arrange fields in order to minimize nutrient loads to water system. In practice this means that grass fields, which have lower nutrient loads than the fields that are tilled at autumn and that have no vegetation cover at winter, should be re-arranged to the slopes near water areas from which the nutrient load runoffs are the highest (50 % from the nutrient loads runoff from fields which slope is higher than 3 %, see Uusitalo 2007, p. 23-24; Kolis 2012, p. 9-10). But as there are no valuation methods in practice to valuate either the reduced nutrient loads or its monetary effect it is unknown whether or not these actions should be made in land consolidations.

### 1.2 Objectives and methods

This case study analyses how much phosphorus and nitrogen loads would have reduced if land consolidation that was implemented had included water protection activities. The study estimates the monetary value of the reduced phosphorus and nitrogen loads (Objective A). As a result the study presents a generalization of the effectiveness to include water protection activities to land consolidations. As a conclusion the study considerers if reducing nutrient loads should be one of the objectives that land consolidations have.

To define the reduction of phosphorus and nitrogen loads loading values of VIHMA in corresponding field categories are used. To estimate the monetary value of the water protection activities substitute cost method is used. To define the effectiveness of water protection measures its monetary value is compared to the cost of the project and to the monetary value of agricultural effects which are defined by using production cost calculations.

### 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 e.g. 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). By using VIHMA nutrient loads from arable land from the LCP area were calculated before land consolidation. Nutrient loads after land consolidation were calculated by assuming that the grass fields had been re-arranged to the risk areas (3 % from the fields had a slope that was higher than 3 %, see Kattainen 2012, p. 56).

> *VIHMA is a model for the management of runoff waters from arable land. Model is made for the estimation of nutrient loading from arable land and their variations due to tillage practices and crop covers in a function of field characteristics (e.g. slope, area). (Puustinen et al. 2010, p. 307-309.)*

### 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. This chapter also presents the studied LCP. Chapter 3 defines the methods to calculate the reduction of nutrient loads and the monetary value of it. Chapter 3 also defines the method to calculate LCP's agricultural effect and its monetary value. Chapter 4 presents the results and conclusions. It also presents the discussion and the importance of the results.

## 2. LAND CONSOLIDATIONS IN FINLAND

### 2.1 Rural policy and land consolidation

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 idea of Finnish land consolidation is presented in Figure 1.

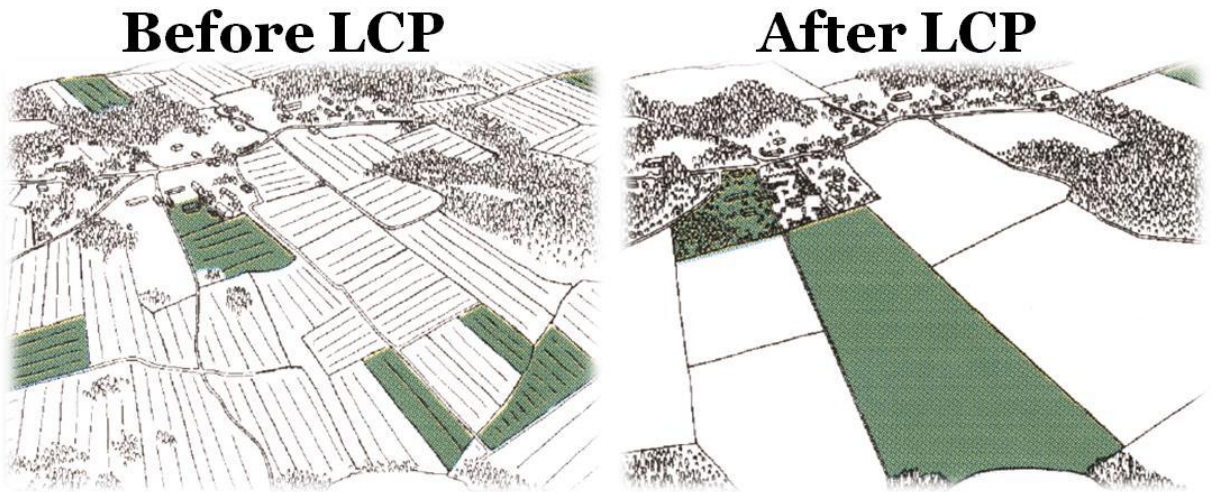


***Figure 1:*** *Idea of Finnish land consolidation project (LCP). Small and scattered land parcels are re-arranged into bigger units that locate near farm compounds. © National Land Survey of Finland*

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 (see Kolis 2012).

## 2.2 Financing land consolidation

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 (Konttinen 2011) from which approximately 40 percent comes from the budget of NLS and 60 percent from national subsidization. EU funds are not utilized in Finnish land consolidations although Finland is applying them in the next subsidy period that begins in 2014. In this context it would be beneficial if nature protection activities could be included in Finnish land consolidations and therefore used as grounds for EU subsidies.

## 2.3 Structural development has revealed the injurious effects of scattered property structure

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 2* and *Figure 3* present an example from Finnish village which property structure is scattered. *Figure 2* represents the situation that a single farmer has. *Figure 3* represents the situation that the farmers in the whole village have to deal with. The red lines represent the

distance between farm compound and cultivated land parcel. From these red lines it can be seen that the property structure is not optimal, either for the farmer or for the environment.

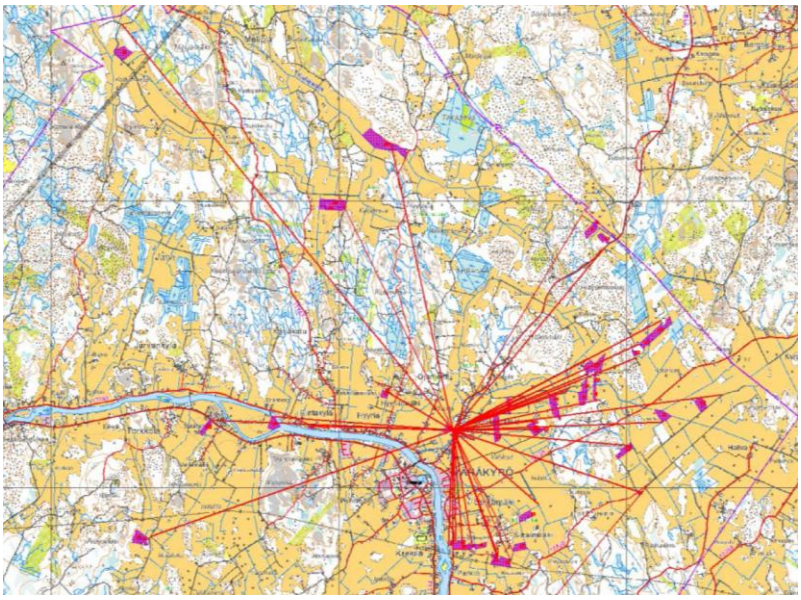

***Figure 2:*** *An example from Vähäkyrö in Finland. The red lines represent the distance between farm compound and cultivated land parcel. This picture represents a quite typical situation: farmer has more than twenty small land parcels around the village. © National Land Survey of Finland*

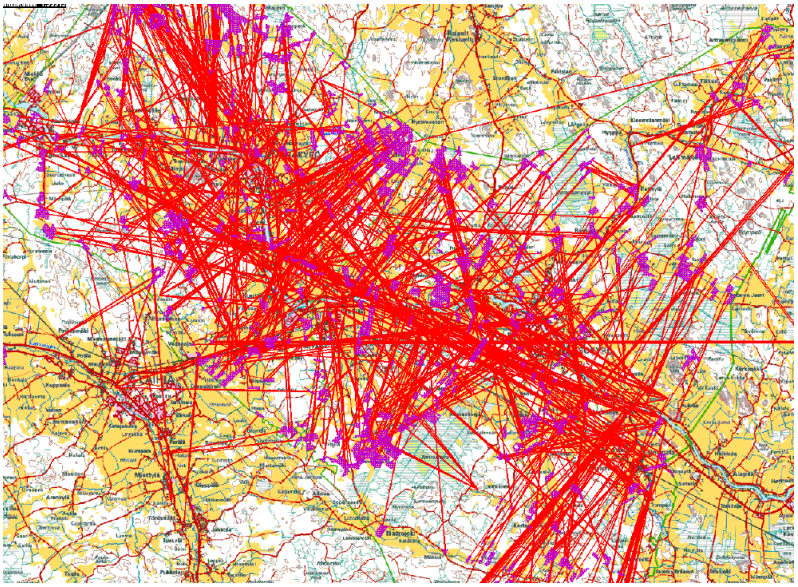

***Figure 3:*** *An example from Vähäkyrö in Finland. The red lines represent the distance between farm compound and cultivated land parcel. This picture represents a quite typical situation: the village is full of farmers that have numerous small land parcels around the village. © National Land Survey of Finland*

## 2.4 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.

## 2.5 Proceedings and executive organization

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, valuates 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.)

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 (MAF) 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.)

## 2.6 Land consolidation project in Järilä

### 2.6.1 Location of the project area

The field area of Järilä is situated on the border of Kokemäki and Harjavalta in south-west Finland (see Figure 4). 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. The topography in Järilä is flat and quite similar to other parts of Finland (especially west coast) where land consolidations are mostly done. There are mainly vegetable and grain farms in Järilä. Only few percent of farms are cattle farms. (Kattainen 2012, p. 56; Konttinen 2004.)

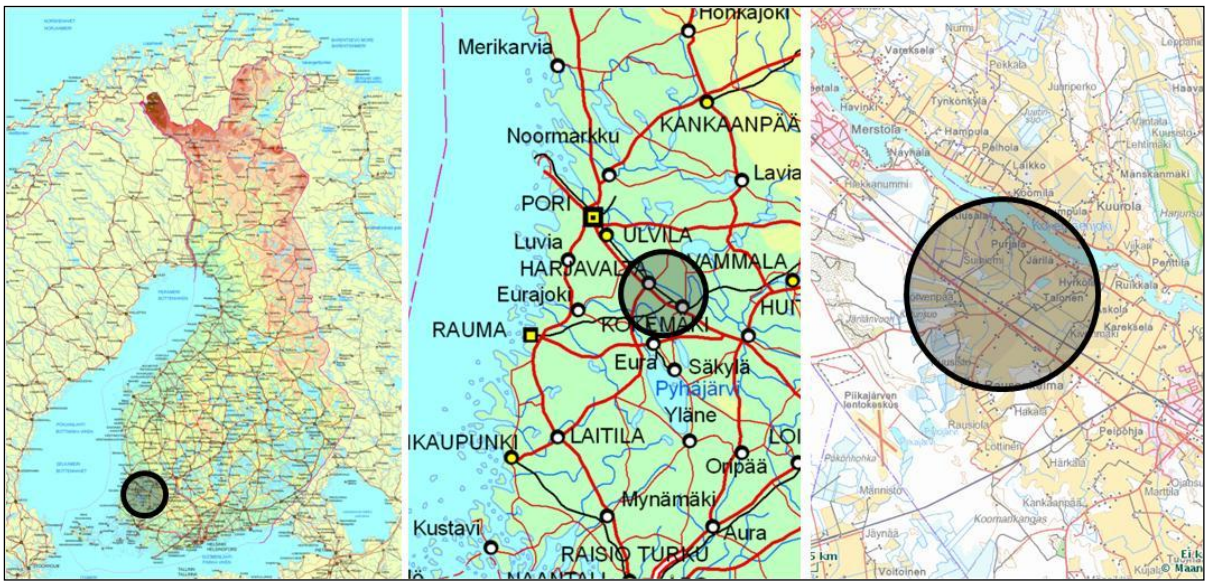


***Figure 4:*** *The project area locates in Kokemäki and Harjavalta cities in south-west Finland.*

2.6.2 Main phases of the project

In November 2003 seven farmers made a request to the District Survey Office that possibility of land consolidation should be evaluated in Järilä. In the beginning of 2004 surveyor's report revealed the potential of land consolidation. In August 2004 farmers decided to apply for the project. In December 2004 the MAF 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 re-allocation plan was presented to the farmers, and a year later, the third re-allocation 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.)

2.6.3 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. 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). (Hiironen et al. 2010a; Hiironen 2012, p. 138; Hiironen & Niukkanen 2012.)

## 3. EVALUATION OF THE REDUCTION OF NUTRIENT LOADS

The study estimates the monetary value of the reduced emissions to water system due to the changes in phosphorus and nitrogen loads (Objective A). To estimate the monetary value of the environmental effect to water system, 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 water system 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 (phosphorus P and nitrogen N) and the levels of the good (changes of P and N). 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 VIHMA and the data collected from LCP it can be calculated that nutrient loads to water system before LCP are 0,98 Pkg/ha/year and 20,00 Nkg/ha/year. If grass field had been re-arranged to risk areas phosphorus loads had been reduced 2,4 % and nitrogen loads increased 0,1 %. (Nitrogen loads are not reducing because it isn't dependable on the slope of the field (Kattainen 2012, p. 58; Koskiaho et al. 2002).) This means that in this LCP phosphorus loads would have decreased 22,55 kgP/year and nitrogen loads increased 19,18 kgN/year.*
>
> *The second step: The average cost of reducing phosphorus loads from Finnish agriculture is 18 €/kgN and 348 €/kgP (Honkatukia & Perrels 2005, p. 16). (notice: costs are index-corrected by cost-of-living index ( STAT 2012)) In this study these costs are considered to be the marginal cost of P and N loads. The substitute costs are not selected to equal the cheapest cost because a variety of actions, which have different price tags, are done in Finnish agriculture in order to minimize nutrient loads. Water protection requires different kind of activities depending on the local situation – the most cost-effective way is not always possible or enough to reduce nutrient loads.*
>
> *The third step: By using the information about the level of reduction of P and N (22,55 kgP/year and 19,18 kgN/year) and the marginal cost of P and N loads (348 €/kgP and 18 €/kgN), it can be calculated that the monetary value of water protection activities in Järilä LCP is 7 502 €/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 effect is 115 327 €.*

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. To define the agricultural effect 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 (see NLS 2011a; NLS 2011b). Among other things these calculation provide information about cultivation cost and travelling cost in a function of parcel size and distance to compound. The most recent information about cultivation cost in a function of parcel size and travelling cost in a function of distance to compound are presented by Hiironen (2012).

The data included information of 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 Hiironen 2012 (p. 99-124) the total reduction of production costs can be defined.

In this study the reduction was calculated in two different ways. First the reduction was calculated by using real information from LCP without the assumptions (chapter 1.3: ..by assuming that the grass fields had been re-arranged to the risk areas) made in this study (*value 1*). Then the reduction was calculated by assuming that cattle farms production costs would not have been decreased because their fields would not have been re-arranged in order to minimize production costs but rather to minimize nutrient loads (*value 2*). The difference between these two values, which were also capitalized like other effects to 30 years with 5 percent interest rate, was considered to be cost of the water protection activity (*cost = value 1 – value 2*). Value 1 is 1 053 000 euro (see Hiironen & Niukkanen 2012, p 7) and value 2 is 1 031 940 euro. This means that the cost of water protection activity with the presented method is 21 060 euro.

## 4. RESULTS AND DISCUSSION

The monetary value of the changes in nutrient loads in the assumed situation is 94 000 euro in total. This can be seen as a significant benefit since the total cost of the project are 546 000 euro. However, as the topography of the landscape differs significantly between different project areas, similar results might not occur in all LCPs. Also other measures like construction of wetlands and buffer zones might be more efficient. Therefore additional studies are needed especially for areas where the re-arrangement of grass fields is not an efficient solution when the target is to reduce nutrient loads.

The assumption of the marginal cost is something to debate on, especially whether to use the lowest or the average substitute cost. Also the assumptions behind calculations that production costs remain the same for cattle farms might also be misleading because for cattle farms it is especially important that parcels locate near farm compounds. Therefore the cost of water protection activities might be underestimated and thereby the benefits overestimated in this study. It might also be very difficult to convince the farmers to participate in a project that might have harmful effect on their profitability. Most probably compensations, land or money, would have to be paid for the process to go smoothly.

Based on the results of this study it can be stated that water protection activities should be taken into consideration when the objectives of land consolidation are defined and the re-allocation plan drawn.

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## BIOGRAPHICAL NOTES

Mr. Juhana Hiironen, Doctor of Science (Land management) 2012, Department of Real Estate, Planning and Geoinformatics at Aalto University School of Engineering. Since 2008 Chief Expert in National Land Survey of Finland, Development Centre. Dr. Hiironen has made his Doctoral Dissertation on "On the Impacts and Profitability of Farmland Consolidation".

Ms. Kirsikka Niukkanen, Master of Science (Engineering) 2009, Helsinki University of Technology. Since 2010 Doctoral Student, Department of Real Estate, Planning and Geoinformatics at Aalto University School of Engineering. Ms. Niukkanen is preparing her Doctoral Dissertation on "Property Rights in Finland".

## CONTACTS

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

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