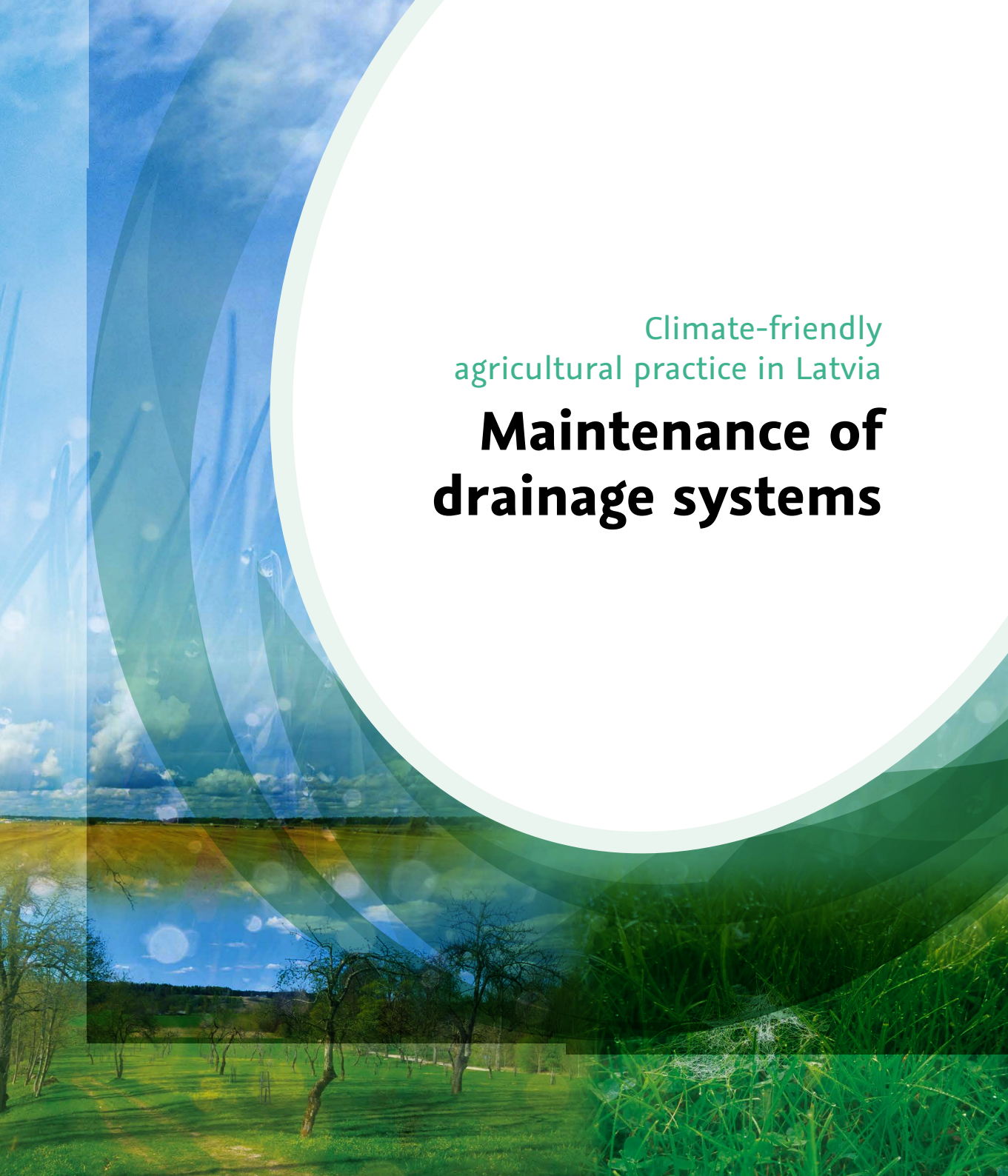

Climate-friendly agricultural practice in Latvia

Maintenance of drainage systems

Aim for the maintenance of drainage systems

The measure includes the restoration of existing drainage systems or the installation of new systems in wet arable land. The drainage system allows to drain the excess water from the root zone of the crop, thus oxygen is provided for the roots, as well formation of an optimal moisture regime is enhanced. This contributes to higher yields (for example, the results of studies in clay soils show that after the installation of drainage systems, wheat yields increased by 1 t ha-1), as well as prolongs the working season by up to 3 weeks. Improved soil structure provides better fertilizer uptake and lower N runoff, thus affecting N2O emissions.

Essence of the measure

The maintenance of drainage systems has a complex effect on the soil and its fertility. Both too wet and too dry soils are unsuitable for growing crops. Until now, drainage of wetlands has become increasingly topical in Latvia; however due to the climate changes, double-sided moisture regulation and a complex approach to land issues become a necessity. One of the main tasks of hydro-technical drainage system is to regulate the groundwater regime. In Latvia, which is located in the humid soils zone, it mainly means draining of the excess water. The performance indicator of drainage systems is the depth of groundwater. Prolonged high groundwater level has a negative effect on soil aeration, it damages plant roots and soil structure. During tillage, the depth of groundwater should normally be ~ 50-60 cm. Drainage water is the filtrate that has passed through the filter of the drained soil layer. Soil-bound substances remain in the soil filter (soil), but the excess substances dissolved in water are washed away. In the section of the filtration road to the drain or groundwater, Maintenance of drainage systems 3 Climate-friendly agricultural practice in Latvia, nitrogen compounds can bind to

the soil or increase their concentration in the runoff, therefore in Latvia conditions the content of plant nutrients in the soil in autumn after plant vegetation is important. A. Lagzdins and other scientists of Latvia University of Life Sciences and Technologies have found that the largest runoffs occur from December to March (April). Drainage systems lower the groundwater level in a relatively short time (especially in spring, after snow melting, in autumn after heavy and prolonged rainfall), thus prolonging the filtration path of biogenic elements in the soil. Fertilizer does not enter the groundwater directly. In this way, there is a greater chance that the fertilizer will remain in the topsoil, where it is more accessible to plants. The better the condition of the drainage (drainage) system, the sooner the groundwater level is lowered, the deeper it is, in spring agricultural machinery can move through the fields earlier, if necessary fertilizer can be applied earlier and there is less risk of leaching from the soil. Fertilizer does not enter the groundwater directly. In this way, there is a better chance that the fertilizer will remain in the topsoil, where it is more accessible to plants. The better the condition of the drainage (drainage) system, the sooner the groundwater level is lowered and is the deeper, thus in spring agricultural machinery can move through the fields earlier, and if necessary, fertilizer can be applied earlier and there is less risk of its leaching from the soil. In summer (during the growing season), drainage is either small or it does not exist at all, thus leaching of plant nutrients is insignificant. In non-drained soils, in case of heavy and prolonged rainfall, there is a higher risk that surface run-off may occur and thus nutrients may also be removed from the soil by surface run-off (with soil particles). In such cases, plant nutrient losses will certainly be more serious. Some studies show that it is especially dangerous to apply liquid manure (including fertilizer in general) in early spring during periods of intensive drainage runoff and periods with high groundwater level, which are typical for non-drained or poorly drained areas. When liquid manure is applied to water-saturated soil (lack of soil filter layer), the nitrogen concentration in the runoff increases up to 10 times (Sudars, 1998).

Protection zone along the ditch.
Source: archive of the farm "Vilciņi-1"

In order to reduce this harmful effect in Latvian farms, it is necessary to maintain a protection zone along drainage ditches or natural water flows, as well as it is recommended to build sedimentation areas or wetlands to capture nutrients. Such structures reduce the inflow of nutrients into reservoirs, control soil erosion as well as enrich the water with oxygen and promote water self-purification.

Wetland before reconstruction.
Source: archive of the farm "Vilciņi-1"

Wetland before reconstruction.
Source: archive of the farm "Vilciņi-1"

Positive experiences on farms

- Mitigation of unfavourable weather conditions on agricultural lands.

- Longer working period in the field.
- More efficient use of nutrients - higher yield, better yield quality.

Hindering factors for the implementation of the measure on a larger scale

→ Inappropriate measure for biodiversity conservation in wetlands.

Aspects	Limitations	Solutions
Technological	• Limited availability of special equipment services. • The business does not create a need for the service. • There is a lack of experience and so far there has been no interest in the construction of land drainage for double-sided water regulation. • Lack of control (aeronautical control) for the construction of drainage systems.	Services for the use of modern equipment at an affordable price.
Environmental	• Nature reserves and related restrictions on UAA management. • Adjusting the number of beavers, as beavers damage drainage systems. • Insufficient understanding and knowledge of N2O and NH3 emissions in wetlands. • Dual effect on organic soils.	• Establish a national framework for communal systems. • Environmental elements in the drainage system (on a larger scale).
Economic	• Expensive measure. • Inadequate implementation costs. • Restrictions specified in regulatory documents to lease new equipment purchased with the support of the European Union.	• Long-term economic benefits. • Promoting the use of local resources (liming material). • Support is needed for system installation and maintenance, as well as training. • Maintenance measure in case of special terrain.
Social aspects (knowledge, experience, cooperation)	• Farmers' knowledge about the maintenance of drainage systems is limited. • Lack of specialists. • High fragmentation, non-coordinated actions, such as disagreements and uncoordinated actions between landowners.	• Promotion of positive examples. • Easement drainage. • To promote the use of drainage system care equipment for the provision of services, more intensive support for purchasing equipment, if it is planned to provide services.

Example:

According to the monitoring data of agricultural drainage in 2009, the nitrogen output was 17.17 kg N ha-1 (the specific year was chosen because the nitrogen output corresponds to the average values during the whole observation period). At the average annual rate of nitrogen application 84 kg N ha-1, the leaching factor is 0.2 (20%).

Assuming that the soil is not drained, *a longer period of very high groundwater level is possible in the spring. During this period, fertilizer is applied, in a situation where, for example, manure storage facilities are over-packed. Theoretically, by increasing the leached nitrogen concentration by 5 times in one month (for example, in March) (from ~ 6 to 30 mg L-1), the annual nitrogen output would reach 34.35 kg N ha-1. The leaching ratio would increase from 0.2 to 0.4 (40%).*

Maintenance or installation of drainage systems

Taking into account the climatic conditions of Latvia, the measure is important for all farms where the areas used for agriculture suffer from too much moisture. Particular attention should be paid to the existence or operation of drainage systems on those farms, in which the number of livestock units requires the construction of manure storage facilities and manure storage in winter period. There is often a significant amount of manure that needs to be removed to the field as early as possible in the spring, while in the autumn the storage facilities must be emptied to ensure the manure storage during the winter period. In turn, the functioning of drainage systems in crop farms is directly related to the condition of sowings and crop yield. Every farm needs to get the drainage system map and monitor its condition. The positive aspect is that Latvia has accumulated a huge experience in the designing, construction or

reconstruction of drainage systems. Moreover, owing to the development of technologies, it is possible to use the services available both in the world and in Latvia. For example, the Canadian company Trimble is one of the leading developers and service providers of GIS-related technologies and equipment for various industries, including agriculture, engineering and building construction infrastructure. Land drainage software Trimble®WM-Drain ™ is designed to enable farms to detect the need for drainage and find the best solutions for its design, installation and mapping, both above and on the ground.

The map of the drainage system.
Source: archive of the farm "Vilciņi-1"

Drainage planning and implementation includes the following activities:

- survey creation. It is a collection of 3D field data;
- 3D field data analysis for decision making;
- development and testing of a 3D drainage system planning or even development of the drainage system on-the-go in real time from the operator's working equipment without leaving it;
- installation. Transfer of the previously developed drainage plan to the field, precise burial of drainage pipes in the ground and excavation of surface ditches;
- mapping. The map shows the exact location of the drainage pipes or ditches, which will be useful for further maintenance of the system and expansion of the drainage.

The map of the drainage on the farm Vilciņi-1.
Source: archive of the farm "Vilciņi-1"

Cleaning of drainage ditch and outflows.
Source: archive of the farm "Vilciņi-1"

The maintenance of drainage systems on farms in Latvia is defined as a mandatory cross-compliance measure, therefore system repairs are often necessary.

Drainage system repair
Source: archive of the farm "Vilciņi-1"

Drainage system rinsing
Source: archive of the farm "Vilciņi-1"

Drainage system repair
Source: archive of the farm "Vilciņi-1"

Sludge discharge from the drainage system
Source: archive of the farm "Vilciņi-1"

Risks of drainage

The main limitation for the maintenance of drainage systems, but especially for their installation, is the relatively large financial investments required. However, the consequences of inappropriate interventions in nature are often observed in Latvia. The main task of amelioration (drainage) is to drain "excess" water as soon as possible, therefore in many places rivers are straightened, where their water flows much faster into the river or sea. Natural rivers with bends, deepening and wetlands serve as a sponge, naturally maintaining moisture in the environment even in drier periods, but reduce the power and impact of water during floods. However, each situation is different and requires a specific solution, which also points to the need to carry out an environmental

assessment conscientiously when constructing each facility. The experience of the Netherlands is interesting, where already in 2001 the national government and non-governmental organizations agreed on a paradigm shift in the approach to water management. Instead of increasing drainage capacity, the emphasis has been changed to controlled drainage in three stages: (1) water retention in the soil during increased precipitation; (2) storage of excess water in the field or in a drainage system; (3) controlled water consumption. The overall objectives are to reduce maximum emissions during periods of rainfall, which benefits water system operators, and to store water during periods of drought (benefit to the farmer).

Costs for the implementation of the measure

It is practically impossible to estimate approximate costs of implementing a measure in an uncertain situation. The costs depend on the current condition of the existing drainage system or the need to build new system, the drainage method, specific environmental conditions, builder's offers, as well as the amount of work to be done, which may differ significantly in different objects. Maintenance of drainage systems 9 Climate-friendly agricultural practices in Latvia.

Possible activities:

- overgrowth removal (in areas, ditches, gutters);
- earthworks (restoration or re-excavation of ditches);
- levelling of excavated soil;
- cleaning, repair or reconstruction of gutters;
- installation or reconstruction of drainage systems;
- restoration of existing drainage

system outflows, drainage wells;
→ installation of gutter fasteners etc.

For example: bush harvesting ~ 500 EUR ha-1; Construction of a 1 m drain could cost ~ 10 EUR, but excavation of 1 m3 of land ~ 3 EUR. In any case, the costs can only be determined after the project has been developed and estimated.

According to approximate calculations, the reconstruction and renovation of the drainage system requires about 5000 EUR ha-1, or the annual operation and maintenance costs of 50 EUR ha-1. The benefits consist of an increase in yield, which can be as much as 40% for wheat, 35% for maize and 26% for hay, but the financial gain depends on the price of the produced product.

It should be taken into account:

→ these and other data mentioned in the literature refer to the period when the first soil drainage was performed. Of course, in many places it is necessary to renovate drainage systems, where drainage systems operate with less intensity and thus are incomplete. In such areas, lower productivity gains are to be expected;
→ The financial benefit of drainage measures should be assessed together with amelioration measures would not be correct, it is a complex indicator.

When investing in the maintenance of drainage systems, but especially in the development of new systems, it would be necessary to develop a complex approach to the regulation of moisture in soils, including taking into account natural conditions - such as terrain and soil characteristics. The initial theoretical

rationale for soil moisture management needs to be complemented by latest findings and innovative solutions that can reduce the risks of floods and droughts, have a lower impact on the environment, including pollution. The precision and control of the use of fertilizers and plant protection products, as well as meaningful cultivation of crops, preventing nutrients from leaching from the soil or the degradation of organic matter as a result of intensive management, are important in the future when setting up expensive double-sided moisture control systems.

Impact of draining on the reduction of GHG emissions

The existence and maintenance of drainage systems is related to the formation of indirect N2O emissions as a result of nitrogen leaching (the amount of nitrogen leakage from intensively used agricultural areas directly determines the amount of emissions). Improved soil structure provides better fertilizer uptake and lower N leaching, thus reducing N2O emissions. Calculations for Latvian conditions, based on the data on Drainage systems maintenance 11 Climate-friendly agricultural practices in Latvia on agricultural runoff monitoring collected by the Department of Environment and Water Management of the Latvia University of Life Sciences and Technologies since 1994 show that on average in Latvia climate conditions the nitrogen leaching factor decreases by 7%.

IN ADDITION TO GHG EMISSIONS, THE MEASURE MUST ALSO BE CONSIDERED IN COMBINATION WITH OTHER AGRICULTURAL MEASURES

- The deadlines for starting field work in the spring and their impact on yields are changing.
- Stable and guaranteed yields are ensured.
- Reclamation measures (drainage)

affect the air, nutrients and microbiological regime in the soil: - by increased soil porosity and water penetration, water and air regime is improving, as well as soil structure is improving;

- anaerobic processes in soil are replaced by aerobic ones (reducing the risk of release of gases specific to anaerobic processes, such as methane, which is also a greenhouse effect gas);

- organic substances mineralize faster and become usable for plants.

→ In soils with controlled moisture regime, crops are developing with stronger and deeper root system; they can better use plant nutrient elements that are embedded into the soil with fertilizers, thus leaching of unused nitrogen by plants is reduced.

→ As soil structure improves, soil adsorption increases, which also reduces the leaching of unused nitrogen from plants.

Considerable experience

In the USA, controlled drainage is used primarily to reduce nitrogen (N) losses (especially in the form of nitrate nitrogen [NO3-N]). With the introduction of a controlled drainage system, it was found that N losses through the drainage system decreased by 73% in summer and by 32% in winter, and total P losses by 77% in summer and by 30% in winter. The experience of several countries shows that the main elements of the new approach are: 1) moisture storage; (2) groundwater level control; (3) controlled water outflow; (4) better use of water and nutrients; (5) lower maximum outflow and (6) reduced nutrient loss. In general, such a system reduces the risks of both floods and droughts. In sandy areas, controlled drainage can increase groundwater level and thus reduce drought stress, although this effect depends to a large extent on the specific conditions.

Many studies show that the amount of nitrogen in controlled wastewater has decreased, thus having a positive effect on the quality of drainage wastewater. A system that combines regulated drainage with weather forecasting is a promising approach for both water managers and farmers. However, controlled drainage solutions are very site-specific and customized solutions are a prerequisite for success.

Latvia University
of Life Sciences
and Technologies

Ministry of Agriculture
Republic of Latvia

Material is prepared by Latvia University of Life Sciences and Technologies in cooperation with the Ministry of Agriculture of the Republic of Latvia

Autori:

Dr. sc. ing. **Ritvars Sudārs**
Dr. oec. **Dina Popluga**
Dr. agr. **Dzidra Kreišmane**

2020