WATER MANAGEMENT AND WATER PROTECTION IN AGRICULTURE

How to promote efficient methods with local co-operation

Kati Berninger
Tyrsky Consulting Ltd.

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)

Table of contents

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)

1. Introduction

Water management in agriculture has recently become an increasingly important topic since it has potential both for improving field condition and controlling nutrient runoff, and it is an essential question in the adaptation of our food system to the climate change. In Finland many local projects like MAISA, ympäristökompassi or OPET, have targeted practical mater management issues in agriculture. In Sweden Jordbruksverket has recently published guidebooks on the issue. Internationally, the question has been discussed in the Greener Agriculture for a Bluer Baltic Sea conference in August 2013 and the Nordic Association of Agricultural Scientists (NJF) seminar in September 2013, and it is on the agenda of HELCOM Agriculture-Environment Forum.

This is a report of two events that were organized in Finland on drainage and water management in agriculture in June 2014. The first was a seminar with presentations on research results of the PVO2 project, the second phase of the "Field drainage methods and optimizing water management of agricultural fields". This seminar was a relevant introduction to the workshop on how to promote efficient methods of water management and water protection through local co-operation. Many of the participants of the workshop also participated in the preceding seminar.

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)

2. The need for field drainage and its effects on water quality – seminar summary

The seminar was held on June 2nd, 2014 on the farm Gårdskulla Gård in Siuntio. The Finnish Drainage Foundation and the Field Drainage Association organized the happening.

The material of this seminar (in Finnish) is found on the website of the Finnish Drainage Foundation: http://www.tukisaatio.fi/ajankohtaista/2014/06/03/peltokuivatuksen-tarve-ja-vesistovaikutukset/

Figure 2.1. There were over 42 participants representing research organizations and foundations, state administration, media as well as practical actors in agriculture and water protection issues.

Programme:

9.00 Coffee

9.30 The first session

Opening words, Gustav Rehnberg Finnish Drainage Foundation

Agriculture and pollution load on water bodies, Ilkka Herlin, BSAG

The need for drainage, Laura Alakukku University of Helsinki

Nutrient washout from field areas, Maija Paasonen-Kivekäs Sven Hallin Research Foundation

Effects of agricultural water protection measures, Sirkka Tattari Finnish Environment Institute

9.30 Poster session

9.30 The second session

The effect of drainage techniques on the yield, soil structure and nutrient loading to water bodies, PVO research project, Helena Äijö Field Drainage Association

Mathematical models in field water management, the FLUSH model as an example, Lassi Warsta Aalto University

Controlled drainage as a tool to reduce the water quality effects of acidic sulfate soils Jaana Uusi-Kämppä Agrifood Research Finland

Wikiscien database on field experiments related to controlled drainage, and the map atlas of the Baltic Sea Region, Tapio Salo Agrifood Research Finland

Discussion and summary

12.50 Lunch and coffee

13.50 Field visit to see the measurement systems of the PVO project in Gårdskulla Gård

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)

2.1 The first session: drainage, nutrient loading and water protection measures

President of the Council of the Finnish Drainage Foundation Gustav Rehnberg from the Gårdskulla Gård opened the seminar. He told that the Finnish Drainage Foundation supports several research projects related to water management on the fields. These projects help to build up a solid knowledge base to support agricultural policy. In the Gårdskulla Gård there have been two measuring points of the PVO project for seven years. At first, the farm was of conventional agriculture, but it was converted to organic farming three years earlier. Thus the project has been able to measure nutrients both from surface runoff and field drains coming first from conventional, and then from organic agriculture.

Ilkka Herlin from the Baltic Sea Action Group (BSAG) gave an overview of nutrient recycling that can be seen the solution for many problems of the Baltic Sea. Some of the key questions are: the availability of phosphorus, eutrophication, energy intensive production of chemical nitrogen, reduction of the carbon content in agricultural soils, and biodiversity. We need to look at the food system as a whole including the origin of the fodder protein, which is now mostly imported. The question of nutrient recycling touches the whole food chain including industry, retailers, consumers and wastewater treatment plants. About the half of our field area is cultivated for fodder. The large part of the solution is in an efficient use of manure. Also changes in the wastewater treatment processes are needed. At the moment the nitrogen is released to the air, and phosphorus is made poorly available to the plants. We need science, politics and agricultural work to achieve better nutrient recycling.

Laura Alakukku from the University of Helsinki gave a summary of the need of field drainage and how it is related to the growth of field crops. The hydrological year on the field can be divided into two parts: the growing season when the main focus is on the good growth of the crops, and the months outside the growing season when the main focus is on controlling the environmental load. Drainage is beneficial in clay soils improving soil structure and increasing earthworm activity, for example, but in organic soils drainage increases the decomposition rate, and growth conditions may even deteriorate. Excess water on the field during the growing season is detrimental to plant growth and nutrient intake. Reduced tillage requires well-drained fields. Else there may be problems in growth and yield formation resulting in elevated nutrient balances. Drainage has an important role in the prevention of soil compaction. Compaction of the deep layers of soil is a cumulative long-term process and the effect may be seen even for 30 years. At the moment, the critical time in water management is in the spring: the fields have to be dry enough for the machinery to go to there. In the future the availability of water per biomass produced will decline. Thus it is important to improve the efficiency of water use. Water also needs to be returned to the fields when it's needed. In order to achieve this, more systemic solutions and broad co-operation is needed. Research should produce solutions and tools like hydrological models that used together with wireless measurement systems may be used to get accurate information on when it is possible to go to the field.

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)

Maija Paasonen-Kivekäs from the Sven Hallin Research Foundation gave a presentation on nutrient leaching from drained field areas with clay soils. In Finland, 58% of the field area is drained with field drains and 27% with open drains. Drainage is especially needed on clay soils, acidic sulphate soils and peatlands. Via macropores like root and earthworm burrows in the clay soil water may move directly to field drains, which means large nutrient concentrations in drainage runoff for example after fertilization. On Gårdskulla Gård, measurements have been carried out on two field plots. Most of the runoff measured was from field drains, and considerable nutrient concentrations were measured from water coming from field drains. The effect of building additional drains on the runoff and on nutrient loading has been studied on Nummela experimental field in Jokioinen. It was detected that building of new field drains or additional drains increased N load. The effect lasts for a few years. Drainage has both positive and negative effects on nutrient loading. It is important to reduce both surface runoff and the nutrient leaching from drainage systems. Priority should be given to the methods focusing on reducing the nutrient leaching from the fields; methods outside field area are secondary methods. During discussion it was mentioned that on well-managed field nutrient loading primarily comes from field drains.

Sirkka Tattari from the Finnish Environment Institute presented research results on the efficiency of agricultural water protection measures. In the Baltic Sea region there are only a few measuring stations on catchment areas where majority of the land is covered by fields, and only Finland and Denmark cover catchment areas with 100 % of field area. In most of the cases there are several land uses, and it is difficult to separate the effect of agriculture from the other uses. The efficiency of different methods varies depending on local conditions and the way they are applied. It is thus difficult to point out a single best method. Modeling is needed since it is not possible to measure everywhere. Models may also help to understand what we don't know yet, and they can be used to produce scenarios. In Finland, Vihma model is used for estimating nutrient leaching from agricultural areas. The soil P content is part of the initial data, but N fertilization is not part of the model. Using the model it is possible to compare different measures. The most efficient measures are those carried out on agricultural fields since they have a potential for large areas. A scenario exercise with areas from Denmark, Sweden and Finland showed that different measure combinations may be the most efficient to reduce nutrient loading in different areas. In Aurajoki basin the most efficient measures were a combination of reduced soil P content, reduced tillage, buffer zones and wetlands. With an extensive use of these measures it would be possible to reduce P loading by 29 % and N loading by 16 %. The documentation of water protection measures in agriculture should be improved to facilitate research on their efficiency. It may be concluded that a reduction in nutrient loading can be reached by reducing nutrient concentrations.

2.2 The second session: research results on drainage and water quality

Helena Äijö from the Field Drainage Association presented results of the PVO research project on the effect of drainage techniques on the yield, soil structure and nutrient loading to water bodies. The distance between drainpipes had a large effect on the field water balance, but no considerable difference was detected in yields. Different materials were used to protect field drainpipes from blocking. The traditional material is gravel and different organic materials were also studied. Coconut fiber and filter cloth had decomposed and in clay soils the pipes were partially silted. The majority of nutrient loading came from field drains, and it is thus essential to control nutrient loading both form surface runoff and drainage runoff.

Lassi Warsta from Aalto University told about the FLUSH model, a three-dimensional field scale hydrological model. With the model it is possible to describe water flow and movements of different substances like sediment as well as reactions between substances. The development of this model will continue within the new TOSKA project.

Jaana Uusi-Kämppä from Agrifood Research Finland gave a summary of the use of controlled drainage to reduce the water quality effects of acidic sulphate soils. It is a special soil type on the west coast of Finland. Under surface soil there is a layer of sulphate soil, and under the ground water level an anaerobic sulphide layer with a pH about 7. Building of drainage system lowers the ground water level and the layer comes into contact with oxygen. Oxygenation lowers the pH to about 4. In Söderfjärden different methods were studied to keep the ground water level high enough also during summer droughts. Controlled drainage was not enough, but feeding in additional water into the system was needed to keep the groundwater level above the limit.

Tapio Salo from Agrifood Research Finland introduced the Wikiscien database (http://mapserver.mtt.fi/geoserver/www/bc.html), which contains basic information on research locations related to water management in agriculture including short descriptions of results obtained. He also introduced the Agro-technology Atlas with extensive information on different agricultural technologies (http://www.agro-technology-atlas.eu/). A third useful material is the map atlas of the Baltic Sea Region, which is available as a DVD.

During the discussion it was mentioned that there is high-level research in Finland, but we also need more information and the work must go on. It is surprising how large share of the nutrient load comes from field drains. It is important to find methods to reduce it. It is also important to think about water management both as a need to control excess water and the need to move water back to the fields during dry summer time. This larger topic is very fragmented also in administration. A combination of different methods is needed and it is important to reach large area coverage. Water management should be planned as large entities including buffer zones, water storage for irrigation, and slowing down the movement of water in wetlands or meandering channels. In the new Rural Development Programme there is funding available for pilot projects that are carried out co-operation between farmers, researchers and extension workers, for example.

2.3 Field visit: measurement systems in Gårdskulla Gård

In Gårdskulla Gård the PVO and PVO2 projects have had a research area consisting of two field plots of clay soil. On both areas there is a measuring station that includes a measurement well and a data logger. On one area rainwater has been collected in containers. The following parameters have been measured:

- Surface and field drain runoff (continuous every 15 minutes)
- Automatic sampling of water flow from the surface and field drains
- Precipitation (continuous every 15 minutes)
- Surface water level (manual)
- Snow depth and water content (manual)
- Frost depth

Figure 2.2. A measurement well in Gårdskulla Gård.

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)

3. Water management and water protection in agriculture – workshop results

The workshop took place on June 13th, 2014 in Hotel Haven in Helsinki. It was part of the activities of the Baltic Compact Project in Finland. Kati Berninger from Tyrsky Consulting Ltd. organized the workshop.

Material of the short presentations (in Finnish) made during the workshop is available on the Internet: www.balticcompass.org

Programme:

9.00-9.30 Coffee
9.30-9.45 Introduction
9.45-10.45 The agricultural water management methods in use and how to promote them
10.45-11.45 What kind of new methods are needed?
11.45-12.45 Lunch
12.45-13.45 How to catalyze local water management projects?
13.45-14.00 How to get forward?

Participants:

1. Eija Hagelberg, BSAG
2. Pirjo Peltonen-Sainio, Agrifood Research Finland
3. Maija Paasonen-Kivekäs, Sven Hallinin tutkimussäätiö
4. Laura Alakukku, University of Helsinki
5. Merja Myllys, Agrifood Research Finland
6. Sirkka Tattari, Finnish Environment Institute
7. Markku Puustinen, Finnish Environment Institute
8. Helena Äijö, Field Drainage Association
9. Airi Kulmala, The Central Union of Agricultural Producers and Forest Owners MTK
10. Lassi Warsta, Aalto University
11. Harri Koivusalo, Aalto University
12. Heidi Salo, Aalto University
13. Mika Turunen, Aalto University
14. Juha Järvelä, Aalto University
15. Sauli Jaakkola Pyhäjärvi Institute
16. Jaana Uusi-Kämppä, Agrifood Research Finland
17. Ulla Ovaska, Agrifood Research Finland
18. Anni Karhunen, The ELY Centre of Southwest Finland
19. Päivi Joki-Heiskala, Paimionjoki Association
20. Johanna Moisa, Agrifood Research Finland
21. Kaj Granholm, SLU
22. Tapio Salo, Agrifood Research Finland
23. Kati Berninger, Tyrsky Consulting Ltd.

3.1 Introduction

The workshop was organized around the question how farmers would more often use efficient water management measures and what is needed to catalyze local action. In the beginning the participants were challenged to consider whether the question is more about developing new methods or making a better use of existing methods (Figure 3.1). Most participants thought it is a combination of both. There was a trend that participants close to farmers and landowners considered a better use of existing methods a key question while research-oriented participants claimed a need for new measures.

Figure 3.1. Workshop participants were asked to place themselves on the continuum "We need new methods"(on the left) – "Current methods should be used better" (on the right).

As an introduction to the topic Kati Berninger presented an overview of water management as a series of three figures that illustrate the issues of diverse measures used on fields or outside fields (Figure 3.2), scale (Figure 3.3) as well as local and regional actors that may be involved in water management projects (Figure 3.4).

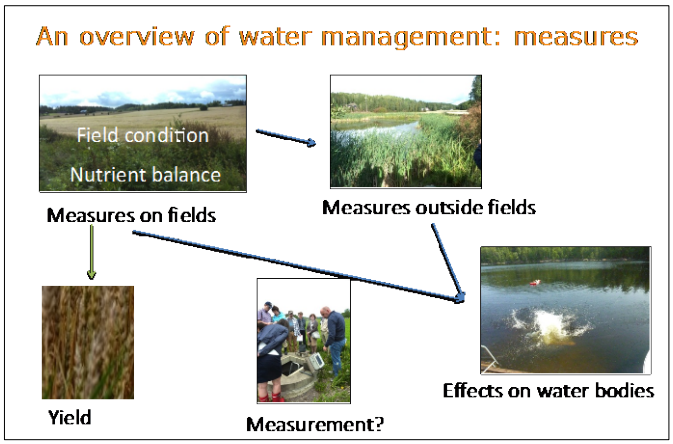

Figure 3.2. Water management measures include those used on fields and the ones used outside fields. The efficiency of both can be measures and they have effect on water bodies. The methods used on fields have an effect on field condition, nutrient balance and yields.

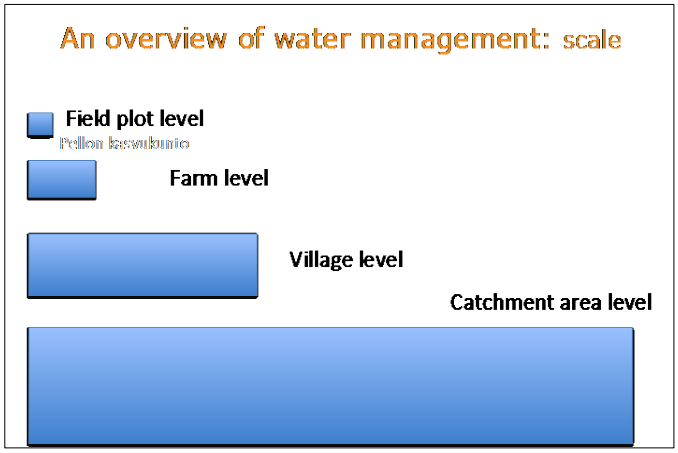

Figure 3.3. Water management methods and projects vary according to the scale in question.

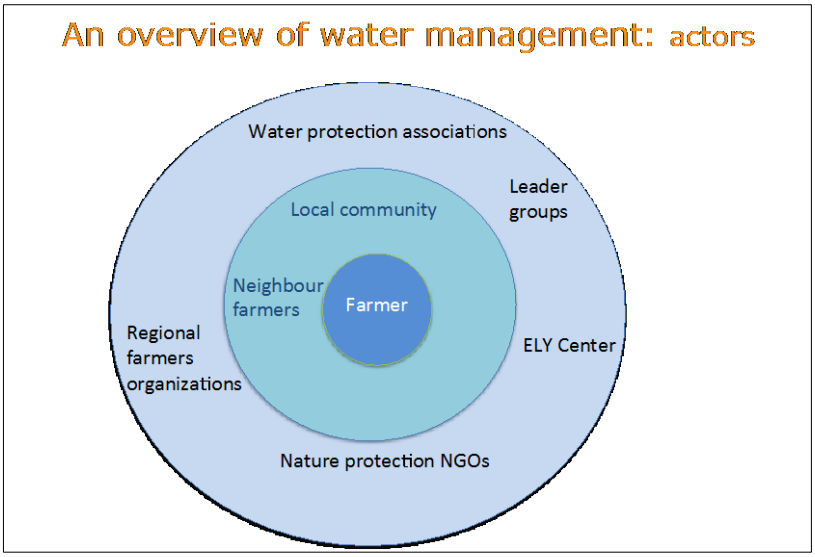

Figure 3.4. Local and regional actors that may be involved in water management projects.

3.2 The agricultural water management methods in use and how to promote them

Anni Karhunen from the ELY Centre of Southwest Finland introduced the subject with a presentation about the establishment of constructed wetlands. The most important success factors in a wetland project are the positive (or not negative) attitude of landowners and a person that coordinates the project during the whole process. The person(s) negotiating with local people should be the same throughout the project. The landowners should be given the possibility to have a say about the project. Good projects have failed because they have been presented to landowners at a too advanced stage. It is essential to clarify the responsibilities in maintenance and management of an established wetland.

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)

Negative brainstorming was used to discuss selected agricultural water management methods. Each of the four groups worked on one of the following methods: Constructed wetlands, controlled field drainage, natural runoff water treatment, and irrigation. At first the groups listed reasons why farmers don't adopt the methods (minuses in the list). Then methods were exchanged and the groups continued the work with developing ways how to overcome the challenges another group had listed (pluses in the list).

Group I Constructed wetlands

1. *Bureaucracy*

- From where to get specific information?
- Difficulty in starting a large project
- From where to get the money? Financing the planning phase.
- Fear of supervision, fear of authority
+ If public funding is used, a certain amount of supervision must be accepted. Many farmers have decided to construct a small wetland without support.

2. *Uncertain efficiency*

- Differs according to case
- Many factors affecting
+ There are cost-effective technical solutions available

3. *Challenges in co-operation (with neighbors)*

- Changes related to drainage
- Long term engagement needed
+ Define clear rules, make contracts

4. *Values*

- Is this the next place to be protected?
+ There are more valuable sites to be protected in agricultural environments like traditional biotopes

Group II Controlled field drainage (irrigation via field drainage)

- Not suitable for own fields (soil type, crops)
+ Clarifying suitability criteria
+ Use on the right field plots, use of GIS for site identification

- Economic benefit case-dependent
+ A good measure in a large palette used on the suitable field plots

- Laborious to manage
+ Informing farmers better on the benefits (for example not as dependent on weather conditions as regular field drainage) will motivate management
+ Automatic systems would reduce work load

Group III Natural water retention measures

- There are no practical lines of action for the use of natural water retention measures in design of main drainage channels

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)

- Farmers don't know about the possibility
- The new Water Act: restrictions and obligations
- Socioeconomic reasons
+ There are guide books in preparation about this issue
+ Providing more information for farmers on the method, legislation and funding possibilities and establishment of demonstration plots
+ A "channel caretaker" to provide services to a large amount of farmers. It may be beneficial to have an external coordinator.
+ Education of drainage planners and research on the issue

Group IV Irrigation
- The cost structure in agriculture, lack of incentives
- Requires new investments
- Need for growing intellectual capital
+ Recycling of drainage water (water storage) to be a part of agricultural water management

Figure 3.5. Groups worked on the question why farmers don't adopt a certain water management method.

3.3 What kind of new methods are needed?

Tapio Salo from Agrifood Research Finland gave an introduction to the topic. There are not so many new technologies available. It is many times a question of developing the existing ones for example by using integrated methods of controlling flow speed in large geographical areas or utilizing new measurement technology or automatic solutions. There are also interesting chemical treatment methods that could be used as "end-of-pipe solutions", but they are not cost effective at the moment.

Following solutions were suggested in the discussion:
- Combining different methods like planning and construction of wetlands at the same time with field drainage.
- Smart recycling of runoff water

- Infiltrating runoff water with buffer zones also in the middle of large fields.
- Use of catchment models to
    - Fit measures better into field conditions
    - Estimate water storage capacity or a flood control need for a certain catchment.
- User testing of methods, many times researchers suggest methods that are too complicated.
- Developing monitoring methods suitable for farmers.

3.4 How to catalyze local water management projects?

Päivi Joki-Heiskala from the Paimionjoki Association introduced the subject by telling about the practical work of their association. Paimionjoki Association was founded in 2010 by the initiative of Somero municipality. Now members include 7 municipalities, local associations of the farmers union, nature protection associations, fishing districts, and companies that regulate the water level for hydropower. It is especially important that the farmers associations have been involved in the work right from the beginning. The Paimionjoki Association is trying to make methods to work in practice. They have organized a series of wetland excursions and picnics, hired an extension worker who goes to the farms and carried out biodiversity and wetland general planning. It is important that the work plan is written together to enhance the ownership of the plan. A key question is how to motivate people so that they want to establish measures on their own land.

During the discussion it was concluded that in order to promote agricultural water management measures, it is essential to take the time for the different actors like researchers and farmers to learn to understand each other's language. Farmers should be involved right from the beginning of the project. A local or regional neutral contact person is needed. It helps the process if the goal of the project/intervention can be crystallized and communicated to the involved actors so that it appears meaningful for their personal situation and the intervention can be justified with scientific evidence.

It would be interesting to study why some methods are in use (e.g. wetlands), but others are not used (e.g. gypsum) or not even studied (e.g. structural liming) much in Finland.

Two concrete project ideas were presented:

- Markku Puustinen from the Finnish Environment Institute is preparing a research and development project on natural water retention measures. It should be a broad co-operation project with different actors involved.
- There could be a research project on the functionality of water protection measures combining field-testing with decision analysis on all actors involved. With the decision analysis different alternatives and conflicts of interest may be identified.

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)