APPROACH ON HOW TO CALCULATE N(S)WRM COSTS IN A RIVER BASIN

Final Version

11 2020

CONTENT

LIST OF ABBREVIATIONS

AC	Economic cost by manpower
AMIF	Asylum and Migration Fund
BMP	Best management practises
BMVI	Border Management and Visa Instrument
BOQ	Bill of Quantities
CA	Cost analysis
CAP	Common agriculture policy
CE	Central Europe
CF	Cohesion Fund
CFE	Combined food and energy system
CT	Conventional Tillage
CTF	Controlled traffic farming
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EEC	European Economic Community
EIB	European Investment Bank
EMFF	European Maritime and Fisheries Fund
ERDF	European Regional Development Fund
ESF+	European Social Fund Plus
ETC	European Territorial Cooperation
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FIDIC	International Federation of Consulting Engineers
FTE	Full-time equivalent
GI	Green Infrastructure
GIS	Geographic Information System
ISF	Internal Security Fund
MC	Economic cost by mechanization
MS	Member State
NPV	Net Present Value
NRCS	Natural Resources Conservation Service
NT	No Tillage
NWRM	Natural (small) water retention measures
O&M	Operation and maintenance
OP	Operational Programme

OPEX	Sustainable Agriculture Research and Education (SARE
OTSG	Original terrain slope gradient
RBMP	River Basin Management Plan
RT	Reduced Tillage
RTG	Reduced Tillage plus Green Manure
SEC	labour and socioeconomic cost
SRC	Short rotation coppice
SRWC	Short rotation woody crops
TSP	Technical service providers
TTV	Terrace trend width
USDA	US Department of Agriculture
WF	Wheat-fallow
WFD	Water Framework Directive
WSB	Wheat-sorghum-soybean
WSF	Wheat-sorghum-fallow

1. SUMMARY

The Approach on how to calculate NWRM costs on a river basin scale is designed to provide the user with information on N(S)WRM costs and impacts of the overall investment.

The document describes the methodology of how to calculate the costs of selected measures. The selected measures are grouped into structural (engineered structures, mainly hydro-technical) and non-structural (measure using knowledge, practice or agreement) N(S)WRM. The document reflects on how prices differ across the Central European Region.

For the structural measures' typical investment project phases and activities are described. The cost analysis for structural measures includes different cost evaluation approaches, i.e. detailed and simplified approach. Detailed approach for assessment of construction costs of engineered NWRM is based on the detailed design where construction costs are broken-down in Bill of Quantities (BOQ). Meanwhile simplified approach comprises of two cost assessments; cost by comparison (similar project estimation price per unit, e.g. €/ha) and cost by typical group of works (works that have greatest impact on the construction costs).

For the structural measures total investment costs are divided into groups of project documentation costs and implementation cost (labour, machinery, material...). The Approach also presents experiences from Slovenia for implementation process and project documentation of different N(S)WRMs.

The Approach allows the choice of the most suitable financing resources and instruments for NSWRM, and preparation of a financial plan for the implementation of the measures.

2. INTRODUCTION

Natural (small) water retention measures (NWRM) are dispersed within the river basin, thus their cost assessment is complex and goes beyond the administrative boundaries. The idea of cost analysis of NWRM is consistent with broader ambitions of accelerating NWRM implementation.

Within the project FramWat, an Approach on how to calculate NWRM costs on a river basin scale was developed by project partners from Central European countries: Slovenia, Croatia, Hungary, Poland, Slovakia, and Austria. This document summarizes experience gained from testing the developed Approach on three pilot river basins: Bednja (Croatia), Middle Tisa (Hungary) and Kamienna (Poland).

Evaluating NWRM costs on a catchment scale requires a robust approach, which acknowledges uncertainty. Financial analysis of benefits derived from NWRM implementation and operation in a basin was not a focus of this document.

Cost analysis (CA) is an analytical tool used to appraise an investment decision. It is a systematic approach aiming to estimate the costs of different options and can be used to prioritize measures over a longer time period. It has two main applications:

- To determine the investment costs;
- To provide a basis for comparing investments.

The CA can be carried out by practitioners (engineers or consultants experienced in NWRM design) in partnership with policy officials, planners, water managers, or other stakeholders and groups of interest.

3. INVESTMENT PROCESS

What is an investment process?

Investment process consists of all activities throughout the life of the project, from the idea to the successful, normal operation of the investment.

The life cycle of investment projects has four phases:

- Planning;
- Implementation
- Operation;
- End of the lifespan of investment.

The following figure illustrates the investment project life cycle.

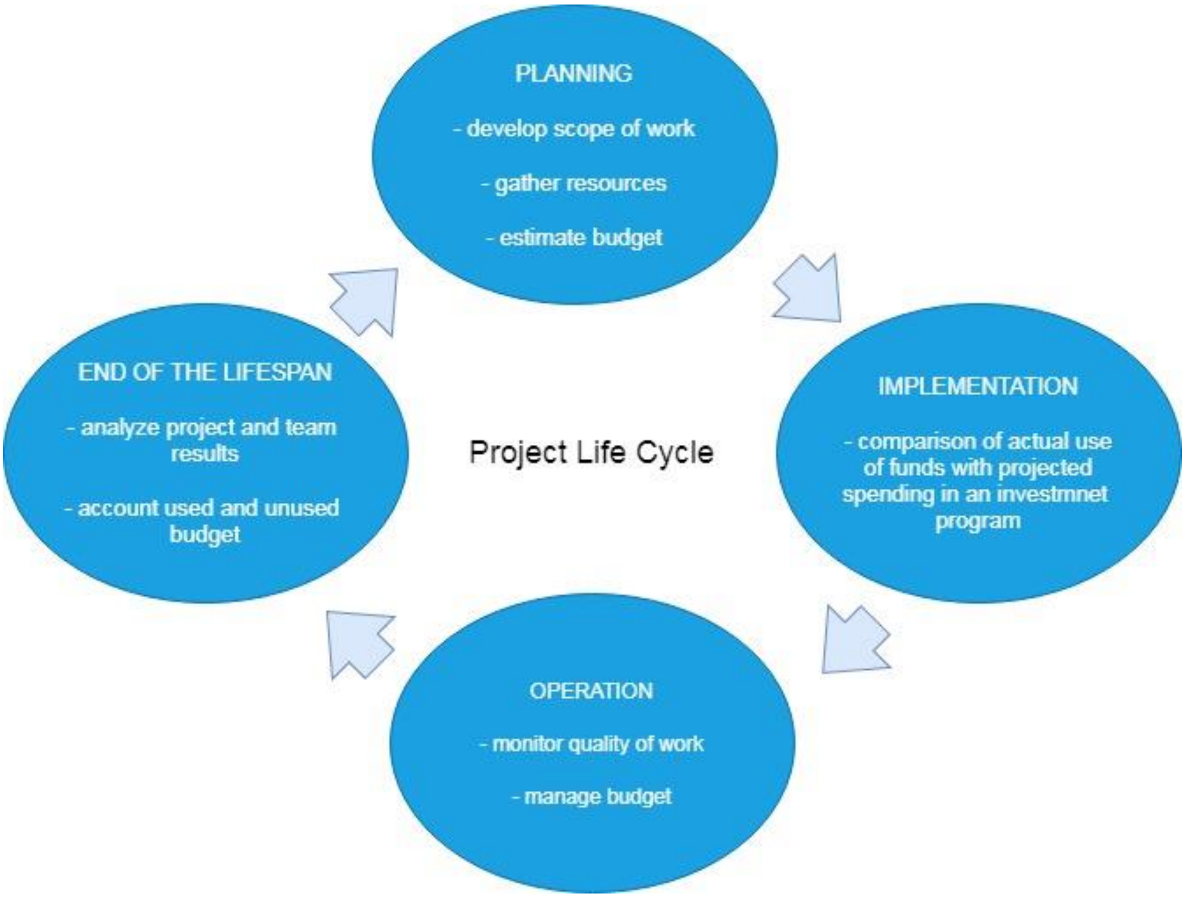

Figure 1: Investment project life cycle.

Financial resources are allocated in the budget to fund both the planning and the implementation phase, as well as project operation and maintenance once the project has been implemented.

The project financial structure depends on the scope of the investment activities. Budgeting is a dynamic process that generally involves financial planning, project identification and prioritization, program and project management, monitoring, and evaluation.

3.1. The EU's main investment policy

Regional Policy is the EU's main investment framework for Members states and its regions. Common Strategic Framework, the central tool to reach the objectives of the Europe 2020 Strategy, is about to end in 2020. For the next long-term EU budget 2021-2027, the European Commission proposed to modernise Cohesion Policy with a new set of rules. The proposal for a Common Provisions Regulation (CPR) sets out common provisions for seven shared management funds[1]:

1. the European Regional Development Fund (ERDF),
2. the Cohesion Fund (CF),
3. the European Social Fund Plus (ESF+),
4. the European Maritime and Fisheries Fund (EMFF),
5. *the Asylum and Migration Fund (AMIF),*
6. *the Internal Security Fund (ISF) and*
7. *the Border Management and Visa Instrument (BMVI).*

Regional Policy is delivered through two main funds: the European Regional Development Fund (ERDF) and the Cohesion Fund (CF).[2] While ERDF focuses on investments linked to improving companies' competitiveness and providing services to citizens[3], the Cohesion Fund supports interventions within the area of transport and environment. **In the latter, the Cohesion Fund specifically supports investment for climate change adaptation and risk prevention, investment in water and waste management sectors, and the urban environment.**[4] Combining grants and financial instruments is made easier and the new framework also includes special provisions to attract more private capital.[5]

Small Water Retention Measures (SWRM) fall under a policy objective 2 - a greener, low carbon Europe by promoting clean and fair energy transition, green and blue investment, the circular economy, climate adaptation and risk prevention and management as they support climate and environmental objectives trough following intervention:

- (040) Water management and water resource conservation (including river basin management, specific climate change adaptation measures, reuse, leakage reduction)

Specific ERDF and CF fund objectives within a policy objective 2, which enable SWRM implementation:

- (2.4) Promoting climate change adaptation, risk prevention and disaster resilience
- (2.6) Promoting green infrastructure in the urban environment and reducing pollution

Budget formulation for the policy and its use align with common rules for the European Structural and Investment Fund (ESIF) and rules specific for each Fund. Budgeting frameworks is decided by the European Council and the European Parliament based on a proposal from the Commission.[6]

[1] https://www.eerstekamer.nl/eu/documenteu/pe_625152_europees_parlement/f=/vkrgbrx7a2uo.pdf

[2] https://ec.europa.eu/regional_policy/en/policy/what/investment-policy/

[3] Regulation (EU) No 1301/2013 of the European Parliament and of the Council of 17 December 2013 on the ERDF and on specific provisions concerning the investment for growth and jobs goals and repealing Regulation (EC) No 1080/2006

[4] https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

[5] https://ec.europa.eu/regional_policy/en/2021_2027/

[6] https://ec.europa.eu/regional_policy/en/policy/how/stages-step-by-step/

3.1.1. Operational Programmes for the Implementation of the EU Cohesion Policy

National authority (e.g., Ministry) is responsible for water protection, use, management, and sanitation tasks. It is in charge of the planning process relevant for the achievement of WFD goals (Directive 2000/60/EC) and other complementary Directives (the Groundwater Directive 2006/118/EC, the EU Floods Directive 2007/60/EC, the Bathing Directive 2006/7/EC, 76/160/EEC, the Nitrates Directive 91/676/EEC etc). National authorities' water protection actions are complementary with Nature directives (the Birds Directive 2009/147/EC and Habitat directives 92/43/EEC) and focus on achieving international biodiversity targets and sustainable development goals. The policy is implemented by national and regional bodies in partnership with the European Commission.[7]

The programming period is established for a period of 7 years and is relevant for all EU policies, including cohesion policy framework. The coming funding/programming period covers the years 2021-2027.

At Member State (MS) level, increased efforts are required to develop and implement NSWRM in national strategies and frameworks to mitigate floods, draughts and pollution by increasing the buffer capacity of the landscape, as the FramWat project proposes. A set of measures to receive support from the European Investment and Structural Funds (ESI Funds) is drafted in the process of the preparation of Operational Programme (OP). The measures are designed with consideration of the European and National Strategy targets and agreements.

Operational programmes are detailed plans in which the Member States decide how the money from the European Structural and Investment Funds (ESIF) will be spent during the programme period. They can be drawn up for a specific region or a country-wide thematic goal (e.g. Environment). For the European Territorial Cooperation goal, cross-border or interregional operational programmes are drawn up.

Member States submit their operational programmes based on their Partnership Agreements. Each operational programme specifies which of the thematic objectives that guide cohesion policy in the programme period is addressed through the funding available under the operational programmes.[8]

EU and national steps in the process of programming and implementation of investment policy based on the European Structural and Investment Funds Regulations 2014-2020 are distinguished in the table below.

Table 1: Overview of the planning and implementation of investment policy[9]

Phase	EU level	National level (Member states)
Planning phase	- The budget for the policy and the rules for its use are jointly decided by the European Council and the European Parliament - Process of consultation between the Commission and the EU countries - Negotiations between Commission and national authorities on the final content of the Partnership Agreement, as well as each programme.	- Each Member State produces a draft Partnership Agreement, which outlines the country's strategy and proposes a list of programmes. - Member States present draft operational programmes (OP) which cover entire Member States and or regions and cooperation programmes involving more than one country.
Implementation	- The Commission commits the funds.	- The programmes are implemented

[7] https://ec.europa.eu/regional_policy/en/policy/how/stages-step-by-step/
[8] https://ec.europa.eu/regional_policy/en/policy/what/glossary/o/operational-programme
[9] https://ec.europa.eu/regional_policy/en/policy/how/stages-step-by-step/

Phase	EU level	National level (Member states)
phase	- The Commission pays the certified expenditure to each country. - The Commission monitors each programme, alongside the country concerned. - Reporting to EC	by the Member States and their regions. - Selecting, monitoring and evaluating of projects. - Work is organised by 'managing authorities' in each country and/or region. - Reporting to EC – Operational level

3.1.2. SWRM in Operational programmes 2014-2020 in CE Region

Operational Programmes 2014-2020 taking SWRM into account were envisaged, in order to determine the level of SWRM integration into EU funding streams. The programmes are prepared by each Member State (MS) and/or region and financed under the European Regional Development Fund or the Cohesion Fund.[10]

In the European level report Evaluation of the contribution of Operational Programmes to the implementation of EU water policy the content of OPs was studied[11]:

- **to identify whether any relevant measures and/or contributions to the common indicator 'population benefiting from flood prevention measures' have been planned in the OPs;**

  Green infrastructure, NWRM or eco-based solutions are clearly mentioned as flood prevention measures. These measures include e.g. green roofs, green walls or sustainable urban drainage systems, as well as the afforestation or restoration of natural flood plains and watercourses in the planned investments for flood prevention. [12]

- **to identify whether any 'good practice' or innovative measures, other than traditional grey infrastructure measures, will be considered and supported in the current programming period**.

  In most of the analysed OPs the good practices and innovative measures that have been identified are related to the use of green infrastructure, ecosystem-based measures, and to NWRMs. Identified measures in some MS include afforestation and other natural measures that enhance the soil retention capacity, the inclusion of flood risks in spatial plans, studies to improve forecasts of climate change impacts and risks of natural disasters. Similarly, the good practices and innovative solutions identified in the European Territorial Cooperation (ETC) Programmes relate to green infrastructure, NWRMs, and the restoration and conservation of wetlands/ floodplains primarily.

  In some cases the innovative solutions planned concern synergies between flood prevention, nature protection, and coastal and marine area protection measures such as preparation of common action plans to protect marine fauna and flora around ports; pilot actions for green infrastructure, blue and green corridors; green technologies to reduce and prevent pollution from transport and port activities; and new methods to recycle marine litter.[13]

[10] https://ec.europa.eu/regional_policy/en/atlas/programmes?countryCode=SE&regionId=304
[11] https://ec.europa.eu/environment/water/pdf/EU_overview_report_%20operational_programmes%20.pdf
[12] https://ec.europa.eu/environment/water/pdf/EU_overview_report_%20operational_programmes%20.pdf
[13] https://ec.europa.eu/environment/water/pdf/EU_overview_report_%20operational_programmes%20.pdf

3.1.3. How to better include SWRM into programming process and implementation?

NWRM are part of Green Infrastructure (GI).[14] However, the common understanding and terminology used in the OP creates confusion what is the connection between NWRM and GI.

Recommendation 1: The strong supportive relationship of GI and NWRM is currently missing in reviewed documents. Findings related to the NWRM are, in principle, the same as findings related to GI information availability presented in the document Supporting the Implementation of Green Infrastructure. The overview performed within FramWat project, showed relatively week NWRM representation in Operational programmes in all six partner countries of the CE.

Recommendation 2: The NWRM mostly appear as measures to improve climate change adaptation and measures to protect the environment and biodiversity status, but in broad and general context. They are often referred to as non-structural flood protection measures or eco-system measures. The labelling of measures should be more uniform to give the measures greater visibility and a link to GI. Much progress can be made by implementing the NWRM concept with the link to the thematic objectives of OP.

Recommendation 3: An ex-post assessment[15] of the operational programmes has suggested that in spite of some progress, more needs to be done to promote strategic and integrated programmes; and that planning of larger-scale GI and NWRM could provide benefits for water quality, protect against floods and fulfill biodiversity objectives.[16] FramWat deliverables are in line with the planning opportunities and planning processes. Since the process of implementing NWRM is dependent on several factors, a better understanding of costs will improve NWRM positioning in OP and will create more opportunities for funding.

The EU green infrastructure strategy promotes the incorporation of green infrastructure into related plans and programmes.[17] Guidance on NWRM was developed[18] and their implementation via EU structural and agricultural funds encouraged in the elaboration of Member States operational and agricultural programmes[19].[20] It is important to connect FramWat results, especially cost analysis with efficiency factors, but these should not be the only criteria for implementation as some NWRM are needed as pro-environmental practices. National support of NWRM implementation also depends on national or regional needs and specific national circumstances.

Involved stakeholders (Observers) in the FramWat project that are responsible authorities and/or stakeholders in the planning process are empowered to recognise the value of the projects' results and have the capacity to:

a) involve SWRM into the supported actions/measures in the next funding period (2021-2027),
b) identify and cooperate with responsible authorities and/or stakeholders in other related sectors (ex. agriculture, forestry etc).
c) cost analysis provided by FramWat is recommended to be applied as a one of the crucial steps within NWRM planning on the river basin scale (RBMP).

[14] https://ec.europa.eu/environment/nature/ecosystems/docs/green_infrastructures/GI%20Final%20Report.pdf

[15] https://ec.europa.eu/environment/water/pdf/EU_overview_report_%20operational_programmes%20.pdf

[16] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019DC0236&qid=1562053537296&from=EN

[17] https://ec.europa.eu/environment/eir/pdf/eir_2019_policy_background.pdf

[18] European Commission (2014). EU Water Policy Document on Natural Water Retention Measures. WFD CIS Working Group Programme of Measures. https://circabc.europa.eu/sd/a/2457165b-3f12-4935-819ac40324d22ad3/Policy%20Document%20on%20Natural%20Water%20Retention%20Measures_Final.pdf

[19] https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/rural-development

[20] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019DC0236&qid=1562053537296&from=EN

3.2. Investment project size

Within this project, we have identified four categories of investment project size in terms of required investment resources: micro, small, big and major. The main differences are highlighted in Table 2.

Table 2: Investment project size in terms of required investment resources

Project size	Description	Financial threshold (EUR)
Micro	- Private investor or legal entity - Private financing - Measures located on privately owned land - Micro-scale projects in terms of size of measure and finances compared to other project size categories	0, 5 M
*Small	- Local (municipal) problem - Investor is a local authority - Public financing through a tender/call - Scope of the project is limited by the administrative (municipal) boundaries - Small-scale projects in terms of size of measure(s) and project scope and finances compared to big or major projects	>2,5 M
*Big	- Regional problem - Investor is a local authority and/or state authority - Public financing through a tender/call - Scope of the project not necessarily limited by the administrative boundaries (intermunicipal)	< 50 M
Major	- Project of national importance - According to Article 100 (Major projects) of Regulation (EU) No 1303/2013, a major project is an investment operation comprising 'a series of works, activities or services intended to accomplish an indivisible task of a precise economic and technical nature which has clearly identified goals and for which the total eligible cost exceeds EUR 50 million.' The total eligible cost is the part of the investment cost that is eligible for EU co-financing.[21] In case of operations falling under Article 9(7) (Thematic objectives) of Regulation (EU) No 1303/2013, the financial threshold for the identification of a major project is set at EUR 75 million. - May be financially supported by the European Regional Development Fund (ERDF) and Cohesion funds (required preparation of corresponding	≥ 50 M

[21] See Preamble 92 to Regulation (EU) No 1303/2013.

Project size	Description	Financial threshold (EUR)
	national strategic documents for EU financing) - Ensuring resilience to the adverse impacts of climate change and reducing the emission of greenhouse gases	

Source: Consultant`s estimation.

4. STRUCTURAL MEASURES

Structural measures are any physical constructions aiming to reduce or avoid possible impacts of hazards, or the application of engineering techniques or technology to achieve hazard resistance and resilience in structures or systems.[22] NWRM structural measures are engineered structures, mainly hydro-technical.

Typical investment project phases include the activities listed in Table 3. The complexity of the investment process depends on the legislation and regulations, project scope and size, organizational structure and funding.

Table 3: Investment project

Planning phase	Implementation and operational phase
Preliminary: - market analysis - cost-effectiveness assessment - Investment project identification document **Preparatory (pre-investment works):** - studies, research, spatial and environmental issues - conceptual solutions - Pre-investment assessment **Designing:** - project documentation: detailed design (building permit) - investment documentation (investment program, a study of the intended investment) **Procurement and orders:** - tender documentation - public procurement procedure - FIDIC[23] international standard for use on national and international construction projects (red, yellow, silver, green book) - Contracting (examination of tenders)	**Establishment of legal, financial and organizational basis for implementation of the project** **Land acquisition** **Construction:** - preliminary works - construction works - installation works - finishing work **Supervision:** - construction supervision (professional, cost, and project schedule supervision elements). - engineering supervision - consultants supervision **Pre-commissioning** - correction of all deficiencies and malfunctions **Commissioning:** - preliminary performance tests **Process optimization during defects liability period** **Technical inspection** **Permits and certificates** **Operation and maintenance manual**

[22] https://www.preventionweb.net/terminology/view/505

[23] FIDIC, the International Federation of Consulting Engineers, is the global representative body for national associations of consulting engineers

Planning phase	Implementation and operational phase
	Training and knowhow transfer Report on the implementation of the investment project Investment monitoring report

4.1. Investment documentation

Formulation of investment documentation is required for all investment projects and other measures financed under the regulations governing public finances. Investment documentation can be adapted to requirements and methodology of public tenders/calls or other financial sources (credits, loans), when applying with investment for the acquisition of complementary funding sources.[24] **Depending on the estimated value of the investment and the investment phase of the project various kinds of investment documentation is required in the process.** Evidence-based and successful policy requires making investment decisions based on objective and verifiable methods.[25] This is why investment documentation related to major projects is mandatory and each country sets the national regulations for investment documentation.

Economic evaluation is of key importance for an investment. All the required elements and calculations enabling a comprehensive evaluation of financial, marketing, economic and other consequences of an investment decision are included in a well-prepared investment documentation. Investment documentation in the field of public finances requires preparation of:

- Investment project identification document
- Pre-investment study;
- Investment program;
- A study of the planned investment;
- Report on the investment implementation;
- Investment monitoring report on the results and effects of the investment.

4.2. Investment costs

Investment costs of structural measures present initial investment[26]. Total investment costs can be divided into the following groups:

- Land acquisition;
- Costs of project documentation;
- Costs of construction;
- Costs of staff training;
- Costs of dissemination.

[24] http://www.jhp.si/en/area-of-work/152/preparation-of-investment-documentation/

[25] https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

[26] Including fixed and non-fixed assets.

The category costs (excl. land acquisition cost) are estimated using a percentage of the initial investment as presented in Table 4. The estimated proportion is only indicative, because every NWRM is site specific and custom designed.

Table 4: Category costs in % of initial investment

Category	% of initial investment
Project documentation	5 - 20 %
Construction	55 - 95 %
Staff training	0 - 5 %
Dissemination and communication	5 - 20 %

Source: Consultant`s estimation.

The following Figure illustrates, in detail, investment costs of implementing a construction project. The illustrated process is characteristic for a major investment.

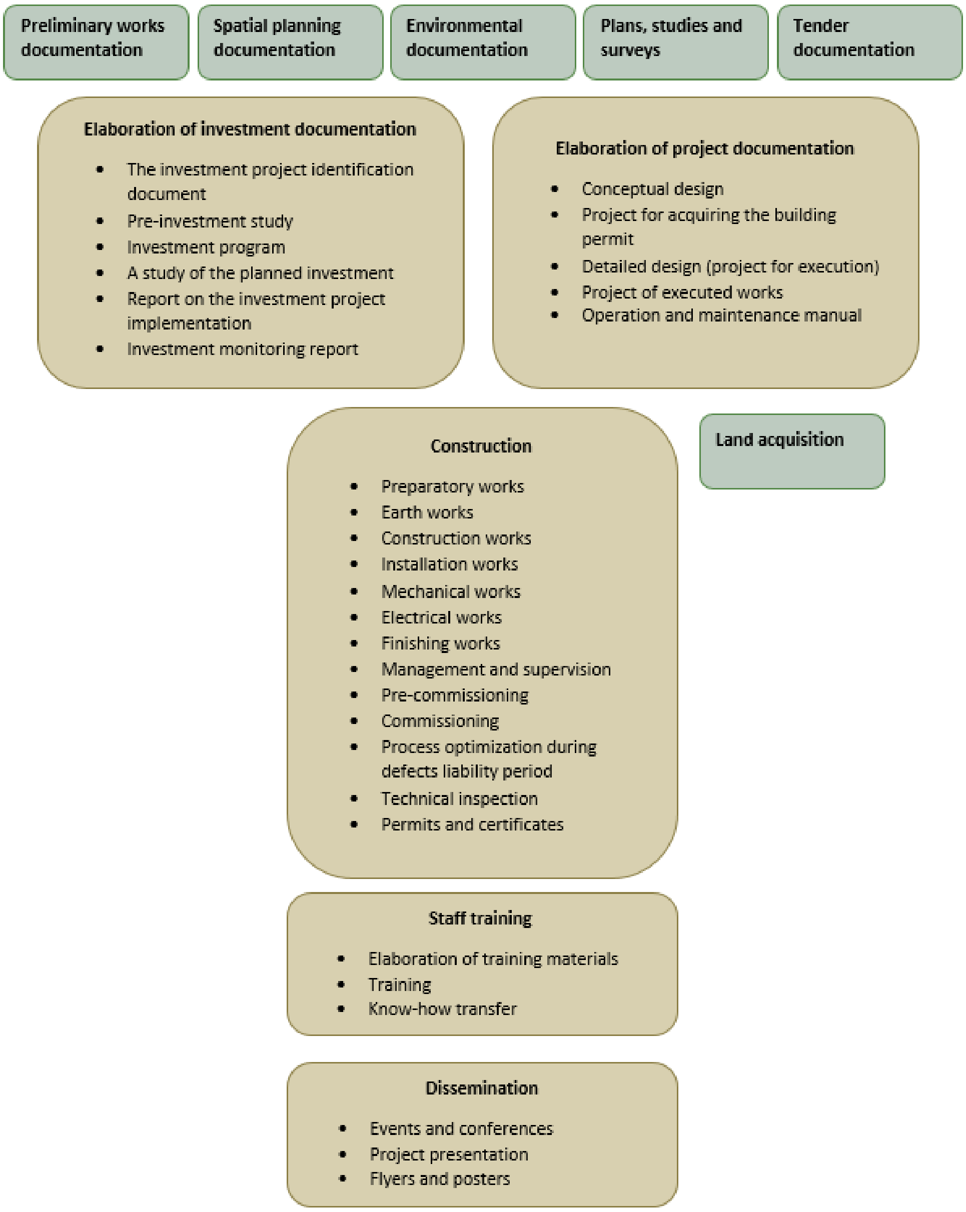

Figure 2: The steps of implementation of major NWRM projects

4.2.1. Land acquisition

NWRM structural measures are rather high land-demanding measures. One of the primary costs is therefore the cost of land acquisition or the opportunity cost of not using that land for development. Land acquisition cost depends on the land value at the site under consideration and cannot be generically quantified.[27] The cost of land may vary greatly depending on its current use, its productivity, potential alternative uses and its availability, thus generalization for CE Region is not applicable within the scope of this project. However, land costs are highly relevant to the entire investment and should be included in cost analysis.

Land cost is a typical administrative risk (land costing higher than predicted) and can cause procedural delays. Availability of land is a key aspect when selecting the location for NWRM. Land acquisition is usually part of the pre-construction phase (pre-tender phase). When it comes to large NWRM projects, the approvals of the municipal (detailed) spatial plan take up most of the time and this has to be done before submission of the final design for building permit. In order to avoid land costs and long procedures, NWRM can be placed on municipal land. Otherwise, municipality has the pre-emptive right. Only up to 10 % of land acquisition costs are eligible costs for EU cohesion funding scheme, which must be taken into account when preparing the project proposal. In principle, land requirements should be included in the planning process and calculated on a project-by-project basis. Beside land acquisition costs, not using that land for development can also create **opportunity costs and compensation costs**. For example, there may be opportunity costs associated with the overland flow area on productive forest land. Using an area for overland flows instead of forest production may negatively impact tree growth and the income which could potentially be obtained from forest harvesting[28].

Average land acquisition costs of agricultural land are presented in Table 5.

Table 5: Average agricultural land prices CE Region in 2018 price[29]

CE country	Austria	Croatia	Hungary	Poland	Slovakia	Slovenia
Land acquisition cost (€/ha)	25.000[30]	3.285	4.632	10.318	3.432	18.460

4.2.2. Design documentation

In the planning of NWRM, it is important to recognize the close relationship between design and construction. These processes can be viewed as an integrated system. Broadly speaking, design is a process of creating the description of a new facility, usually represented by detailed plans and specifications; construction planning is a process of identifying activities and resources required to make the design a physical reality. Hence, construction is the implementation of a design envisioned by architects and engineers. In both design and construction, numerous operational tasks must be performed with a variety of precedence and other relationships among the different tasks. [31]

Elaboration of design documentation (Table 6) is closely connected to the cost assessment of works. The first rough cost estimation is part of the conceptual design or feasibility study, while detail cost analysis is performed in detail design.

[27] http://nwrm.eu/sites/default/files/nwrm_ressources/n1_-_basins_and_ponds_0.pdf
[28] http://nwrm.eu/sites/default/files/nwrm_ressources/f14_-_overland_flow_areas_0.pdf
[29] https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=apri_lprc&lang=en
[30] https://www.immowelt.at/landwirtschaft-kaufen
[31] https://www.cmu.edu/cee/projects/PMbook/03_The_Design_And_Construction_Process.html

Table 6: Design documentation

Design documentation	Other closely connected group of documentation

• Conceptual design;
• Project for obtaining building permit;
• Detailed design (execution project);
• Design as built;
• Proof of facility assurance (Operational and maintenance manual)
	• Preliminary works
	  ○ Studies
	  ○ Research
	  ○ Concept solutions
	• Spatial planning documentation
	  ○ National spatial plan
	  ○ Regional spatial plan
	  ○ Municipal (local) spatial plan
	  ○ Detailed spatial plan
	• Environmental documentation
	  ○ Comprehensive assessment of environmental impact
	  ○ Environmental report
	  ○ Environmental impact report
	  ○ Environmental approval
	• Investment documentation
	• Tender documentation
	• Other studies, plans and surveys

Depending on the type of NWRM and its size, it needs to be assessed what level of project documentation needs to be prepared and which permits need to be acquired before construction. Less documentation usually means shorter administrative procedures and lower costs of project documentation.

The required project documentation level depends on the complexity of the construction works (intended use, size/surface/volume, etc.), which determines the activity's resource quantities needed (man hours, tools, materials, etc.).

Building regulations set minimum requirements for safe, healthy, energy-efficient, and accessible buildings. The general characteristics of the building control systems in European countries are similar. Designs must be prepared and submitted to an authority that approves compliance with zoning demands and building regulations. During construction, site inspections guarantee that the structure is built according to the design and that it complies with the building regulations. Once construction is complete, a final check is conducted, and a completion certificate or a use permit is issued.

Types of procedures[32]:

- **Exemptions:** construction works that have to meet the planning demands and the technical requirements but are exempt from the permit procedure.
- **Building notice:** building works that have to be reported to the construction authority but can be carried out without a building permit.
- **Light procedure:** construction works that require a building permit but compliance with building design with building regulations is only ensured for part of the technical requirements.

[32] https://www.irbnet.de/daten/iconda/CIB_DC24512.pdf

- **Regular procedure:** construction works that require a building permit and compliance with building design with building regulations is ensured for all the technical requirements.

In the majority of the EU countries, there has been an increase in the number of construction works exempted from controls and an increase in the number of construction works that shifted from a regular procedure to a light or building notice procedure.[33] That means shorter procedure times, simpler and faster procedures of obtaining a building permit. From the NWRM perspective, simpler procedures can foster NWRM implementation and lower the investment costs.

Below is presented an overview of building procedures in CE countries.

Table 7: Permit procedures

Procedure	Austria	Croatia	Hungary	Poland	Slovakia	Slovenia
Exemptions	✓	✓	✓	✓	✓	✓
Building notice	✓	✓		✓	✓	✓
Light procedure					✓	
Regular procedure	✓	✓	✓	✓	✓	✓

4.2.2.1. Permit procedure and project documentation (experience from Slovenia)

NWRM to improve hydro-morphology are mainly hydro-technical measures such as basins, ponds, polders, dams, etc. Type of permit procedure depends on the complexity of the works as presented in the Table 8.

Table 8: A type of permit procedure according to complexity of works in Slovenia

Complexity of works	Permit procedure
Simple works	Exemptions
Non demanding works	Building notice / Light procedure
Less demanding works	Regular procedure
Demanding works	Regular procedure

Engineered structures are classified according to their intended use in the Decree on the classification of structures (Official Gazette of the Republic of Slovenia, No. 37/18, Annex 1). Classification of water structures is presented in the Table 9.

Table 9: Objects classified according to their intended use in Slovenia[34]

Water structures	Work complexity
Dams, weirs, ramps,	Dams - less demanding works

[33] https://www.irbnet.de/daten/iconda/CIB_DC24512.pdf

[34] Decree on the classification of structures: http://www.pisrs.si/Pis.web/pregledPredpisa?id=URED7671

Water structures	Work complexity
barrages	Big dams[35] - demanding works in accordance with the Regulation on the monitoring of seismicity in the area of large dams
Dug-out reservoirs and similar water storage facilities	Retention volume: • up to 250 m^3 - simple works • up to 2.000 m^3 -non demanding works • bigger than 2.000 - less demanding works
Structures for protection of river and sea banks and riverbed regulation	Dimensions: • length < 5 m and height < 2 m - simple works • length < 20 m and height < 3 m - non demanding works • 3 m < height < 10 m - less demanding works • height above 10 m - demanding works
Embankments and similar structures for flood protection	Height: • up to 1 m - non demanding works • from 1 to 10 m - less demanding works • above 10 m - demanding works
Drainage ditches and other structures for soil (land) drainage (systems for irrigation and drainage)	Simple works: • height up to 10 m • depth up to 4 m • span of up to 5 m Non demanding works: • height up to 4 m • depth up to 1 m • span of up to 4 m Less demanding works: works that are not classified as simple, non-demanding or demanding. Demanding works: • is a facility with caisson foundation • is a facility with pile foundation, if the piles are longer than 15 m, • its subsurface parts are more than 15 m deep, • has three or more underground floors, • the height of the facility exceeds 25 m or has a pre-stressed structural element made on the construction site with a beam span exceeding 10 m.
Dikes, excavations, fortified embankments, constructed areas of urban	Simple works: • height up to 2,5 m

[35] Big dam is a dam of 15 m height or more and a dam between 5 m and 15 m in height with a reservoir whose volume exceeds 3 million m3.

Water structures	Work complexity
gardens	• depth up to 2 m • the ratio of its length to the height of the slope is not greater than 2: 1, if the height of the second construction intervention is more than 1 m; • the lowest point of its construction is no more than 2 m above the ground. Non demanding works: • height up to 10 m • depth up to 3 m • the ratio of its length to the height of the slope is not greater than 2: 1, if its height is more than 2 m, and • the lowest point of its construction is more than 2 m but less than 5 m above the ground. Less demanding works: works that are not classified as simple, non-demanding or demanding. Demanding works: • its area exceeds 10.000 m^2, • its volume exceeds 30.000 m^3, or • the lowest point of the structure of the building is more than 5 m above the ground.

Regular procedure requires elaborating a detailed final design in compliance with all the technical requirements and a building procedure, which is often the most expensive permit procedure.

The price for developing a project documentation and obtaining building permits mainly depends on the type of facility, location of the project, required expert-design man-hours, the total investment value of the project, and fees that may be required. The value of the fee to obtain a building permit is determined on the basis of the construction costs. Beyond the building permit fee, other fees may be required, e.g. fees for submitting an application, obtaining the use permits, etc.

4.2.2.2. Prices of design engineer's hours in CE Region

The price for elaborating project documentation and obtaining a building permit mainly depends on the required expert-design man-hours and total investment value of the project.

The cost of an engineer-hour in CE countries are presented in Table 10.

Table 10: Average hourly rate for an engineer in the CE countries

Country (CE)	Austria[36]	Croatia[37]	Hungary	Poland	Slovakia[38]	Slovenia[39]

[36] https://www.arching.at/mitglieder/sondervereinbarungen/basiswertindices.html and https://www.arching.at/fileadmin/user_upload/redakteure/Sondervereinbarungen/leistungsfaktoren_zur__zeitgrundgebuehr_gemaess__at__97.pdf

[37] Consultant`s estimation - prices from water authorities (Croatia).

Country (CE)	Austria[36]	Croatia[37]	Hungary	Poland	Slovakia[38]	Slovenia[39]
Engineer	82,98 EUR	15,00 EUR	40,82 EUR	8,00 EUR	8,7 EUR	47,00 EUR
Charted engineer	103,73 EUR	20,00 EUR	48,71 EUR	10,00 EUR	9,1 EUR	60,00 EUR
Project leader	124,47 EUR	30,00 EUR	99,80 EUR	12 EUR	12,1 EUR	72,00 EUR

4.3. Construction cost

Construction costs are incurred during the construction of the built asset, such as hydro-technical structures and other engineered structures.

There are several approaches on how to assess the construction costs of engineered NWRM. In principle, we distinguish them for a detailed and simplified approach. The advantages and disadvantages of these different cost approaches are summarized in the Table 11.

Table 11: Comparison of cost evaluation approaches

Cost method	Advantage	Disadvantage	Applicability
Simplified approach - cost by comparison	No cost assessment needed.	Can lead to major mistakes and poor judgement.	Not recommended
Simplified approach - cost by typical group of works	Only a rough estimation.	Needs basic design. Common use in feasibility studies. Possible mistakes.	Applicable for experts for screening or deciding which among several measures to proceed with.
Detailed approach	Most accurate method.	Needs a detailed design and time consuming.	Applicable for experts.

The most accurate cost assessment is based on detailed design. However, when talking about NWRM planning process on a river basin scale, it is questionable whether detailed approach is reasonable. The choice of approach depends on:

- Project type and purpose (what you need cost assessment for);
- Number and complexity of measures;
- River basin size;
- Available resources.

[38] https://www.platy.sk/platy/stavebnictvo-a-reality

[39] http://www.izs.si/fileadmin/dokumenti/Dobra_praksa/Priporocena_bruto_placa_in_priporocena_cena_ure-IZS-10-1-2018.pdf (2018)

4.3.1. Detailed approach

Detailed approach for assessment of construction costs of engineered NWRM is based on the detailed design where construction costs are broken-down in Bill of Quantities (BOQ). BOQ is a comprehensive list of materials, quantities / dimensions pertaining to a particular project. The document is mostly used for seeking estimated costs of the items for tendering or construction. Detailed BOQ (**Napaka! V ira sklicevanja ni bilo mogoče najti.**) is usually elaborated in the last phase of the design process (detailed design), prior construction. It is showing the total materials and costs for the project.

Table 12: Example of a template table for items in the bill of quantities

Item	Description	Unit / Dimensions	Quantity	Price per unit (EUR/unit)	Amount (EUR)

BOQ for the project constitute of various bills such as:

- Bill No. 1: Preliminaries
- Bill No. 2: Earthworks
- Bill No. 3: Mechanical works

  .
  .
  .
- Grand Summary

Taxes, customs and import duties must be quoted and entered separately in the BOQ.

Construction costs can also include:

- Internal construction supervision by the project engineer to meet essential requirements;
- Trial operation;
- Unforeseen costs; etc.

BOQ does not include independent professional construction supervision to supervise work done by the contractor. Construction supervision is required by the national laws and regulations and covered from a different budget setting. Investor usually issues a separate call for construction supervision.

4.3.2. Simplified approach - cost by comparison

In the last decade, a few projects attempted to estimate capital and operational costs of hydro-technical measures and express them in unit costs as in EUR/ha, EUR/km or EUR/m^3. This kind of generalization can be very misleading because it can cause major mistakes. This problem is illustrated in the following figure and shows how in most cases, costs don't have linear connection with the volume of retained water or area restored.

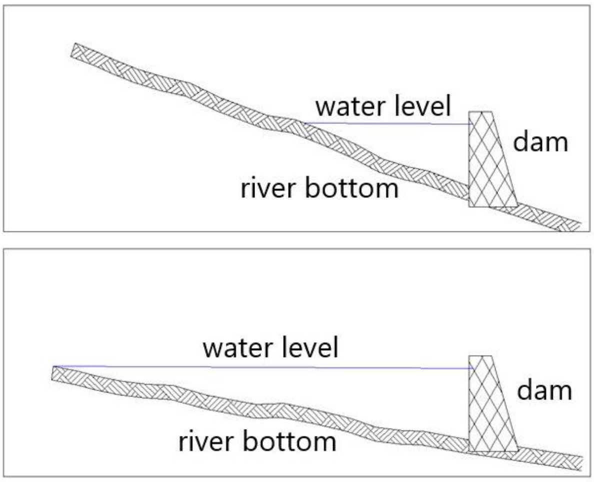

Figure 3: Diagram with dams of the same height but with different volume of water retention

The generalized prices listed below (Table 13) are only indicative and not intended for cost estimation. Once again, we have to emphasize that the cost assessment with the use of simplified approach - cost by comparison is not recommended.

Table 13: NWRM costs for hydro-morphology sector published in NWRM Catalogue[40]

Hydro-morphology	Capital Costs	Maintenance Costs
Basins and ponds	~44,000 € /ha	~60 €/ha/year
Floodplain restoration and management	**Dyke heightening** Standard 300-2,000 €/m Wall on top 800-2,500 €/m Sheet pile wall 3,500-5,000 €/m Quay wall (Antwerp) 16,100 €/m **Flood control area** Inner dike adaptation 770 €/m Outer dike construction 840 €/m Outlet sluices 19,000 €/ha Inlet sluices CRT 4,000 €/ha **Engineering cost** 10% investment cost	0.5-1.5% investment cost
Re-meandering	400 000 €/km	n/a
Reconnection of oxbow lakes and similar features	EUR 100,000 - 2,000,000	EUR 10,000 - 1,000,000
Removal of dams and other longitudinal barriers	EUR 50,000 - 1,000,000	1 - 5% investment cost
Lake restoration	4,000 €/ha	Minimal
Temporary sediment trap[41].	pcs	EUR 555
Peak flow control structures[42]	According to the EPA, typical costs for wet detention ponds range from 26.00 €-50.85 € per cubic meter of storage area. Dry detention basins	

[40] http://nwrm.eu/measures-catalogue

[41] https://stormwater.pca.state.mn.us/index.php?title=Sediment_control_practices_-_Sediment_traps_and_basins

[42] http://nrcsolutions.org/floodwater-detention/

Hydro-morphology	Capital Costs	Maintenance Costs
	typically cost around 14.5 € per square meter (0.43 € per cubic foot) for smaller basins and 7.2 € per square meter (0.22 € per cubic foot) for larger basins.[43]	

Cost assessment of hydro-technical measures is very case specific and thus costs cannot be transferred from one location to another. In general, costs are impacted by the:

- Type and complexity of the measure;
- Location of the measure;
- Size of the measure;
- River/catchment typology.

Measures can also be very complex and assembled from many measures or groups of works. The closest to obtaining a cost assessment without a detailed design, is an assessment of cost groups that have the most significant impact on the construction costs.

4.3.3. Simplified approach – cost by typical group of works

A simplified approach is an alternative to the detailed approach when an estimated investment cost without the detail design is needed. Such situations are common, and officials on such occasion trust expert judgement. Estimations are usually used for pre-tendering, screening possible solutions, and even on-site inventory of damages caused by natural disasters. When addressing structural NWRM on a river basin scale, the approach can be used for the financial planning of NWRM as part of the RBMP.

Basic or conceptual design is a basis for cost estimation in the simplified approach. Conceptual design is an early phase of the design process that formally establishes the initial idea and provides the investor with information such as: purpose of the design, location of the measure, dimensions, basic descriptions, technology, aesthetics, scope of work, maintainability; expected costs, drawings and sketches.

Simplified approach contains (Table 14):

- elaboration of basic design;
- assessment of typical group of works;
- assessment of other works (preparatory and finishing works);
- assessment of difficulty factor.

Table 14: Example of template table for simplified cost assessment

Measure	Sizing (m, m2, m3…)	Difficulty factor (1; 1,5; 5)	Preparatory and finishing works (25%)	TOTAL (EUR)

4.3.3.1. Typical groups of works

Each structural NWRM consist of one or more typical groups of works. Thus, simplified approach is based on typical groups of works that have the greatest impact on the construction costs. For

[43] Equivalent to 2020 prices.

example, construction of a small pond consist of excavation works, establishment of an outlet structure and bank protection.

The typical group of works for structural NWRM can be divided into following groups:

- Earthworks;
- Concrete works;
- Transverse structures;
- Bank protection, etc.

Indicative prices of typical group of works in CE countries are summarized in Annex 1.

Overview of typical group of works for structural NWRM costs is presented in the table below.

Table 15: Cost groups that have the biggest impact on the construction costs

Hydro-morphology	Typical group of works
Basins and ponds Sediment capture ponds	Construction of a weir or outlet structure to retain water Excavation if there is no natural depression Installation of dykes if needed Bank stabilization Establishment of vegetation
Floodplain restoration Wetland restoration Restoration of natural infiltration to groundwater Overland flow areas in peatland forest	Removal of stream bank protection Lowering the floodplain Dyke relocation or installation of weir Channel modification Installation of flood by-pass
Re-meandering	Excavation of meander Construction of a weir for flow diversion Sanitation of the old stream Bank stabilization Establishment of vegetation
Stream bed re-naturalization Riverbed material re-naturalization Natural bank stabilisation Elimination of riverbank protection	Concrete removal Bank re-naturalization River bank stabilisation by bioengineering Establishment of riparian vegetation
Restoration and reconnection of seasonal streams Reconnection of oxbow lakes and similar features	Construction of a weir for flow diversion Excavation of former stream • Option 1: Excavation, transport to the off-site disposal • Option 2: Excavation, relocation, installation Bank stabilization Establishment of vegetation
Removal of dams and other longitudinal barriers Widening or removing of flood protection dikes	Stream modification Bank re-naturalization Riverbank stabilisation by bioengineering Removal of dam Relocation or transport of the material to the off-site
Lake restoration	Removal of accumulated sediment Structural changes (size, area) Modifications of inflow/outflow structures

Hydro-morphology	Typical group of works
	Riverbank stabilisation by bioengineering Establishment of riparian vegetation
Regulated outflow from drainage systems	Installation of outlet structure or small weir inside the drainage
Water damming in ditches, weirs with constant crest (valleys)	Construction of a dam or weir in a ditch Bank stabilization
Construction of micro reservoirs on ditches	Construction of a weir Construction of dikes Bank stabilization Establishment of vegetation
Infiltration reservoirs and ditches Construction of reservoirs on outflows from drainage systems	Installation of an outlet structure Excavation of reservoir/ditch, relocation, installation of embankments Bank stabilization Installation of dikes when needed
Polders, dry flood protection reservoirs, sediment trapping dams	Installation of outflow with elements/mechanism for regulation/operation Excavation Construction of dikes if there is no natural depression
Construction of small reservoirs on rivers (dammed reservoirs)	Installation of a dam and outflow structure Construction of dikes if needed Bank stabilization
Peak flow control structures	Excavation works Liner Outlet structure (outlet riser pipe, flood stage outlet, trash rack Bank protection
Appropriate design of roads and stream crossings	Excavation Tampon/gravel Bank protection (Forest roads may need to be longer to avoid excessive slopes and to follow the contours of the landscape. Stream crossings may be more expensive as they will need to be larger and more robust than in a minimalist approach[44].)

4.3.3.2. Difficulty factor

In addition to typical groups of works, simplified approach also considers the level of difficulty of accessing the construction site and performing work. Thus, the calculated costs have to be multiplied by the difficulty factor. Difficulty factor can be tailored to local circumstances - the value depends on the location, altitude, topology, etc.

Indicative values of difficulty factor:

- Normal availability: 1.00;
- Difficult to access (special machinery) 1.50;
- Extremely difficult work (manual work only, helicopter) 5.00.

[44] http://nwrm.eu/sites/default/files/nwrm_ressources/f8_-_appropriate_design_of_roads_and_stream_crossings_0.pdf

4.3.3.3. Other works

In the last phase of structural NWRM cost assessment, the previously calculated costs (total of typical group of works multiplied by the difficulty factor) can be increased by other tasks, which were not part of the previous cost assessment. Typically, other costs are usually preparatory and finishing works.

Indicative value for preparatory and finishing works:

- 25% of all construction costs.

4.4. Staff training

Structural NWRM require maintenance and operation. Transfer of the technical know-how of personnel can be executed separately or as part of the trial operation. Training sessions should familiarize employees with work and duties to be performed to operate and maintain the engineered structures. Once the constructed object complies with legislation and operational staff is qualified, the object is taken over by the investor or the concessioner. Therefore, it is recommended that investment in NWRM also covers staff training.

The cost of training is commonly defined by the hours of training per certain period (man-hours of the lecturer, travel costs, field trip, etc.) or with the % of investment (e.g.≈5 %).

4.5. Dissemination and communication

The cost of dissemination and communication is defined by the scope of activities (FTE - full-time equivalent or man-hours, number of workshops and conference, dissemination and communication documents and materials, web page, brochures, social network, etc.)

Dissemination

Sharing results, lessons learned, and outcomes and findings beyond the participating organizations enable a wider community to benefit from work that has received EU funding, which attaches fundamental importance to the link between the funding programme and policies. Therefore, each of the projects supported by the funding programme is a step towards achieving the general objectives defined by the funding programme related to NWRM. Dissemination activities answer questions such as: what, why, who, when, where, and how.[45] Dissemination and communication should be considered as the essential component of any project (with activities dedicated exclusively to it). When assessing NWRM project costs for a project proposal or funding application, it is recommended to include dissemination activities if supported by the call/program.

Some funders/investors have particular rules when it comes to ensuring visibility of the efforts invested into implementation of investment projects. Communication of opportunities and results of all Cohesion policy programs and projects is a task for the national Managing Authorities and the beneficiaries in the Member States. For each fund of any EU policy (cohesion, agricultural, social, etc.), guidelines are prepared to ensure and define the expected dissemination activities of beneficiaries.

Annex XII of 1303/2013 orders a permanent visibility board for operations (financing of infrastructure or construction and environmental operations) where the total public support for the operation exceeds EUR

[45] https://ec.europa.eu/programmes/erasmus-plus/book/export/html/378_en

500.000. It is mandatory to ensure a harmonised visual identity for information and communication measures for operations in the area of Union cohesion policy.

Related EC organisations that fund investments (EIB, EBRD) also take necessary measures to ensure the visibility of EU financing or co-financing to demonstrate common EU engagement and organisation of communication events and the general implementation of the communication strategy (different communication tools), thereby contributing to the visibility of the Union and the project.

General involvement of stakeholders
The investor/funder can ensure a participative process by engaging all relevant stakeholders in different stages and using various communication and consultation tools and methods according to the occasion, type of stakeholders, context, timing, and resources. Activities should involve the following target groups:

- impacted individuals,
- impacted communities.

Activities gathering target groups could result in suggestions for improvements in the project design, where appropriate, fit the needs of the beneficiary groups and promote technology (NSWRM) and ensure process transparency and accountability. Investors should establish a regular communication channel with involved communities, whether through non-technical summaries of progress updates, engagement activities, public meetings, etc.

4.6. Operation & maintainance costs

The operation and maintenance (O&M) costs must be planned in order to maximize protection against the harmful effects of waters or to protect the water regime. The preventive maintenance and operating techniques will ensure that the purpose of NWRM is preserved.

Like all stormwater infrastructure, green infrastructure (NWRM=GI) requires regular inspections and maintenance to assure proper functioning. Maintenance of GI generally requires more labour and less heavy equipment than maintenance of grey infrastructure[46] and depends from the site and which maintenance activities are requested. In some areas mowing and grazing is needed, in others maintenance of hydraulic structures, etc.

O&M costs of NWRM can vary greatly and can reach up to 5% of capital costs according to the review of NWRM platform[47].

Maintenance of water infrastructure shall comprise:

<u>1.The operation and maintenance of water infrastructure intended for the preservation and regulation of water quantity.</u>

The types of water infrastructure operation tasks relate primarily to the operation of facilities as components of water infrastructure and are determined for individual facilities by a project of maintenance and operation. The types of public service tasks are in particular:

- retaining and regulating the outflow and inflow of water, while regulating the dams, overflows, latches, inlet and outlet structures and facilities,
- transmission of water quantities by pipelines, trenches, channels etc.,
- the handling of facilities and systems for artificial enrichment or recharging of water bodies, and

46 https://www.epa.gov/green-infrastructure/green-infrastructure-operations-and-maintenance
47 http://nwrm.eu/

- professional and other similar tasks.

Maintenance of water infrastructure includes the performance of:

- regular maintenance work,
- investment maintenance work.

Regular maintenance work involves performing minor repairs and work that does not change the facility's performance, does not interfere with the construction, and does not alter the facility's size, purpose, or appearance. The routine maintenance work includes:

- regular repairs of minor damage to the stone, wooden and concrete parts of facilities, earth fill dams, dikes and all types of dams and weirs,
- regular painting, lubrication of metal parts of facilities,
- the removal of harmful overgrowth on earth embankments and reinforced embankments, and
- mechanical and manual consolidation of surface water banks and bottoms.

Investment maintenance works include repairs, construction, installation and craft work, which does not interfere with the construction of the facility, does not change its capacity, size, purpose and appearance, but can update and improve the associated devices, equipment, installations etc. The types of investment maintenance work are in particular:

- repair and replacement of equipment and devices (e.g. dams, lifting mechanisms in water dams, pipelines), and
- minor construction work relating to the repair of the facility (e.g. damage repair, construction work related to the investment maintenance of associated facilities).

2.The operation, maintenance, and monitoring of the condition of water infrastructure intended for protection against the harmful effects of water.

3.The implementation of emergency measures during the period of an increased risk level resulting from the harmful effects of water. The measures should comprise of in particular:

- measures applied to water land use, waterside land and other land and water infrastructure to prevent escalation of the consequences of the harmful effects of water,
- 24-hour duty service provided by the public service provider,
- increased supervision over water infrastructure and in water protection areas,
- the removal of floating debris and ensuring the flow capacity of flowing water bodies,
- the implementation of provisional measures (the construction of flood protection dikes, barriers, dam breaks),
- monitoring of potential sudden water pollution.

4. The implementation of emergency measures following a natural disaster caused by the harmful effects of water. The emergency measures should be measures aimed at deterring an imminent threat to the life or health of people or property and shall include in particular:

- completion of the intervention measures,
- measures applied to water land use, waterside land and other land and water infrastructure to prevent escalation of the consequences of the harmful effects of water,
- 24-hour duty service provided by the public service provider,
- increased supervision over water infrastructure in water protection and risk areas,
- the removal of floating debris and ensuring the flow capacity of flowing water bodies,
- the implementation of provisional measures (the construction of flood protection dikes, barriers, dam breaks).

5. The maintenance of water land use and waterside land. In particular:

- the reinforcement of the banks and beds of surface waters and the sea coast,
- securing the flow capacity of flowing water bodies and the abstraction of excessive alluvium,
- mowing and removing overgrown vegetation on regulated sections,
- removal of overgrown vegetation on natural sections in water and coastal land, which significantly reduces the flow in the riverbed or could cause landslides, damages of embankments, or other,
- the removal of floating debris, waste and other abandoned or discarded items and substances from surface waters and from water land use and waterside land managed by the Ministry,
- surface water level cleaning and preventing the pollution of water land use and waterside land.

6. Ensuring supervision over waters under prohibitions, restrictions and protection regimes. The tasks of water protection supervision should be:

- direct monitoring of water status and the water regime,
- supervision of the implementation of prohibitions,
- identifying the facts in the event of violations according to the regulations issued,
- Informing people about the expected behaviour related to water pollution.

The types and extent of the public services should be defined in a work programme drafted by the Ministry pursuant to the programme of measures for the implementation of the objectives defined in the National Water Management Programme and in water management plans for river basin districts.

- regular repairs of minor damage to the stone, wooden and concrete parts of facilities, earth fill dam, dikes and all types of dams and weirs,
- regular painting, lubrication of metal parts of facilities,
- the removal of harmful overgrowth on earth embankments and reinforced embankments, and
- mechanical and manual consolidation of reinforced embankments.

Indicative prices of regular maintenance work in CE countries are summarized in Annex 2.

5. NON-STRUCTURAL MEASURES

Non-structural measures are measures not involving physical construction, which use knowledge, practice or agreement to reduce disaster risks and impacts, in particular through policies and laws, public awareness raising, training and education.[48] NWRM non-structural measures include a wide range of measures derived from land use change and agricultural and forestry practices.

5.1. Initial investment costs

Initial investment costs of structural measures are much higher than those of non-structural measures.[49] Since the non-structural measures are less complex, their investment costs can be quite low. The cost and protection effect might not be related to the size of the measure, both must be evaluated through project documentation elaboration. Rather it says that because non-structural measures can be used on a very small scale the first costs can also be small making it especially attractive in situations where investment capital is limited. Measures which allow a wide range of initial costs may have a better opportunity for implementation than those which have a comparatively high initial cost. Investors can also be encouraged by the possibility of project implementation in phases. Non-structural measures allow this flexibility.[50] While structured measures are usually financed from public sources, non-structured measures are mostly privately financed, but can also be supported by the government.

Total investment costs can be divided into the following groups:

- Costs of project documentation;
- Costs of implementation (labour, machinery, material…).

5.1.1. Land acquisition cost

Note: Change of land management practices does not involve land acquisition or change in land ownership. In case of agricultural measures, land is usually owned by the farmer, while NWRM for forests are usually applied by private forest owners or the land has been owned by the municipality or state. In addition, it is unlikely to be financially feasible to purchase high value agricultural or urban land for conversion.[51]

5.1.2. Project documentation

NWRM non-structural measures planning and implementation requires certain outside assistance. Plans and programs prepared by the government make the process of implementation easier and more efficient. System planning includes identification of baseline conditions, definition of goals, objectives and needs,

[48] https://www.preventionweb.net/terminology/view/505

[49] https://books.google.si/books?id=ZyeDDwAAQBAJ&pg=PA194&lpg=PA194&dq=Initial+investment+costs+of+non-structural+measures&source=bl&ots=13VThEqv5X&sig=ACfU3U1ysygXzihcO7VUie9wdfn3kC2fBg&hl=sl&sa=X&ved=2ahUKEwjuyq2JpIPnAhXzAhAIHbs5DTMQ6AEwAnoECAcQAQ#v=onepage&q=Initial%20investment%20costs%20of%20non-structural%20measures&f=false

[50] https://books.google.si/books?id=FOnNBr0QeiYC&pg=PA6&lpg=PA6&dq=Initial+investment+cost+of+structural+measures+is+much+higher+than+those+of+non-structural+measures&source=bl&ots=a13gGlARP-&sig=ACfU3U1l2eoCW19J15N3nChvsHP7paElYg&hl=sl&sa=X&ved=2ahUKEwjdh9aLpYPnAhXpAhAIHS8dAyEQ6AEwAXoECAoQAQ#v=onepage&q=Initial%20investment%20cost%20of%20structural%20measures%20is%20much%20higher%20than%20those%20of%20non-structural%20measures&f=false

[51] http://nwrm.eu/sites/default/files/nwrm_ressources/f5_-_land_use_conversion_0.pdf

appraisal of feasible solutions, definition of priorities, cost-benefit evaluation of proposed measures, financing program and legal documents needed to implement the adopted measures.

Non-structural NWRM do not need design projects as structural measures does. Documentation for non-structural NWRM can be divided in two main groups:

- Documentation elaborated and aligned with the spatial planning documents (e.g. land use change);
- Implementation documentation or business plan (e.g. planting plan, fertilization plan, cost analysis, revenue estimations)

The following Figure 4 illustrates the steps of implementation of non-structural NWRM.

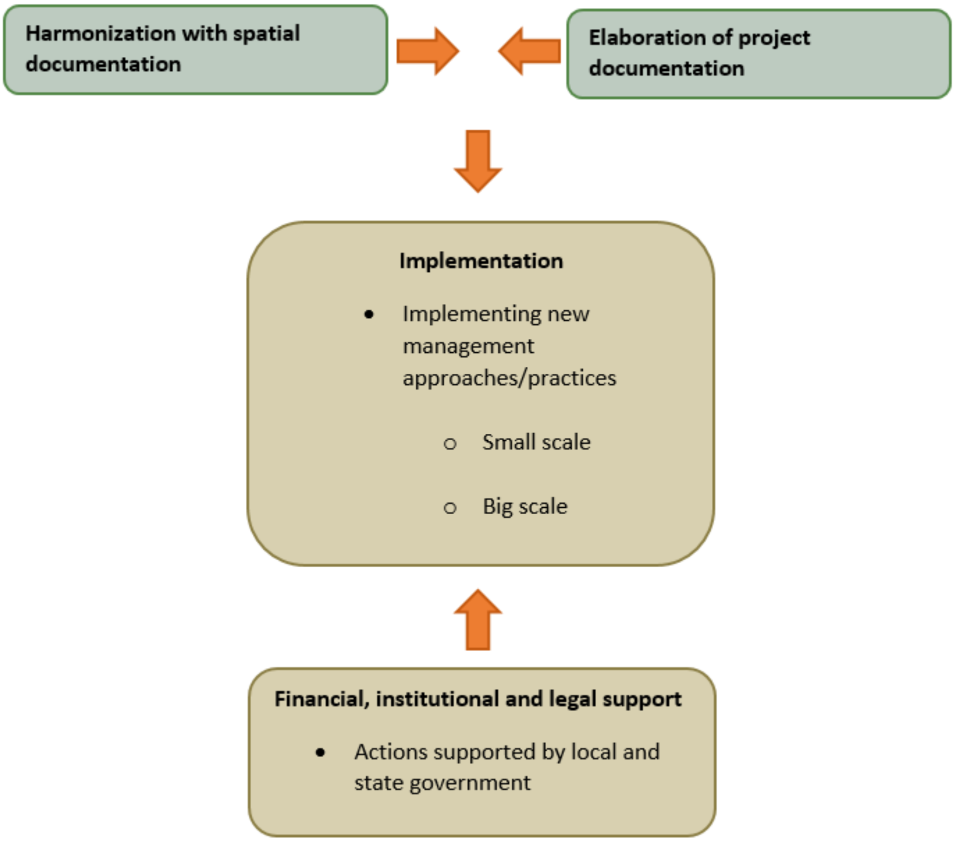

Figure 4: The steps of non-structural NWRM implementation

5.1.2.1. Implementation process and project documentation (experience from Slovenia)

- **Meadows and pastures**

Arable land can be turned into grassland. However, Slovenia is very scarce in arable land (only 800 m^2 per capita - the lowest in the EU), which have to be protected because of food security reasons. Thus, this is not a common practise. Change between land categories can only be carried out at the request of the landowner and includes a Survey on land categories conversion[52].

[52] https://www.e-prostor.gov.si/zbirke-prostorskih-podatkov/nepremicnine/zemljiski-kataster/#tab2-993

- **Buffer strips and hedges**

Local authorities can include **buffer strips** in local spatial planning documentation (e.g. municipal detail spatial plan for industrial zone) where they can define the exact location and width of a buffer zone. They can also suggest the use of local (woody) native vegetation or define species (e.g. willows).

Table 16 shows how the implementation process of buffer strips and hedges depends on the type of land use.

Table 16: Procedure and documentation for buffer strips and hedges in Slovenia

Type	Description
Buffer strips and hedges at the margins of transport infrastructure	In accordance with Roads Act (ZCes-1, Official Gazette of the Republic of Slovenia, No. 109/10, 48/12, 36/14 , 46/15 in 10/18), the applicant of an intended construction within a state road buffer zone shall have no right to require the implementation of protection measures against the effects of the road and the traffic on it. The state road buffer zone shall be 40 metres on motorways, 35 metres on highways, 25 metres on main roads, 15 metres on regional roads, 5 metres on state cycle routes. The municipal road buffer zone shall be a maximum of 10 metres on local roads, 5 metres on public routes, 2 metres on municipal cycle routes. Within the state and municipal roads shall not be permitted to establish any vegetation that would reduce the visibility of the road, intersection or access road. The use of space within a municipal road buffer zone is limited but not prohibited. For reasons of transparency, the height of the hedge should not exceed 75 cm above the level of the carriageway, the trees growing along these roads must be trimmed so that the free height above the road is at least 4,5 m and the shrubs or trees must be trimmed at least to the outer edge of the bank. For state roads Agency and for municipal roads the municipal road operator decides in favour or against buffer strips.
Buffer strips and hedges at the margins of a watercourse	In accordance with Water Act (ZV-1, Official Gazette of the Republic of Slovenia, No. 67/2002), ensure area for 1st order watercourse type is 15 meters and 5 meters for 2nd order watercourse type. Main function of coastal line is the provision of interim zone between watercourse and area of intervention (construction, farming etc.) thus enabling water pollution mitigation. Buffer stripes and hedges can be implemented as measures to improve hydromorpholigical and biological properties of surface waters or as measures for nature conservation. Owner of the land decides in favor or against riparian corridor.
Buffer strips and hedges at the margins of arable land	**Hedges in rural areas under Natura 2000 protection** Rural Development Program of the Rep.of Slovenia (2014-2020) supports environmental functions of farming. It targets increased implementation of natural/sustainable farming practices for sustaining biodiversity. The program includes preservation of hedges, particularly in 6 defined areas within Natura 2000. The following definition is agreed: a hedge is min. 10 m long and 20 m wide (canopy parameter) group or line of trees or shrubs that is not being

Type	Description
	interrupted on 10 m distance with a permissible gap of max.3 m. The subsidy received is 1,6 eur/m per year (under defined conditions).[53]. **Buffer stripes and hedges at the margins of arable land** Rules on the register of agricultural holdings[54] (Official Gazette of the Republic of Slovenia, No. 83/16). It determines that limited areas that aren't in direct farming use are included in legal farming unit (basic for CAP subsidy receipt). Buffer strips and hedges that are wider than 2m are excluded from legal farming unit and therefore abandoned by farmers and replaced by cultivated land subjected to subsidies. In case of buffer strips and hedges, narrower than 2m, the farmer gets to decide on their preservation/removal. There are no refunds and subsidies for land or income loss for buffer strips and hedges implementation.

- **Changes of agricultural practices**

Measures deriving from changes in agricultural practices:

- Crop rotation;
- Strip cropping along contours;
- Intercropping;
- No till agriculture;
- Low till agriculture;
- Green cover;
- Early sowing;
- Traditional terracing;
- Controlled traffic farming;
- Reduced stocking density;
- Mulching/fertilization;
- Deep plowing (removing the plow's sole).

The reasons leading to changing agricultural practices are closely related to social and economic changes in the region. For now, the decision is up to the farmer or landowner.[55] Adopting these practices seems like the obvious choice, but many farmers continue traditional farming due to systematic financial challenges.[56] Financial instrument, which supports farmers to achieve the scale of agricultural change that may be necessary to keep up with the climate change[57] is presented below. However, pursuing a greener production system requires farmers to embark on uncharted territories with no guarantee of immediate success. Farmers usually experience decreased yields during the transition process, as they gain the required experience to learn and perfect the implementation of more regenerative and beneficial practices.[58]

[53] https://www.program-podezelja.si/sl/knjiznica/133-navodila-za-izvajanje-operacije-ohranjanje-mejic-v-okviru-kmetijsko-okoljskih-podnebnih-placil-kopop-2017/file

[54] http://www.pisrs.si/Pis.web/pregledPredpisa?id=PRAV12579

[55] https://www.sciencedaily.com/releases/2017/08/170803095954.htm

[56] https://www.weforum.org/agenda/2019/09/here-s-how-we-can-use-agriculture-to-fight-climate-change/

[57] https://www.sciencedaily.com/releases/2017/08/170803095954.htm

[58] https://www.weforum.org/agenda/2019/09/here-s-how-we-can-use-agriculture-to-fight-climate-change/

Rural Development Program of the Rep. of Slovenia (2014-2020) supports following changes in agricultural practice[59] presented in the Table 17.

Table 17: Subsidies supporting change in agricultural practices in Slovenia

Agricultural practice	Measure supported; price
Crop rotation	Defined conditions, timeframe and number of crops. Subsidy: 114,78 EUR/ha/y
Strip cropping along contours	Measure supported for meadows (grass not being cut under conditions). Subsidized: 20,10 – 50,04 EUR/ha/y
No till agriculture Low till agriculture	Minimum tillage for the defined crop; no plowing. Subsidized: 40,68 EUR /ha/y
Green cover	Sowing plants for green fertilization. Subsidized:126,00 EUR /ha/y Greening of arable land Subsidized: 113,88 EUR /ha/y
Mulching/fertilization	Green coverage; mulching (orchards, vineyards). Subsidized: 105,30 – 171,12 EUR /ha/y

5.1.2.2. Implementation process and project documentation for forests (experience from Slovenia)

- **Afforestation**

Afforestation is part of many NWRM in the forestry sector as listed below:

- Forest riparian buffers
- Afforestation of headwater catchments (maintenance of forest cover in headwater areas)
- Afforestation of reservoir catchments
  - Afforestation of artificial surfaces and agricultural area is land use conversion.
- Creation or preservation of forests in reservoir catchments (land use conversion)
  - Planting of artificial surfaces and agricultural area is land use conversion
- Targeted planting for 'catching' precipitation
- Afforestation of artificial surfaces, agricultural areas and semi-natural areas
- Continuous cover forestry

Afforestation implementation refers to land use change to forested land. Land conversion can have legal implications for the owners since forest land is subjected to management constraints in several European countries and conversion to other land uses may be prohibited.[60]

[59] http://www.kmetzav-mb.si/KOPOP_2015-2020_1.pdf

[60] http://minisites.ieep.eu/assets/298/wp4_nd_afforestation_in_europe.pdf

Forest management in Slovenia is based on natural regeneration. Thus, afforestation in Slovenia is carried out only on a small scale or in the face of natural disasters. Bare terrain within the forest cannot be planted unless approved in forest management plan. Cutting all trees within an area is not permitted; unless this is supported by a management plan and contributes to sanitary or security purposes.[61] The owner of the forest must manage its property in accordance to the forest management plan.[62]

Implementation of NWR measures in the forest would improve if embedded within the forest management plan recommendations. They are updated every 10 years. The proposed NWR measures must be aligned with natural functions of the forest ecosystem (soil protection, hydrology function, biodiversity conservation, climate function, protective function, hygiene and health function, recreational and well-being function).

According to the law of Slovenia, reforestation is obligatory but there are no detailed regulations concerning natural regeneration. Article 6 of the Forest Act determines that forest programmes and plans shall ensure "preservation and establishment of natural stands of living forest communities and forest management which is based on the successful natural regeneration of stands". The Forest Service shall issue an administrative order to forest owners, which defines the necessary silviculture work for renewing forests and the time limits for carrying out such work.[63]

Article 21 of the Forest Act claims that the approval of the Slovenia Forest Service must be obtained for the construction and interventions in the forests.

- **Coarse woody debris in stream channels**

In Slovenia, a more common measure is coarse woody debris removal than allowing it to naturally decay. Reasons for poor implementation of coarse woody debris in stream channels in Slovenia are discussed below, but mainly due to torrential nature of streams and potential negative consequences of altered flow regimes (flood protection). This measure is optimal for improvement of conditions in watercourses in the plains.

If monitoring, irregularity notification or inspection discloses wood being discarded in the riverbed which critically obstructs the flow of the river and consequently endangers the water infrastructure and flood safety, the Water agency issues a work order for emergency intervention (intervention budget available). Where a large amount of wood and / or fallen trees are identified, the situation is tackled under routine maintenance activity plan, which is adopted for the following year and is implemented according to available priorities. Unfortunately, non-priority cases can remain untackled. Such intervention is predefined by a program for the removal of floating debris from the riverbed, which is considered a minor intervention and is approved and audited by the Water agency.

For the removal of overgrown vegetation along the banks, Article 100 of the Water Act (ZV-1, Official Gazette of the Republic of Slovenia, No. 67/2002) dictates to the owners of water and embankment properties to carry out the removal of overgrown vegetation, debris and deposited material on the banks of watercourses of rank 2. This imposes an obligation of embankment clean-up upon the property owners. In cases where property is defined as embankment of watercourses of rank 1 and belongs to the state; the location is included in the regular maintenance plan for the following year, given the establishment of overgrowth and thereby threat to the flow of the riverbed (after monitoring or notification).
Such minor maintenance tasks can be funded by a local intervention plan, that is immediately executed.

[61] http://pisrs.si/Pis.web/pregledPredpisa?id=ZAKO270

[62] https://www.gov.si/teme/gozdnogospodarsko-nacrtovanje/

[63] http://www.fao.org/3/a-ae892e.pdf

Excessive overgrowth and debris is eliminated in case of a significantly reduced flow rate or in the event that this overgrowth and material causes flooding and threatens the stability of the water infrastructure facilities, buildings or natural embankments. If a steep, potentially eroding slope is overgrown with larger trees, they should be limited to reduce the slope load. Thicker (taller) trees along the slopes are also problematic in case of wind, icebreak, eroding and rotting of the roots. In case such tree breaks down it can damage a large part of the slope and cause a potential erosion site. If a tree falls into the riverbed, it causes disturbance and swirling of the water flow impacting downstream areas with greater local load on the river bottom and banks causing potential damage. Consequences of pressure from other materials would be the same.

Afforestation as protection of the riverbanks and eroded areas is implemented under the activities of bank rehabilitation. As rivers in Slovenia are predominantly of torrential nature, the embankment afforestation alone is not sufficient for stabilization, therefore other stabilization measures are used as well (various bioengineering methods). For these maintenance works or remediation activities, which also need to be included in the maintenance plan (or the rehabilitation program in the event of flood), a project design must be approved by the Water agency. In case of Natura 2000 or National Park, a permit for intervention must also be obtained.

In case the monitoring reveals a collapsed tree in the riverbed which does not obstruct the flow of the riverbed, it can be left there. The introduction of such measures is usually the result of natural processes rather than elaboration of project documentation (ex. re-naturalization project). Prior to the final decision of the designer to implement this measure, the flow of the watercourse must be verified.

5.1.3. Implementation costs

5.1.3.1. Soil conversion practices

Total costs for implementation of non-structural NWRM derived from changes in agricultural practices can be understood from the perspective of the cost of farming.

Total investment costs can be divided into the following groups:

- **Fixed costs -** independent from the amount of production
    - Building costs (e.g. warehouses)
    - Infrastructure (e.g. irrigation system)
    - Machinery (e.g. farm tractors, combine harvesters, machines)
        - Agricultural machinery purchase costs (significant costs)
- **Variable costs** – depends on the production volume
    - Material
        - Fertilisers
        - Plant production products
    - Labour
        - Number of working hours x number of employees
    - Energy
        - Fuel for farm machinery

Costs of implementation

- Electricity and water for the irrigation system
- Machinery
  - Rental costs

Activities which generate costs (both require machinery):

- Tillage and harvest operations
- Chemical input

Cost drivers of variable farming costs are presented in the table below.

Table 18: Variable cost drivers based on average 2019 market prices

Cost item	Austria	Croatia	Hungary	Poland	Slovakia	Slovenia
Fertiliser (€/t)	10-40 €[64] per 100 kg	30-70	5.0	200-290	9,46	176-508[65]
Labour (€/h)	8-12[66]	5-10	4.3	5.5-10 net	6.24[67]	min. 5.16[68]
Fuel (€/l)	1.06[69] Diesel	1,06	0.97-1.21	1-1.2	1.36[70]	1.00[71] Diesel
Machinery rent (€/h)	e.g. excavator + driver 7.5t: 60-80	20-30	22	25 gross		30[72]

Annual implementation costs vary by location and watershed setting. Location is one of the important factors to consider when planning soil conversion crop practices. The BMP implementation in agricultural areas is typically more cost-effective than in urban areas.[73]

5.1.3.2. Tree planting costs

Establishment costs of NWRM derived from planting (e.g. buffer strips and hedges, afforestation) can be broken down into site preparation, the cost of plants and planting. Planting costs depend on:

- geographic location;

[64] https://www.ama.at/getattachment/871325a8-6881-42b4-829f-0980a0190ea1/280_Dungemittelpreise_monatsweise_2019.pdf

[65] Consultant`s estimation

[66] https://ooe.lko.at/kollektivvertrag-f%C3%BCr-die-landarbeiter-innen-in-b%C3%A4uerlichen-betrieben-und-in-betrieben-mit-ldw-dienstleistungen-im-bundesland-o%C3%B6+2500+1793454

[67] https://www.platy.sk/platy/polnohospodarstvo-a-potravinarstvo

[68] https://www.uradni-list.si/glasilo-uradni-list-rs/vsebina/2020-01-0800/odredba-o-uskladitvi-najnizje-bruto-urne-postavke-za-opravljeno-zacasno-ali-obcasno-delo-v-kmetijstvu

[69] https://www.bmlrt.gv.at/energie-bergbau/energiepreise/aktuelle-treibstoffpreise-euro-pro-liter.html

[70] http://statdat.statistics.sk/cognosext/cgi-bin/cognos.cgi?b_action=xts.run&m=portal/cc.xts&gohome= (gas 95, gas 98, diesel without LPG, CNG)

[71] https://www.gov.si/teme/cene-naftnih-derivatov/ (22.06.2020)

[72] Consultant`s estimation

[73] https://www.intechopen.com/books/agroecology/modelling-of-best-management-practices-in-agricultural-areas

- number of hectares planted;
- plant density (number of plants per hectare or kg of seeds per hectare);
- plant size (depends on the age of tree);
- types of plants (species);
- way of planting (hand-planting or machine-planting);
- plant protection (fence).

Cost drivers of planting are presented in Table 19.

Table 19: Cost drivers of tree planting

Cost item (€/ha)	Austria	Croatia	Hungary	Poland	Slovakia	Slovenia[74][75]
*Site preparation - lowland	250 - 400 €/ha	200-400	-		2.300 - 4.000 €/ha[76]	200-400 €/ha[77]
**Site preparation - highland	-	-	-		3.300 - 5.300 €/ha[78]	-
Hand planting	Costs planting 700 - 4.600[79] €/ha	500-1500 €/ha	-			1000 €/ha
Machine planting	-	-	-		-	400-600 €/ha
Tree seedling (1.000 trees/ha)	Costs seedlings 650 - 4.000€/ha	150-400	-	150-450 €/ha	74 - 527 €/ha[80]	200-500 €/ha
Tree seedling with fence (1.000 trees/ha)	-	-	-	2.000-3.000 €/ha		3.000-4.000 €/ha

* e.g. farmland

** e.g. afforestation on soil erosion

Indicative activities and prices are presented below.

- **Site preparation**

Site preparation costs may include:

[74] https://www.uradni-list.si/files/RS_-2008-073-03218-OB~P001-0000.PDF

[75] Consultant`s estimation: G. Fidel. Biotechnical Faculty. University of Ljubljana.

[76] CENKROS (https://www.kros.sk/cenkros, database version II/2019) engineering software solution for planning of expenditures

[77] In Slovenia, we are an exception to this, as we rely primarily on natural regeneration, which means significantly higher costs for planting than abroad (even in comparison to developed countries as Scandinavia, where the cost of labour is much higher). Thus, we rarely use soil preparation.

[78] CENKROS (https://www.kros.sk/cenkros, database version II/2019) engineering software solution for planning of expenditures

[79] https://www.waldverband.at/wp-content/uploads/2018/07/1x1-Aufforstung_Druck.pdf

[80] http://www.forestportal.sk/lesne-hospodarstvo/informacie-o-lesoch/trhove-spravodajstvo/Informan%20listy/1q2018.pdf

- Herbicides
- Mowing
- Removal of top layer (sand)
- Ploughing (disc plough)
- Tillage

- **Tree costs**

Indicative/variable unit prices:

- Black pine: 0,5 €/tree
- Oak: 0,5 €/tree
- Cherry: 1,5 €/tree
- Walnut: 1,5 €/tree
- Robinia pseudoacacia: 1,5 €/tree
- Chestnut: 1,5 €/tree
- Spruce: 0,5 €/tree

Costs for deciduous trees range from 0,5 to 1,5 €/tree. Costs are 2 times higher due to required protective nets. After planting, they also need clamping at least the first year, usually two to three years after planting (500 €/ha/year).

Spruce: 2.000 trees/ha = cc. 2.000 €/ha

Swedish State Forests (Sveaskog)[81]:

- Soil preparation costs are 200 €/ha,
- planting costs 400-600 €/ha,
- seedlings 0,2 € / seedling.

In principle, 2000 container seedlings are planted per hectare, which is approximately 400 € / ha. It's all spruce and red pine. So, for all total of approx. 1000-1200 €/ha.

- **Hand planting**

Indicative/variable hand planting costs:

- Tree planting: 150 trees/day
- Labor: 35 €/day
- Hand planting:
  - 1.000 trees/ha / 150 trees/day = 6,7 working days = 12 * 35 €/day per ha = 233 €/ha
  - 1.800 trees/ha / 150 trees/day = 12 working days = 12 * 35 €/day per ha = 420 €/ha

- **Machine planting**

Indicative/variable tree seedlings (without fence) costs:

- Minimal age of seedlings: 20 years
- No. of trees per hectare (No.) x tree unit price (€/ha)
  - 1.000 trees/ha * 0,5 (or 1,5) €/tree = 500 - 1.500€/ha
  - 1.800 trees/ha * 0,5 (or 1,5) €/tree = 900 – 2.700 €/ha

[81] https://www.slu.se/globalassets/ew/org/inst/sbt/utbildning/avslutade-phd/ersson_bt_140919.pdf

- **Fence**

Indicative/variable fence costs:

- Fence installation: 15 m/day per person
- Labor: 35 €/day
- Variable unit prices:
    - Barb wire: 1,5 €/m
    - Natural (1,5 m high): 1 €/m
    - High fence (2 m high): 2€/m
- Fence costs: 4 €/tree
- No. of trees per hectare (No.) x tree unit price with fence (€/ha)
    - 1.000 trees/ha * 4 €/tree = 4.000 €/ha
    - 1.800 trees/ha * 4 €/tree = 7.200 €/ha

- **Replanting**

Replanting costs depend on the survival rate of the trees. Trees that do not survive have to be replanted again. Indicative calculation of replanting costs is presented below.

- Assumed survival rate: 80 %
    - 200 trees/ha * 0,5 (or 1,5) €/tree = 100 - 300 €/ha
    - 360 trees/ha * 0,5 (or 1,5) €/tree = 180 – 540 €/ha

Costs can be higher in an area where we need fencing to prevent livestock or other animal access. Irrigation needs can also increase capital costs.

5.2. Overview of NWRM non-structural costs

5.2.1. Buffer stripes and hedges

Financial implications of installing buffer strips in an agricultural landscape are as follows:

- Positive
    - Possible subsidies for implementing
    - Potential reduction of pesticide use
    - Potential increase of crop yields production

- Negative
    - Loss of productive land due to the conversion of productive land into a buffer zone
    - Investment costs
    - Maintenance costs

5.2.1.1. Loss of productive land

According to the English project "Strategic placement and design of buffering features for sediment and P in the landscape - PE0205[82]" finished in 2006, lost revenue due to the implementation of buffers depends

[82] http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=11028

on the area of the buffer, crop market price and yield loss. Lost revenues for selected crops are presented below.

Table 20: Loss of yield per unit area of buffer in a field

Crop	Buffer area (ha)	Lost revenue (2020, EUR)
Wheat	0,10 (10 m x 100 m)	107
Barley	0,10 (10 m x 100 m)	79
Potatoes	0,10 (10 m x 100 m)	638
Oilseed rape	0,10 (10 m x 100 m)	88

In the study "Impact assessment of the thematic strategy on soil protection" (European Commission, 2006)[83] loss of revenue in area of erosion risk is estimated at 20 EUR/ha.

5.2.1.2. Buffer strips

According to the study "Impact assessment of the thematic strategy on soil protection" (European Commission, 2006)[84] establishment of a 3m wide buffer strip, every 30m costs from 400 EUR/ha (moderate to severe erosion zones) to 800 EUR/ha (severe erosion zones). This means that 10% of the field is covered with buffer strips. The buffer strips are placed on a steep slope (12-25%) to prevent erosion. The maintenance costs were estimated from 75 EUR/ha (moderate to severe erosion) to 150 EUR/ha (severe erosion).

The same document also provides the investment in buffer strips estimated at 28 EUR/ha (based on an investment of 400 EUR) in moderate to severe erosion zones and 57[85] EUR/ha (based on an investment of 800 EUR) in severe erosion zones.

The European Commission published a report "Costs, benefits and climate proofing of natural water retention measures" (European Commission, 2012[86]) in 2012 presenting the investment, operation and maintenance unit cost of a buffer strip. The annual investment cost is assumed to be 48 EUR/ha in 2011 prices, which is relatively low. However, the annual costs are much higher, almost 10 times higher (509 EUR/ha). They are the sum of maintenance costs, loss of revenue and compensation payments.

[83] https://ec.europa.eu/environment/archives/soil/pdf/SEC_2006_620.pdf

[84] https://ec.europa.eu/environment/archives/soil/pdf/SEC_2006_620.pdf

[85] The minimum and maximum annualized costs are based on a mix of grass and tree strips. Minimum total costs represent grass strips in areas of medium erosion risk, maximum stands for tree strips in high-risk areas.

[86] https://coordinamentoassociazionicdfteverefarfa.files.wordpress.com/2015/11/nat-water-retention-measures-stella-2012_finalreport.pdf

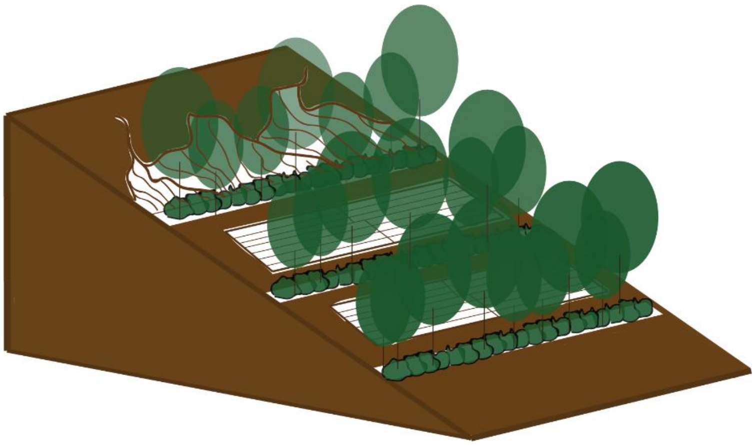

Figure 5: Buffer strips preventing erosion

- Grass buffer strips

UK Department for Environment, Food and Rural Affairs[87] have estimated costs for a grass buffer strip. Costs are summarised in the table below.

Table 21: Estimated costs of a buffer strip

Item	Cost (2011)	Cost (2020)
Establishment		
Plough & press, cultivate, drill & roll	£61/ha	82 €/ha
Spray, light power harrow, broadcast & roll	£54/ha	73 €/ha
Seed costs		
2m grass margin	£45-55/ha	60-74 €/ha
6m grass margin	£55-70/ha	74-94 €/ha
6m grass and wild flower margin	£120-1,500/ha	161-2,012 €/ha
Wild bird seed mix	£115/ha	154 €/ha
Pollen and nectar mix	£80-160/ha	108-214 €/ha
Beetle bank	£50/ha	67 €/ha
On-going management		
Cutting	£13/ha	17 €/ha

DEFRA project (Cranfield University, 2006)[88] identifies that various seed mixes are marketed for buffer strips including wild bird seed mix, and pollen and nectar mix. However, a basic seed mix would cost

[87] http://adlib.everysite.co.uk/adlib/defra/content.aspx?id=000HK277ZX.0BG6V5DHLMS9D
[88] http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=11028

between 3.90 EUR to 4.19 EUR[89] per kg and should be applied at between **20-25 kg/ha**. Table 22 illustrates the cost of seeds for different buffer widths.

Table 22: Cost of seeds required for sowing a 100 m buffer of various widths[90]

Buffer width (m)	Seeds price (2020, EUR)
2	1,69
4	3,40
6	5,13
10	8,55
24	20,43

Field Margins - Guidelines for Entry level Stewardship in England (HGCA leaflet)[91] states that during the first twelve months of establishing a grass strip the buffer may need cutting regularly to control annual weeds and promote good grass growth. Twelve months after establishing a buffer strip, 2 m and 4 m grass buffers require cutting to control woody growth. After this the buffers should be cut again no more than once in five years. With a 6 m buffer the 3 m next to the crop must be cut annually. The rest is cut as for a 2 or 4 m buffer.

It is unlikely that the grass buffer will need reseeding as it should be self-maintaining through natural regeneration. However, the buffer will require spot treatment for invasive weed species.[92]

In the US, Maryland, grass buffer costs vary from 237-565 € per acre[93]. Costs include planting, seeds, site preparation, fertilizer/lime and maintenance.

5.2.1.3. Forest buffer

Tree buffers tend to cost more than grass buffers. Tree buffer costs estimated in the US fact sheet "When a Landowner Adopts a Riparian Buffer--benefits and Costs" (Lynch, 2000)[94] are from 308 € to 1,029 € per acre. Costs include planting, plant material, site preparation, replanting and maintenance. Tree buffer costs are based on a range of 0,19 € to 0,55 € per tree for hand planting and 0,19 € to 0,42 € per tree for machine planting. Cost of the plant material is the cost of seedlings (Lynch, 2000). Shown prices are the equivalent 2020 costs.

Tiwari et al. (2016) in their study compares the opportunity cost of maintaining different buffer zones. They have shown that the cost of leaving a hydrologically adapted buffer zone was cheaper per unit of area than fixed width zones due to lower proportion of productive forested areas. This work demonstrates that by identifying the parts of riparian zone that are wet, and of higher ecological significances, using GIS based hydrological tools can lead to more cost-effective buffer zone protection. Additional protection of

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89 equivalent 2020 costs

90 http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=11028

91 http://adlib.everysite.co.uk/adlib/defra/content.aspx?id=000HK277ZX.0BG7YY1JM420K

92 http://sciencesearch.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&Completed=0&ProjectID=11028

93 https://www.extension.umd.edu/sites/extension.umd.edu/files/_docs/programs/riparianbuffers/FS774.pdf

94 https://books.google.si/books/about/When_a_Landowner_Adopts_a_Riparian_Buffe.html?id=Q4MkOAAACAAJ&redir_esc=y and https://www.extension.umd.edu/sites/extension.umd.edu/files/_docs/programs/riparianbuffers/FS774.pdf

groundwater discharge hotspots increases the ecological functions of the riparian zone even further, as well as offers an additional cost-effective solution for protecting surface waters (Tiwari et al., 2016)[95].

Table 23: The Cost of Retaining Trees Expressed as Net Present Value (NPV) in the Two Sets of Buffer Zone Scenarios*.

Scenarios	Width/ DTW** (m)	Area (ha)	% of catchment area in the buffer zone	Productive forest area in the buffer zone (%)	NPV/ha (2020, €/ha)	NPV/ha productive forest (2020, €/ha)
Fixed width	5	137	1,7	81	2769	3436
	10	267	3,2	81	2795	3439
	15	393	4,8	82	2813	3439
	20	516	6,4	82	2829	3435
	30	755	9,4	83	2846	3419
Hydro-logically adapted	DTW					
	0,1	72	0,6	53	1825	3418
	0,25	194	1,8	63	2092	3310
	0,5	326	3,2	65	2172	3342
	1	560	5,6	67	2269	3368

*The costs are expressed as the total cost of retaining the buffer throughout the entire catchment (total NVP), and as the cost per hectare of 1) all the land (agricultural land excluded) in the buffer zone (NPV/ha) and 2) NPV/ha of the productive forest (excluding low productive land and agricultural areas)

**depth-to-water (DTW) index

5.2.1.4. Hedges on a cultivated land

Scottish Government published the "Agri-environment Standard Payment Rates for Capital Items"[96], which list the standard costs (capital) for the following items:

- Planting or re-planting of a hedge: 5.7 EUR per metre, 2020
  Plants must be established in a double row with a minimum of 6 plants per metre. A single species must not account for more than 75% of plants established. Protection from grazing livestock and rabbits may be in the form of stockproof fencing with, where necessary, rabbit-proof netting.

- Coppicing of a hedge: 6.2 EUR per metre,2020
  Coppicing overgrown hedges ('old' hedges or 1- or 2- year old 'newly-planted' hedges) should be carried out following local tradition. All growth should be cut down to about 75 mm to 100 mm above ground level and left to regrow.

- Laying of a hedge: 12.3 EUR per metre,2020
  A newly planted hedge should not be layed until the hedge has grown to between 2 and 3.5 metres in height. Re-laying should not be required for another 10 to 30 years depending on species, management, climate and soil.

Slovenian "Guidelines for the Conservation of Hedges" (Ministry of Agriculture, Forestry and Food, 2016)[97] defines a hedge as a min. 10 m long and 20 m wide (canopy parameter) group or line of trees or shrubs

[95] https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2015WR018014
[96] https://www2.gov.scot/Topics/farmingrural/SRDP/RuralPriorities/Options/Hedgerows/AgrienviroCapitalItems#a6

that is not being interrupted on 10 m distance with a permissible gap of max. 3m. Example: within 20 m long hedge line 2 interruptions are allowed, within a 30m line 3 gaps etc. Monoculture line structures that are not considered hedges are: spruce, poplar, acacia, pine, cypress, varnish tree (tree of heaven).

5.2.1.5. Filter strip

Study „Modelling of Best Management Practices in Agricultural Areas" (2015)[98] demonstrate the fact that best management practices scenarios and implementation costs can vary by watershed conditions. Pollutant reduction met the requirements for application of a 17 km² filter strip at an estimated annual cost of 12,995 €. In the alternate application, the estimated annual cost was 17,569 €, which resulted from 7,725 € for 10 km² of a filter strip in the agricultural area, 7,785 € for 10 km² of reduced tillage system in the agricultural area, and 2,059 € for 4 km² of vegetative filter strip in the urban area. To summarize, annual costs for a filter strip varied from 764 € per km² in agricultural area to 1.030 € per km² in urban area. Prices are the equivalent of 2020 costs.

5.2.2. Crop rotation

According to the report "Environmental impacts of different crop rotations in the European Union" carried out in 2010, beneficial effects of a rotation, particularly concerning soil quality, lead to increasing yields on a longer term. Crop rotation is generally characterized by higher fixed costs due to higher machinery investment costs and lower variable costs compared to monoculture, notably due to a lower use of chemical inputs. However, on the short-term, yields per hectare are generally lower for rotations compared to monocultures, and the final impact on profit is uncertain, as it also depends on the farmer´s capacity to benefit from advantages of rotation. i.e. the use of adapted management practices.

Compared to monoculture, rotations allow a diversification of risks related to production and price variations. An appropriate choice of crops may allow farmers to reduce their risk exposure. As a counterpart, market opportunities may not be equal for all crops in the rotation.[99]

Study "Benefiting farmers, the environment and the economy (2012)" reported that impact Assessment fails to both estimate the actual costs of crop rotation, or take into account the long term benefits from increasing yields that crop rotation is likely to bring, as it only counts the costs that could be imposed on farmers who move to crop diversification. This omission is disappointing as several studies have shown that any short-term costs from re-introducing crop rotations with legumes can be offset by long term increases in yields[100].

For example, studies that compare the margins for farmers who grow maize and wheat monocultures and include other crops in rotation show that farmers who have maize every 2 or 4 years on their fields can have higher margins compared to maize or wheat monocultures[101].[102]

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[97] https://www.program-podezelja.si/sl/knjiznica/133-navodila-za-izvajanje-operacije-ohranjanje-mejic-v-okviru-kmetijsko-okoljskih-podnebnih-placil-kopop-2017/file

[98] https://www.intechopen.com/books/agroecology/modelling-of-best-management-practices-in-agricultural-areas

[99] https://ec.europa.eu/environment/agriculture/pdf/BIO_crop_rotations%20final%20report_rev%20executive%20summary_.pdf

[100] A 6-years study show that continuous maize under high chemical and soybean-maize-maize and soybean-maize rotations under low chemical management has similar net returns in ridge tillage (26 EUR, 20 EUR, 13 EUR/ha respectively), Environmental impacts of crop rotation in the EU, European Commission DG ENVI, page 87; GL-Pro, 2005. Guidelines for growing grain legumes in Europe. GL-Pro Concerted Action; Nemecek et al (2007). Environmental impacts of introducing grain legumes into European crop rotations, November 2007

[101] Ibid, p. 80ff

In the report Green Infrastructure Implementation and Efficiency (European Commission, 2011)[103], an average annual cost of 32€/ha is calculated for changing crop rotations and increasing fallow index in crop rotations. Introducing a greater diversity of crop types may require investment in specialized machinery (or incur contractor costs) for those crops.[104] The value is taken from the study CARM (2007)[105] for non-irrigated herbaceous crops and rice fields in Murcia, Spain. The affected area was 143,305 ha.[106]

Crop rotating should guarantee an economic impact through the increase of agricultural sales and/or the reduction of costs. Lower energy inputs and costs for machinery, fertilizers and pesticides are also important economic incentives.[107]

In the report "Costs, benefits and climate proofing of natural water retention measures" (European Commission, 2012)[108] crop rotation is not specifically addresses, but as soil conservation practices. In the document is stated that for crop practices, there is no investment, just an annual cost. Operation and maintenance unit cost is estimated at 81 EUR/ha/year.

5.2.2.1. Combined food and energy system (CFE), Taastrup, Denmark

The agronomic productivity and environmental performance of the Danish Combined Food and Energy system (CFE) system was assessed within the project SustainFARM[109] (2017, European Commission). The project description and results from the Factsheet[110] are shortly presented below.

The Danish CFE system is integrating food (spring barley, winter wheat and oat) and fodder crops (lucerne and ryegrass) with mixed stands of short rotation coppice (SRC): willow, alder and hazelnut.

The CFE system consists of 10.1 ha of food components like spring barley, winter wheat, oat and lucerne/ryegrass as fodder components and 0.75 ha of biofuels (biomass belts) consisting of five belts of SRC. Each biomass belt is 10.7 m wide and consists of 5 double rows of SRC; within the five double rows, three in the middle consist of three willow clones (one double row each) of Salix viminalis (L.) "Jor", Salix dasycladus Wimmer and Salix triandra cinerea (L.) bordered by one double row of common hazel Corylus avellana (L.) on one side and one double row of alder (Alnus glutinosa (L.) Gaertner) on the other side The trees are planted at within-row spacing of 0.5 m and between-row distance of 0.7 m. Each double row is 1.3 m apart, with a planting density of 18,600 trees/ha. Along the long edges of the SRC belts, 4 meter-wide "turning headlands" were created by fallowing a grass-ley, this area was only for machinery turning without any crop production. The biomass belts are established at varying distances of 50, 100, 150 and 200 m to assess the spatial effects of distance. The figure below shows the system. Tree density is 18,69 trees/ha. Stand biomass yield is 50,8 t/ha and dry biomass yield 25,6 t/ha. Balance between tree population, spatial distance and cropped area are necessary to achieve optimal complementarity between the species.

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[102] https://www.ifoam-eu.org/sites/default/files/page/files/ngo_policy_crop_rotation_legume_cultivation_position_201207.pdf

[103] Tucker, G. (2011). Final report. Green Infrastructure Implementation and Efficiency. Annex III. Costs of Green infrastructure. Annexes to the Final report for the European Commission, DG Environment on Contract ENV.B.2/SER/2010/0059. Institute for European Environmental Policy, Brussels and London. URL: https://ieep.eu/publications/green-infrastructure-implementation-and-efficiency

[104] http://nwrm.eu/sites/default/files/nwrm_ressources/a3_-_crop_rotation_0.pdf

[105] CARM (2007) Programa de Desarrollo Rural de la Región de Murcia 2007-2013. Consejería

[106] https://op.europa.eu/en/publication-detail/-/publication/c93ca8c6-aacb-4d41-9fc2-91819013fc4c/language-en

[107] https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip-agri_ws_cropping_for_the_future_final_report_2019_en.pdf

[108] https://coordinamentoassociazionicdfteverefarfa.files.wordpress.com/2015/11/nat-water-retention-measures-stella-2012_finalreport.pdf

[109] http://www.sustainfarm.eu/en/

[110] http://www.sustainfarm.eu/images/Factsheet-Denmark.pdf

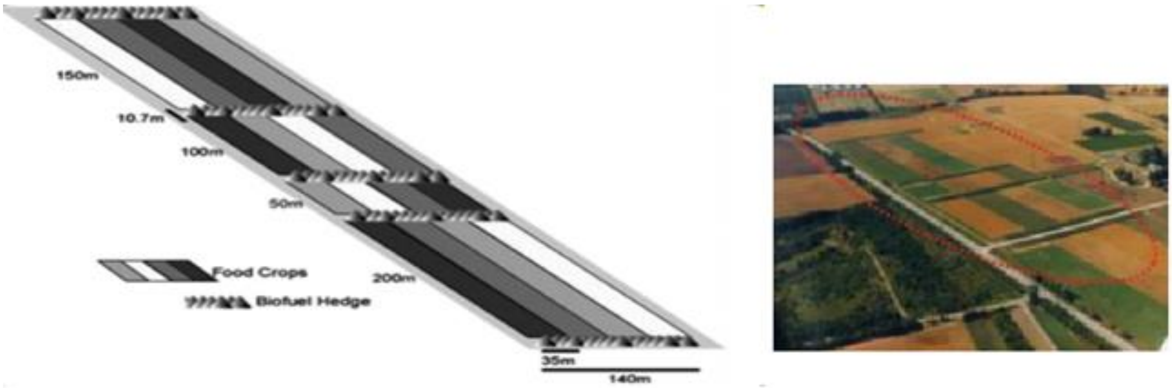

Figure 6: Field site design and layout[111]

The biomass belts are harvested and chipped every 4 years and the wood chips taken to a nearby heat and power station for the production of heat and electricity.

Table 24 presents the total cost, revenues and cumulative net margin of different CFE scenarios after a four year rotation.

Table 24: Cost, revenues and cumulative net margin of different CFE scenarios after a four year rotation are presented[112]

Combined Food and Energy (CFE)system scenarios	Total revenue (EUR/ha)	Total cost (EUR/ha)	Cumulative net margin (EUR/ha)
50m (SRC -winter wheat)	3.637	1.952	1.684
100m (SRC-winter wheat)	4.249	2.164	2.085
150m (SRC-winter wheat)	4.502	2239	2.264
200m (SRC-winter wheat)	4.674	2.287	2.387
Winter wheat	4.474	2.416	2.058
Short rotation coppice (SRC)	1.325	1.535	-210

The 200 m SRC-winter wheat CFE scenario gave the highest return of 2387 €/ha followed by 150 m (SRC-winter wheat) achieving 2.264 €/ha.[113]

Economic viability of agroforestry compared to sole crops in Denmark is presented on the figure below.

[111] http://www.sustainfarm.eu/images/Factsheet-Denmark.pdf
[112] http://www.sustainfarm.eu/images/Factsheet-Denmark.pdf
[113] http://www.sustainfarm.eu/images/Factsheet-Denmark.pdf

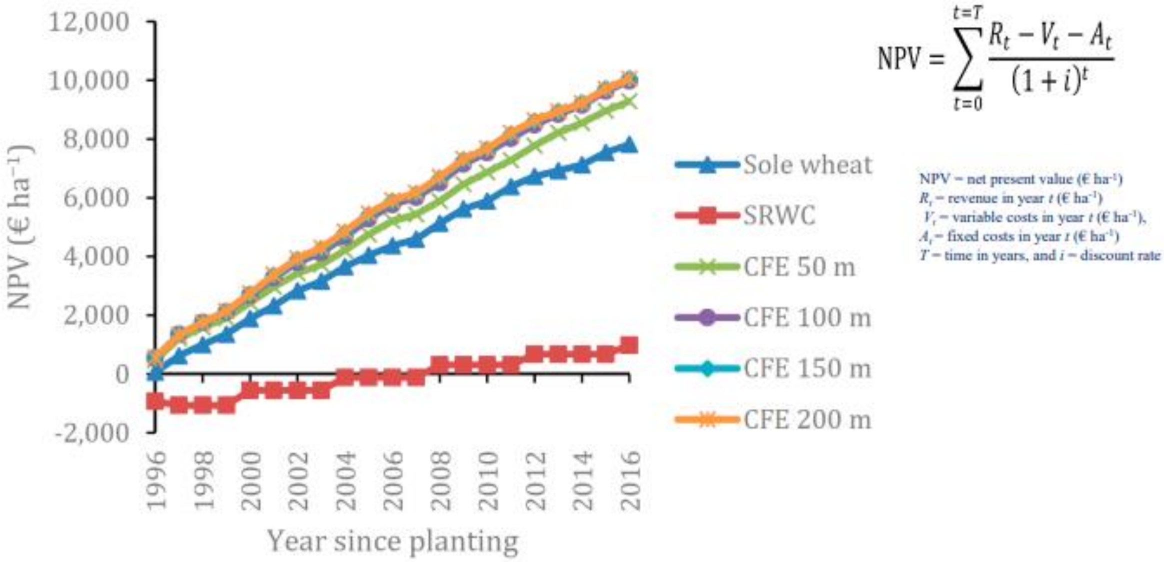

Figure 7: Net present value (NPV) for sole winter wheat, sole short rotation woody crops (SRWC) and SRWC-winter wheat combined food and energy (CFE) agroforestry scenarios over 21 years[114].

Balance between the tree population, spatial distance and cropped area is necessary to achieve optimal complementarity between the species.

5.2.2.2. Subsidies for crop-rotation

In Annex 2c[115] of the CAP Impact assessment, the average subsidy for crop rotation based on the RDP agri-environmental premiums 2007-2013 is €128/ha/year. Therefore, the study assumes an annual cost of €90/ha for soil conservation practices.[116]

5.2.3. Strip cropping along contours

There is usually some expense involved in rearranging fields and in adjusting the cropping system when strip cropping is established. However, these are incidental to improvements. Most farmers who have experienced an increase in the cost of farming report that it is unimportant when compared with the benefits derived from the practice.[117] Costs associated with strip cropping are similar to those for a farm's field preparation and planting rates.[118] The approach enables a more intensive use of sloping fields.

Strip cropping is one of the various soil conversation crop practices as stated in the report "Costs, benefits and climate proofing of natural water retention measures" (European Commission, 2012)[119]. In the

[114] https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/field_event_attachments/eip-agri_ws-almere-2019_edoardo_costantini_full_presentation.pdf

[115] https://ec.europa.eu/transparency/regdoc/rep/2/2011/EN/SEC-2011-1153-F1-EN-MAIN-PART-6.PDF

[116] https://coordinamentoassociazionicdfteverefarfa.files.wordpress.com/2015/11/nat-water-retention-measures-stella-2012_finalreport.pdf

[117] https://books.google.si/books?id=T-G40-2aMusC&pg=PA21&lpg=PA21&dq=strip+cropping+costs&source=bl&ots=cPN_bzk2Oy&sig=ACfU3U06Na2mJxR_evZ_ugtldKzpZ5lNJg&hl=sl&sa=X&ved=2ahUKEwjSw-ee5q3nAhVtlosKHW7rCGEQ6AEwDXoECAgQAQ#v=onepage&q=strip%20cropping%20costs&f=false

[118] https://www.vacd.org/wp-content/uploads/2018/10/Conservation-in-Vermont-Guidebook-Strip-Cropping.pdf

[119] https://coordinamentoassociazionicdfteverefarfa.files.wordpress.com/2015/11/nat-water-retention-measures-stella-2012_finalreport.pdf

document, strip cropping is not specifically addressed, cost is given as annual cost of applying such practices. Operation and maintenance unit cost is estimated at 81 EUR/ha/year.

US Department of Agriculture also considers that strip cropping is one of the least costly conservation practices to install. The investment cost includes labour and/or fuel, and may involve a change in planned cropping sequences. The primary cost for installation could include the cost of establishing grasses and legumes in a long-term crop rotation (US Department of Agriculture, 1997[120]).[121]

USDA-Natural Resources Conservation Service[122] (Carolina, 2014) published costs for two different scenarios of strip cropping:

- Implementation of a strip cropping system that is designed specifically for the control of water erosion or minimizing the transport of sediments or other water borne contaminants originating from runoff on cropland;
- Implementation of a strip cropping system that is designed specifically for the control of wind erosion or minimizing the transport of airborne particulate matter originating from cropland.

Basic design:

- Size of the measure: 80 acres;
- At least two or more strips of approximately equal widths;
- Acceptable protective cover includes a growing crop, including grasses, legumes or grass-legume mixtures; standing stubble; residue with enough surface cover to provide protection; or surface roughness sufficient to provide protection.[123]
- Non-water or non-wind erosion resistant crop species.

.

Table 25: Costs for establishment of strip cropping in Carolina

Cost	Strip cropping-water erosion (2014)	Strip cropping-water erosion (2020)	Strip cropping-wind erosion (2014)	Strip cropping-wind erosion (2020)
Initial investment cost:	4,47 $/acre	4,51 €/acre	1,88 $/acre	2,00 €/acre

A detailed breakdown of prices is summarized in the table below.

Table 26: Strip cropping breakdown

Component Description	Strip cropping-water erosion (2014)	Strip cropping-water erosion (2020)	Strip cropping-wind erosion (2014)	Strip cropping-water erosion (2020)
Equipment/Installation				
Equipment and power unit costs. Labor not included.	$113,94 (3h x	114,93 €	$37,98 (1h x	38,32 €

[120] http://www.fao.org/3/CA3550EN/ca3550en.pdf
[121] http://nwrm.eu/sites/default/files/nwrm_ressources/a4_-_strip_cropping_along_contours.pdf
[122] https://efotg.sc.egov.usda.gov/references/public/NC/CostSenarios585Stripcropping.pdf
[123] https://sera17dotorg.files.wordpress.com/2015/02/bmp_strip_cropping.pdf

Component Description		Strip cropping-water erosion (2014)	Strip cropping-water erosion (2020)	Strip cropping-wind erosion (2014)	Strip cropping-water erosion (2020)
		$37,98)		$37,98)	
	Labor				
Labor performed using basic tools such as power tools, shovels, and other tools that do not require extensive training. Ex. pipe layer, herder, concrete placement, materials spreader, flagger, etc.		$56,37 (3h x $18,79)	56,87 €	$18,79 (1h x $18,79)	19,09 €
Labor requiring a specialized skill set: Includes Agronomists, Foresters, Biologists, etc. to provide additional technical information during the planning and implementation of the practice. Does not include NRCS or TSP services		$187,48 (2h x $93,74)	189,44 €	$93.74 (1h x $93,74)	94,49 €
TOTAL:		**$357,79**	**361,24 €**	**$150.51**	**151,90 €**

Maintenance activities include management to maintain the planned vegetation cover and surface roughness.

Texas water development board in 2013 published information that the cost for preparing contour rows as compared to conventional rows is minimal. The primary cost per acre for contour farming relates to the field layout and surveying of the contours. The cost for surveying varies from 5.2 € to 10.3 € per acre. Secondary costs for contour farming may include additional farming and harvesting costs for small row lengths in corners and ends of the field.[124] More data regarding design is published in USDA pages – contour farming (330)[125].

5.2.4. Intercropping

In the study „Costs, benefits and climate proofing of natural water retention measures[126]“ done by Stella Consulting in 2012, capital costs for intercropping are very low and there is no loss of revenue. Therefore, it was assumed that the only cost is the subsidy given to farmers (estimated at 110 €/ha/year). However, Grain Sa claims that reduced efficiency in planting, weeding and harvesting may add to the labour costs of these operations.[127]

Benefit cost ratio is another important economic parameter in which farmers are interested to see the gain in net returns with a given increase in total costs. Findings from “Economic Assessment of Sugarcane through Intercropping” from 2014 supported the results of a 2006 study[128] which reported that all the intercrops gave higher net return and lower benefit cost ratio compared to a sole sugarcane crop. Based

[124] http://www.twdb.texas.gov/conservation/BMPs/Ag/doc/4.2.pdf

[125] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/?cid=nrcs144p2_027120

[126] https://coordinamentoassociazionicdfteverefarfa.files.wordpress.com/2015/11/nat-water-retention-measures-stella-2012_finalreport.pdf

[127] https://www.grainsa.co.za/the-pros--cons-of-intercropping

[128] Rana, N.S., Sanjay, K., Saini, S.K. and Panwar, G.S. (2006) Production Potential and Profitability of Autumn Sugar-cane-Based Intercropping Systems as Influenced by Intercrops and Row Spacing. Indian Journal of Agronomy, 51, 31-33.

on economics, it is recommended that resource poor farmers grow only sole sugarcane while resource rich farmers prefer to grow sole sugarcane + potato due to high returns.[129]

Intercropping seems to be a cost-effective practice since it provides positive effects on most of the ecosystem services, while no reduction is expected in economic benefits, beyond the machinery and labour cost variations (Rosa-Schleich et al., 2019).

Maintaining two crops involves extra costs which should be considered equally. For instance, intercropping practices may reduce machinery and labour (Rosa-Schleich et al., 2019). Thus, further research is needed to better understand the farm-level economic effects of intercropping and integrate them into a complete cost-benefit analysis, which considers both market and non-market valuations of agricultural practice to set long-term sustainable agroecosystems. Highly efficient crop diversification is the most valued alternative, as environmental and social benefits are maximised. The total economic value (1361.62 €/ha/year) is in fact potentially higher than the crop financial benefits, in some cases of low profitable farmlands, such as almond crops.[130]

5.2.5. No till agriculture

According to European NWRM platform[131] no-till systems require direct drilling machinery as an alternative to ploughing. If no-till is used in conjunction with winter cover crops, rollers may be necessary prior to drilling (technique of sowing) of spring crops. Machinery fixed cost given by Biedermann (2013) for a 100 ha case study farm in Austria, are considerably lower than costs for a ploughing system, but would likely represent an additional cost to farmers changing to no-till. Direct drilling costs are estimated at 10.833 €/100 ha.

Operational costs for no-till are lower due to reduced fuel costs, e.g. 6.8 l/ha fuel compared to 43.55 l/ha for stubble cultivation, ploughing, secondary cultivation and sowing, a saving of 84% (Soane et al., 2012). Biedermann (2013) reports total fuel usage for winter wheat according to soil type:

- Light: 37 l/ha for direct sowing versus 73 l/ha for ploughing = 36 l/ha reduction
- Medium: 40 l/ha versus 96 l/ha = 56 l/ha reduction
- Heavy: 42 l/ha versus 120 l/ha = 78 l/ha reduction

Fuel costs based on 0.84 €/la Soane et al. (2012) report a reduction in labour costs of €21/ha and up to €67/ha reduction in ploughing and cultivation costs. Biedermann (2013) reports additional herbicide and fertiliser costs for no-till of 18 €/ha and 15.75 €/ha (additional 15 kg N/ha at €1.05/kg) respectively. Biedermann estimates average total cost reductions of €24000 per farm for no tillage. Operational costs can be summerized:

- Fuel (€/ha): 30 – 67
- Labour costs (€/ha): -21
- Herbicide costs (€/ha): 5 – 18
- Fertiliser costs (€/ha): 16

Zero or minimum tillage means that farmers can use a smaller tractor and make fewer passes over the field. This also results in lower fuel and repair costs. However, this simple view masks some complexities in making a fair comparison. To capture such complexity, economists distinguish between short-run and

[129] https://www.researchgate.net/publication/276419871_Economic_Assessment_of_Sugarcane_Saccharum_officinarum_L_through_Intercropping
[130] https://www.sciencedirect.com/science/article/pii/S0921800919314429
[131] http://nwrm.eu/

long-run costs. The short-run average costs per hectare were greater than for conventional tillage. However, after adjustments to capital, capital costs fell below those of conventional tillage in the long run.

Offsetting lower machinery costs are higher herbicide applications under no till agriculture conservation practices. Herbicides substitute for the use of machinery to keep weeds under control.

Reduction in labour requirements under no till practices follows from the decreased demand for labour for land preparation at the beginning of the growing season. Some estimates put this reduction at 50-60 percent during this time period. On large mechanized farms in the developed world the true impact of this saving is small as labour costs account for under 10 percent of total per acre costs. However, on some farms in the developed world, the trend towards increased off-farm work has made even the relatively small labour savings under conservation agriculture attractive. Indeed, some case studies have cited the time savings as the primary motivation for the adoption of conservation tillage (Wandel and Smithers, 2000).[132]

Document "Converting to No-till„ (Kansas, 2000)[133] discusses potential drawbacks that farmers must consider before they shift to no-till. One of the drawbacks is the cost of converting machinery. For many farmers, no-till offers the possibility for lower machinery investment in the long run. However, for those situations in which a 100% no-till program is not the most profitable, and the transition period between conventional and no-till when farmers keep their conventional equipment while purchasing no-till machinery, investment may actually be higher.

Study provides formulas to calculate costs per equipment type (remaining value and annual operating costs). Three example central/western Kansas machinery sets that correspond to three different crop rotations – wheat-fallow (WF), wheat-sorghum-fallow (WSF), and wheat-sorghum-soybean (WSB) are shown in Table 27. These machinery sets are used to demonstrate the effect that the implementation of no-till and increased cropping intensity have on machinery costs.

Table 27: Machinery and Associated Purchase Prices Used to Calculate Costs for Crop Rotations[134]

Machine	Size	*WF rotation	**WSF rotation	WSB rotation
MFWD Tractor	105 hp	54,883 €	54,883 €	54,883 €
MFWD Tractor	200 hp	80,447 €	80,447 €	80,447 €
Combine	260 hp (30 ft)	212,233 €	212,233 €	212,233 €
Disk	25 ft	10,921 €	10,921 €	
Sweep Plow	25 ft	10,183 €	10,183 €	
Field Cultivator	30 ft	7,623 €	7,623 €	
Grain Drill	30 ft	25,983 €	25,983 €	
No-till Drill	20 ft			**57,062 €**
No-till Planter	8r30		**43,216 €**	**43,216 €**
Sprayer	50 ft		**7,833 €**	**7,833 €**

* uses conventional tillage exclusively

132 http://www.fao.org/3/y2781e/y2781e04.htm

133 http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.630.9148&rep=rep1&type=pdf

134 http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.630.9148&rep=rep1&type=pdf

** uses conventional tillage prior to sorghum

*** uses purely no-till

The machinery selected for each crop rotation was based on a farm with 1,600 tillable acres. For this example, each machine in the WF is five years old and will be owned for ten additional years. Assuming that the WSF rotation was previously in a conventional WF rotation, a new planter and sprayer were purchased for the addition of no-till sorghum. All tillage equipment from the WF rotation was kept as it will still be used in the wheat crop. Conversely, it was assumed that a purging of tillage equipment was made when the farm went to a WSB rotation. As a result, a new no-till drill, planter, and sprayer were purchased. The switch from WF to WSB requires the purchase of a $40,800 (56,718 €) no-till driller, a $30,900 (42,955 €) no-till planter and a $5,600 (7,786 €) sprayer. In this case though, the sweep plow, disk, and field cultivator were sold for a value of $20,499 (28,500 €), resulting in a net purchase of $56,801 (78,977 €). Again, this is just one example. Farmers may be able to use the no-till drill in the Annual Machinery Operating and Ownership Costs for WF, WSF, and WSB Rotations are presented in the table below (data should be used with caution).

Table 28: Annual Machinery Operating and Ownership Costs for WF, WSF, and WSB Rotations[135]

Cost Category	WF rotation	WSF rotation	WSB rotation
*Total	62,203 €	66,147 €	70,201 €

* Costs include repairs, fuel and oil, labour, depreciation, interest, housing and insurance. Equivalent to 2020 prices.

Study calculated that the WSB rotation had the lowest cost per acre for all cost items except repairs. In case of repairs, WSF was $0.55 (0.77 €, 2020) lower per acre than WSB. All other WSB costs were much lower than for WSF or WF. This is because the WSB rotation has 100% of the tillable acres on the farm planted to a crop while the WSF and WF have only 67% and 50%, respectively. This demonstrates one of the fundamental benefits of no-till: **the opportunity to increase cropping intensity and spread fixed machinery costs over more acres.**[136]

Cropping alternative was also analysed in Garfield County, Oklahoma. The objectives of the study “Cost of Conventional Tillage and No-till Continuous Wheat Production for Four Farm Sizes”[137] (2005) were to determine the costs of conventional tillage and no-till for continuous monoculture wheat production for each of four farm sizes (320, 640, 1.280, and 2.560-acres). Figure 8 and Figure 9 illustrate the results.

[135] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.630.9148&rep=rep1&type=pdf

[136] http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.630.9148&rep=rep1&type=pdf

[137] https://higherlogicdownload.s3.amazonaws.com/ASFMRA/aeb240ec-5d8f-447f-80ff-3c90f13db621/UploadedImages/Journal/231.pdf

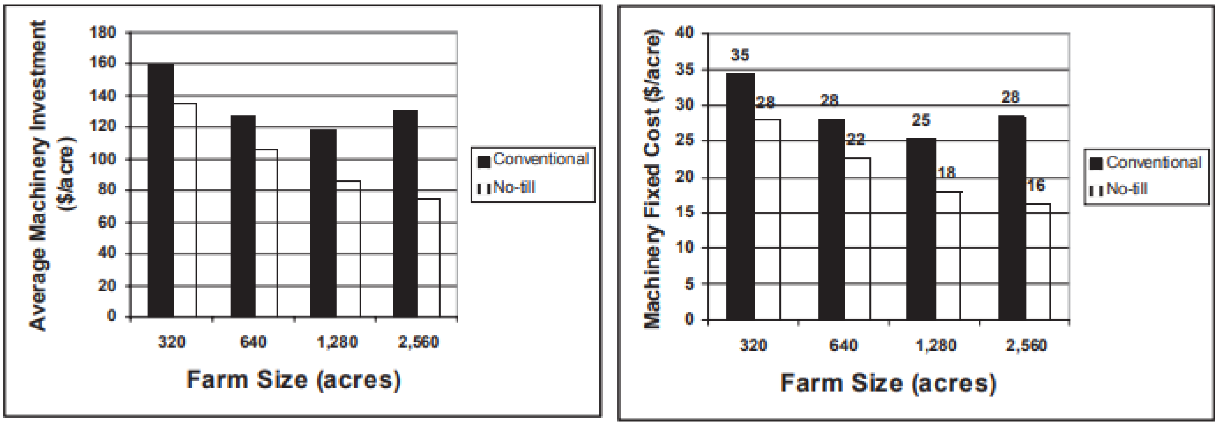

Figure 8:Average machinery investment in $/acre (on the left) and machinery fixed costs in $/acre (on the right) for both conventional tillage and no-till monoculture winter wheat for four farm sizes

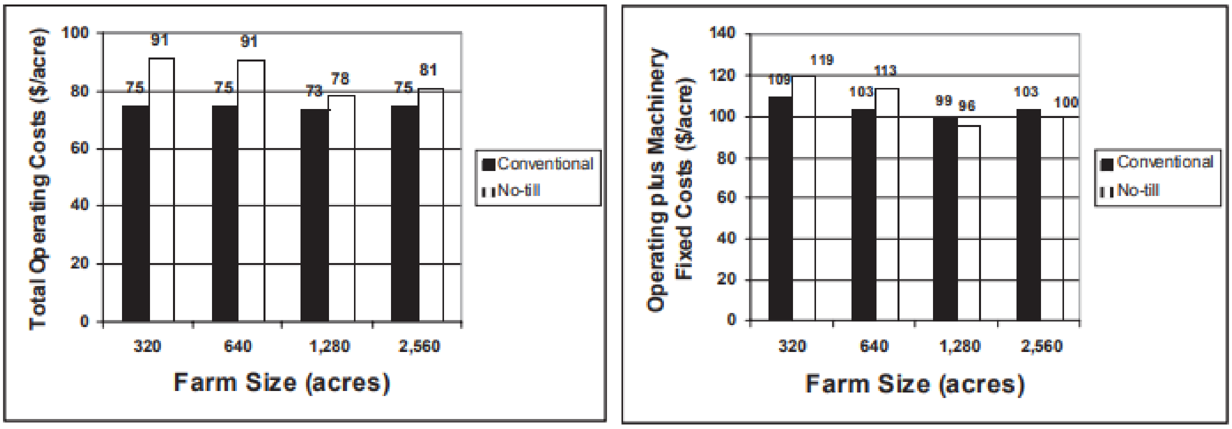

Figure 9: Total operating costs in $/acre (on the left) and total operating plus machinery fixed costs in $/acre (on the right) for both conventional tillage and no-till monoculture winter wheat for four farm sizes

Machinery fixed costs per acre are greater for the 2,560-acre conventional tillage farm than for the 1,280-acre conventional tillage farm primarily because an air seeder rather than conventional drill was budgeted for the larger farm.

Estimated operating costs for the two small farms were approximately $16 per acre (19.6 €/acre) greater for the no-till system. For the two large farms, estimated operating costs for the no-till system are $5 to $6 per acre (6.1-7.4 €/acre) more than for the conventional tillage system. For these farm sizes if yields are equivalent, conventional tillage is more economical. However, for the two large farm sizes, if yields are equivalent, no-till is more economical. The findings suggest that implementation on large farms is likely to precede the small farms.[138]

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[138] https://higherlogicdownload.s3.amazonaws.com/ASFMRA/aeb240ec-5d8f-447f-80ff-3c90f13db621/UploadedImages/Journal/231.pdf

5.2.6. Low till agriculture

- **Comparative costs of cultivation regimes**

Low till refers to an agricultural planting practice - generally using a "planter" or "seed drill". In contrast, in conventional farming practices a field is ploughed to aerate the soil and remove traces of the previous crop before planting occurs.[139] A Serbian case study[140] has outlined the cost differences among tillage and planting systems (Table 29).

Table 29: Comparing the cost of tillage and planting systems

Cost Item	Conventional Tillage	Reduced Tillage	No-till
Seed	same	same	same
Fertilizer	same	same	same
Herbicides	lowest	→	highest
Insecticides	lowest	→	highest
Machinery operating costs (fuel, labour, repairs)	highest	←	lowest
Total variable costs	same	same	same
Machinery ownership costs (depreciation, interest, insurance, housing)	highest	←	lowest
Total cost	highest	←	lowest

Although the costs of herbicides and insecticides are usually greater under either reduced tillage or no-till, machinery operating costs are much higher in conventional tillage systems because many more trips are made over the field with tillage equipment. More trips means more fuel is used, more labour is needed, more types of equipment are required, and higher repair costs are incurred.[141] Even though several studies have shown that energy and production cost savings may be achieved through reduced tillage systems compared with conventional tillage (Hernánz et al., 1995; Holland, 2004), many producers in some European countries are reluctant to adopt such practices as it may have contrasting consequences for crop yields.[142]

A study "Economic and ecological benefits of reduced tillage in the UK (2017)"[143] showed cultivation costs for winter wheat crop from several sources (Figure 10).

[139] https://www.greenfacts.org/glossary/jkl/low-till-farming.htm

[140] Programs to promote adoption of conservation tillage: A Serbian case study: https://www.sciencedirect.com/science/article/abs/pii/S0264837717316241

[141] Programs to promote adoption of conservation tillage: A Serbian case study: https://www.sciencedirect.com/science/article/abs/pii/S0264837717316241

[142] "Carbon emissions and economic assessment of farm operations under different tillage practices in organic rainfed almond orchards in semiarid Mediterranean conditions": https://www.sciencedirect.com/science/article/pii/S0304423819308647

[143] https://www.agricology.co.uk/sites/default/files/Economic%20and%20ecological%20benefits%20of%20reduced%20tillage%20in%20the%20Uk%20-%20Final.pdf

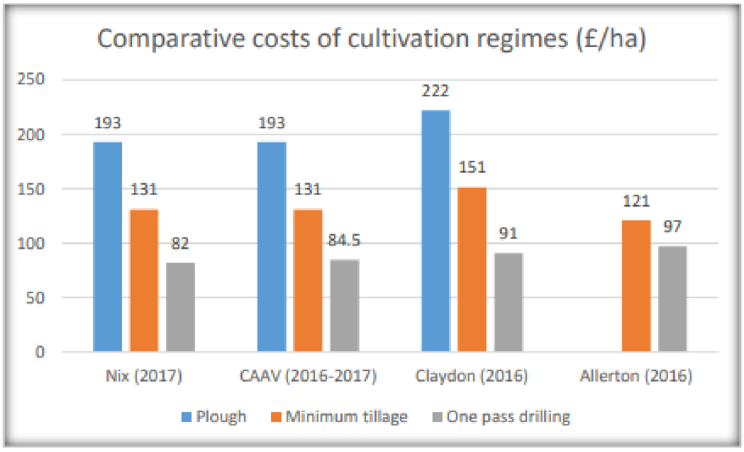

Figure 10: Comparative costs of cultivation regimes (£/ha)

- **Fuel consumption**

The diesel use recorded at the Allerton Project[144] is shown below in litres and £'s per hectare and illustrates the cost savings that can be achieved.[145]

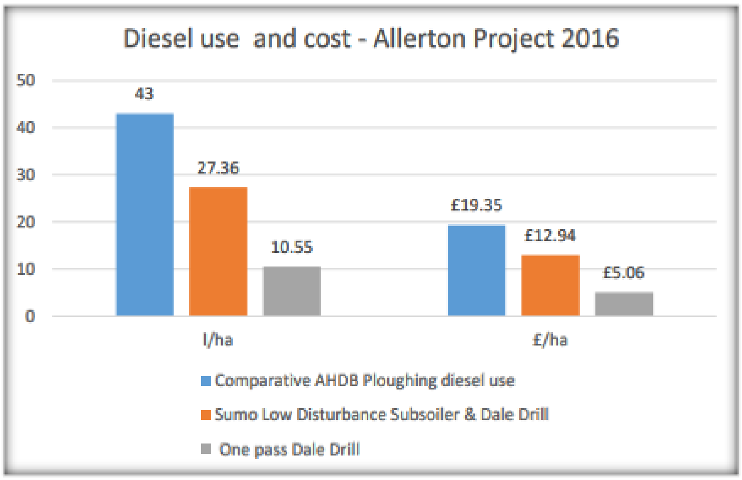

Figure 11: Diesel use and cost - Allerton Project 2016

Typical fuel consumption calculated based on agricultural engineering estimates of tractor power requirements for operating various types of agricultural machinery on medium textured soils[146] are presented in the Table 30. Authors imply that the big difference between conventional till and low till are apparent when comparing the fixed costs of machinery ownership (depreciation, interest on investment, insurance, and housing).

[144] Demonstration farm for the Game and Wildlife Conservation Trust, based at Loddington, Leicestershire, United Kingdom)

[145] https://www.agricology.co.uk/sites/default/files/Economic%20and%20ecological%20benefits%20of%20reduced%20tillage%20in%20the%20Uk%20-%20Final.pdf

[146] ASABE D497.7, Agricultural Machinery Management Data, March 2011.

Table 30: Typical fuel consumption for conventional tillage, reduced tillage, and no-till implements and equipment (l/ha)[147]

Implement/equipment	Conventional tillage	Reduced tillage	No-till
moldboard plow	4,9	-	-
chisel plow	-	2,3	-
disk	1,9	1,9	-
field cultivator	1,2	1,2	-
boom sprayer	0,4	0,4	0,4
row-crop planter	1,3	1,3	2,0
seed drill	2,4	2,4	3,1

- **Energy and labour input**

Scenario simulations in „Operational Analyses and Model Comparison of Machinery Systems for Reduced Tillage (2005)“ show that the energy input associated with the range of operations directed for crop establishment ranges from 122 to 177 kWh ha-1 in the case of traditional soil tillage. This is reduced by 18–29% for reduced tillage with ploughing and by approximately 52–53% in the case of reduced tillage with no ploughing. The most significant reduction is achieved for the direct drilling-no tillage (75-83%). Based on the same aggregations the labour input was derived (Table 31). The study reports that costs for the operations in the studied scenarios ranged from €78 to €150 ha^{-1}, depending on the methods used and assuming a 100% utilisation. [148]

Table 31: Energy and labour input in different tillage systems

System	Energy input, kWh ha^{-1}	Labour input, h ha^{-1}
Traditional tillage	122-177	1.8-2.8
Reduced tillage including ploughing	100–126	1.6-2.3
Reduced tillage excluding ploughing	58-83	0.9-1.4
Direct drilling (no-tillage)	30	0.8

German study spanning up to 18 yr showed that the fuel consumption for conventional tillage can reach 35 l ha^{-1} with 14–25 l ha^{-1} for various degrees of reduced tillage and a minimum of 6 l ha^{-1} for no-tillage (Tebrügge & Düring, 1999). The labour demand for conventional tillage was 2 h ha^{-1} with 0.7–1.0 h ha^{-1} for reduced tillage and 0.4 h ha^{-1} for no-tillage. [149]

[147] https://www-sciencedirect-com.nukweb.nuk.uni-lj.si/science/article/pii/S0264837717316241

[148] "Operational Analyses and Model Comparison of Machinery Systems for Reduced Tillage": https://www.sciencedirect.com/science/article/pii/S1537511005001339

[149] "Operational Analyses and Model Comparison of Machinery Systems for Reduced Tillage": https://www.sciencedirect.com/science/article/pii/S1537511005001339

Grass weed control

Other variable cost is grass weed control, because less tillage increases the need for chemical weed control.[150] Below are presented results from the Allerton project. [151]

Table 32: Correlation between cultivation and grass weed control[152]

Year	Cultivation type	Cultivation Cost (EUR/ha)	Grass Weed Control (EUR/ha)
1999	Conventional Plough	214 EUR/ha, 2020	35 EUR/ha, 2020
2006	Reduced tillage 4 pass	148 EUR/ha, 2020	80 EUR/ha, 2020
2016	Reduced tillage 3 pass	117 EUR/ha, 2020	149 EUR/ha, 2020

Machinery

Capital costs may involve purchasing new cultivation machinery for practices such as discing and harrowing.[153] Farm management Handbook 201/2019 (SAC Consulting, 2019) provides indicative market rates taken from various contractors and machinery rings throughout Scotland with the costs of the driver (generally) included. Fuel is not normally included in contract charges.[154]

Costs for low till agriculture include (equivalent to 2020 prices):

- Discing:
  - Average price: 45.95 €/ha
  - Price range: 33.73-67.15 €/ha
- Power harrow
  - Average price: 58.31 €/ha
  - Price range: 35.65-79.70 €/ha
- Multi harrowing[155]
  - Price range: 34.13-62.58 €/ha

Operational costs

According to "Carbon emissions and economic assessment of farm operations under different tillage practices in organic rainfed almond orchards in semiarid Mediterranean conditions (2020)[156], operational costs for two organic farms (Farm A - Cehegín and Farm B - Zarzadilla de Totana) located in the Region of Murcia, in south-eastern Spain, were assessed (Table 33). The economic benefits associated to reduced tillage compared to conventional tillage were very low, reporting only a 4% reduction in operational cost

[150] Programs to promote adoption of conservation tillage: A Serbian case study: https://www.sciencedirect.com/science/article/pii/S0264837717316241

[151] https://www.agricology.co.uk/sites/default/files/Economic%20and%20ecological%20benefits%20of%20reduced%20tillage%20in%20the%20Uk%20-%20Final.pdf

[152] https://www.agricology.co.uk/sites/default/files/Economic%20and%20ecological%20benefits%20of%20reduced%20tillage%20in%20the%20Uk%20-%20Final.pdf

[153] http://nwrm.eu/sites/default/files/nwrm_ressources/a7_-_low_till_agriculture_0.pdf

[154] https://www.fas.scot/downloads/farm-management-handbook-2019-20/

[155] http://nwrm.eu/sites/default/files/nwrm_ressources/a7_-_low_till_agriculture_0.pdf

[156] https://www.sciencedirect.com/science/article/pii/S0304423819308647

in both farms. It should be noted that with reduced tillage in extensive crops this can reach up to 10% (FAO, 2019).

Table 33: Operational costs for farms A and B considering the different experimental treatments

Field operation		Farm A				Farm B		
		CT	RT	RTG	NT	CT	RT	RTG
Soil management	Harrowing	85.01	56.57	28.34		68.32	45.55	22.77
	Harrowing			28.34				22.77
	Manual sowing			8.72				8.72
	Seeds			75.00				75.00
	Mowing				21.14			
Pruning and management of residues	Hand pruning	505.92	505.92	505.92	505.92	337.28	337.28	337.28
	Pick-up	17.41	17.41	17.41	17.41	14.85	14.85	14.85
Mechanical harvested	Trunk shaker	90	90	90	90	90	90	90
Transport of yield	Farm trailer	11.17	11.17	11.17	11.17	9.77	9.77	9.77
TOTAL OPERATIONAL COST (€/ha):		**709.51**	**681.07**	**764.90**	**645.64**	**520.22**	**497.45**	**581.16**

*Legend: Conventional Tillage (CT); Reduced Tillage (RT); No Tillage (NT); Reduced Tillage plus Green Manure (RTG).

NWRM platform[157] states operational costs derived from ADAS (2001) based on per ha values:

- Non-Inversion: Disc + Cultivator drill (€/ha) 100 - 113
- Non-Inversion: Combination Machines (€/ha) 77
- Minimum/Shallow Tillage (€/ha) 47 - 86
- Direct Drill (€/ha) 47 - 59

These compare to 113 – 143 €/ha for conventional tillage (Plough + power harrow + air drill).

Baylis et al. (2003), using data developed by ERS in the late 1990s for dryland corn-soybean production, found that switching from conventional tillage to conservation tillage caused yields to change between +5,08% in Lake States to +8,7% in Eastern Corn Belt. **Napaka! Vira sklicevanja ni bilo mogoče najti.** from the Economics of On-site Conservation Tillage (2006)[158] shows that shift from conventional till to minimum till (low till) has increased yields and lower per bushel costs of production.

Table 34: Yield and cost comparisons. (Source: Baylis et al. (2002) based on work by McBride and ERS (2000))

Region	Conventional Till	Minimum Till	% Change
Dryland			
Eastern Corn Belt			
Cost/bushel	1.37	1.1	-19.71%
Bushel/acre	133	144	8.27%

[157] http://nwrm.eu/sites/default/files/nwrm_ressources/a7_-_low_till_agriculture_0.pdf

[158] The Economics of On-site Conservation Tillage: Kevin P. Boyle, Agricultural Economist, USDA, NRCS, WNTSC USDA, NRCS, WNTSC (West National Technology Support Center)

Region	Conventional Till	Minimum Till	% Change
Western Corn Belt			
Cost/bushel	1.2	1.06	-11.67%
Bushel/acre	130	139	6.92%
Lake States			
Cost/bushel	1.4	1.07	-23.57%
Bushel/acre	118	124	5.08%
Plains States			
Cost/bushel	1.43	1.01	-29.37%
Bushel/acre	92	100	8.70%
Irrigated			
Plains States			
Cost/bushel	1.72	1.84	6.98%
Bushel/acre	151	147	-2.65%

5.2.7. Green cover (incl. cover crops and catch crops)

Establishment costs can be calculated using the following equation: Establishment costs (€/ha) = seed costs (€/kg) x seeding rate (€/ha) + planting cost(€/ha).

Variables that contribute to cover establishment costs include seed cost (0.95 €/ha), seeding rate (80.23 €/ha), and planting cost (28.49 €/ha) for grains. In the season 2015-206 establishment costs for cover crop grains were 169.06 €/ha. [159]

In addition, costs for cover crops are also impacted by:

- Cost of fertilizer application;
- Cost of termination (herbicides);
- Purchase or rental (of aerial applicator and/or fertilizer dealer);
- Width of seeding equipment;
- Separate trip over the field or combined with another field operation, etc.

The Sustainable Agriculture Research and Education (SARE)[160] published typical costs of seeding cover crops (Table 35). Some farmers in the United States are able to buy cover crops for as little as 5.46-10.43 € an acre if they are using common cereals such as oats, wheat or rye, and especially if the seed is available locally with no shipping costs or has been grown by the farmer. At the other end of the spectrum, for complex mixes that include pricier legumes, it is possible to spend as much as 52.17 € per acre on cover crop seeds.

Table 35: Cost of seeding cover crops

Item	Cost per Acre
Cover crop seed	10.43-52.17 €
Seeding the cover crops	5.46-18.79 €
Termination	0-10.43 €

[159] "A cost analysis approach to valuing cover crop environmental and nitrogen cycling benefits: A central Illinois on farm case study": https://www.sciencedirect.com/science/article/pii/S0308521X17304535

[160] https://www.sare.org/About-SARE

Subtotal range	15.65-81.40 €
*Median cost from survey	38.62 €

*Seeds and seeding

The cost of seeding cover crops can vary. In short, it is possible to buy and seed cover crops for as little as 10.43 €-15.65 € per acre, or to spend three to four times that amount.[161]

NWRM platform reported capital costs for green cover ranging from 29 to 91.50€/ha and maintenance costs about 55 €/ha.[162]

In another study (2018)[163] researchers examined cereal rye at 60 pounds and a blend of 15 pounds of hairy vetch and 45 pounds of cereal rye. Seed costs are estimated at 0,24 € per pound for cereal rye and 2.10 € per pound for hair vetch. Drilling costs are taken from the *2017 Machinery Cost Estimates* and equal 12.49 € per acre. Given these parameters, the establishment costs for the central Illinois farm are 26.81 € per acre for cereal rye and 55.39 € per acre for the rye/vetch blend (**Napaka! Neveljavno samosklicevanje zaznamka.**).

Table 36: Cover crop establishment costs

Unit cost	Cereal Rye			Cereal Rye/ Hairy Vetch		
	Seed Cost (lb)	Rate (lb/acre)	Cost / Acre	Seed Cost (lb)	Rate (lb/acre)	Cost / Acre
Cereal Rye	0.24 €	60	14.32 €	0.24 €	45	10.51 €
Hairy Vetch	-	-	-	2.10 €	15	32.39 €
Drilling	-	-	12.49 €	-	-	12.49 €
		Total Cost:	26.81 €		**Total Cost:**	55.39 €

Cover crops can also provide addition nitrogen to the following cash crop, which can be observed as potential cost savings. Given the 2018 seasonal costs and range of estimated nitrogen credits, cereal rye provides a nitrogen credit of 5.46-14.11 € per acre while a rye/vetch blend provides a credit of 10.43-27.13 € per acre. Assuming an average price and midpoint credit in the budget, a credit of 9.40 € per acre for cereal rye and a credit of 18.79 € per acre for the rye/vetch blend is assumed. When a farmer utilizes the nitrogen credit and reduces Nitrogen application, fertilizer costs are reduced.[164]

From an economic perspective, green cover has establishment costs, while there is not enough evidence to show a positive impact on yields (Li et al., 2019). Indeed, positive or negative changes in yield would depend on the type of crop used as the cover crop (Rosa-Schleich et al., 2019).[165] It is notable that cover crops may result in additional expenses or potential cost savings, depending on existing farm tillage and herbicide practices (farmdoc daily, July 6, 2016).[166]

[161] https://www.sare.org/Learning-Center/Bulletins/Cover-Crop-Economics/Text-Version-of-Cover-Crop-Economics/How-to-Get-a-Faster-Return-from-Cover-Crops/Creating-a-Baseline-for-Cover-Crop-Costs-and-Returns

[162] http://nwrm.eu/sites/default/files/nwrm_ressources/a8_-_green_cover_0.pdf

[163] Understanding Budget Implications of Cover Crops: https://farmdocdaily.illinois.edu/2018/06/understanding-budget-implications-of-cover-crops.html

[164] Understanding Budget Implications of Cover Crops: https://farmdocdaily.illinois.edu/2018/06/understanding-budget-implications-of-cover-crops.html

[165] https://www.sciencedirect.com/science/article/pii/S0921800919314429

[166] Understanding Budget Implications of Cover Crops: https://farmdocdaily.illinois.edu/2018/06/understanding-budget-implications-of-cover-crops.html

Cover crop studies have reported a range of impacts on yield, from minor losses to minor increases in corn yields. For soybeans, some studies have shown that yields are unchanged with cover crops, while others have shown a modest improvement in yields. SARE reports[167]:

- increase in corn yields after one (0,52%), three (1,76%) and five (3%) years, and
- increase in soybean yields after one (2,12%), three (3,54%) and five (4,96%) years

of consecutive cover crop use on a field.[168]

Each farmer's experience with cover crops will vary based on their particular situation. Profitability of green cover implementation is impacted by many factors/situations and each cover crop budget with net return calculations has to be specifically addressed. Impact of cover crops on farm profitability of corn and soybeans in 1, 3 and 5 years are illustrated on the SARE webpage.

5.2.8. Early sowing

Shifting the sowing date, is a low-cost and easy to implement strategy (Waongo et al., 2015; Rurinda et al., 2015), thus it is the key adaptation strategy, which can allow crop growth to occur in the periods with more suitable climate conditions (Zheng et al., 2012).[169]

Optimal sowing dates are usually considered as those that give the greatest yield. However, this date may not represent the economic or social optima. The increased costs of fungicides associated with early sowing in England, especially in a wet winter, may make the economic optimum later than the yield optimum.[170] Paredes et al (2016)[171] reports that sowing led to lower irrigation requirements and water use because high evaporative demand by late spring is avoided contrarily with late sowing, when the crop cycle completes by end June to early July. However, early sowing is likely to lead to lower yields because season climate conditions do not favour a high potential yield.

The measure in itself does not incur capital and maintenance costs. But there may be costs associated with changes in tillage and other practices that are used to implement early sowing.[172]

5.2.9. Traditional terracing

Terracing soil in hilly regions is an expensive and labour-intensive practice, but it results in a more gradual slope and reduced erosion. Well-constructed and maintained structures can last a long time.[173] Kuhlman et al (2010) reports that construction cost for new terraces with the useof heavy machinery would be €893/ha/yr and maintenance costs are 200€/ha/yr for existing terracing.[174] Cots-Folch et al. (2006)

[167] https://www.sare.org/

[168] https://www.sare.org/Learning-Center/Bulletins/Cover-Crop-Economics/Text-Version-of-Cover-Crop-Economics/How-to-Get-a-Faster-Return-from-Cover-Crops/How-Do-Cover-Crops-Impact-Yield-Over-Time

[169] "Adaptation of paddy rice in China to climate change: The effects of shifting sowing date on yield and irrigation water requirement": https://www.sciencedirect.com/science/article/pii/S0378377419305256

[170] Wheat: Ecology and Physiology of Yield Determination: https://books.google.si/books?id=GlmkpdPjf00C&pg=PA133&lpg=PA133&dq=early+sowing+cost+assessment&source=bl&ots=9PcRwe-hse&sig=ACfU3U0EQFvlIBIGIqTfHoj3M6T4emlcww&hl=sl&sa=X&ved=2ahUKEwj6w_Gx9b7nAhUr06YKHaBJCXUQ6AEwCnoECAgQAQ#v=onepage&q=early%20sowing%20cost%20assessment&f=false

[171] "Assessing yield, water productivity and farm economic returns of malt barley as influenced by the sowing dates and supplemental irrigation": https://www.sciencedirect.com/science/article/pii/S0378377416302013

[172] http://nwrm.eu/sites/default/files/nwrm_ressources/a9_-_early_sowing_0.pdf

[173] https://www.sare.org/Learning-Center/Books/Building-Soils-for-Better-Crops-3rd-Edition/Text-Version/Reducing-Erosion-and-Runoff/Addressing-Runoff-and-Erosion

[174] http://nwrm.eu/sites/default/files/nwrm_ressources/a10_-_traditional_terracing_0.pdf

reports that the costs of terracing represent 34% of the total costs for a new terraced vineyard.[175] Example of terracing costs are presented in the Table 37.

Table 37: Example of terracing costs[176]

OTSG (˚)	TTW (m)	Earthwork (m3/ha)	Terracing costs (€/ha)			
			MC	AC	SEC	Total
5	14	1613	1222	392	325	1939
10	10	2454	1508	489	480	2477
15	8	3170	1794	587	637	3018
20	6	3456	2079	685	792	3556
25	4	3191	2364	783	949	4096

*Legend: original terrain slope gradient (OTSG), terrace trend width (TTV), the economic cost by mechanization (MC), economic cost by manpower (AC) and labour and socioeconomic cost, (SEC).

Regarding the cost–benefit relationship, terraces may be effective in soil and water conservation, but expensive to construct and maintain.[177] As terracing costs rise with increasing slope gradients (Table 37), terrace profitability decreased faster than once believed by farmers and stakeholders as indicated by a cost–benefit analysis from 11 cases in Peru (Posthumus and de Graaff, 2005, Bizoza and de Graaff, 2012).[178]

Terrace reconstruction in traditional systems requires use of more traditional techniques and measures. These include re-establishing of the foundations of broken dry-stone wall sections, replacing loose or dislodged stones, cleaning or reconstructing drainage channels, as well as pruning plant roots and/or removing shrubs from walls. For Italian mountain landscapes, dry-stone wall rebuilding costs can reach up to €190 per m^2 of terrace wall (Lodatti, 2012). Therefore, basic cost-benefit analysis is required for the implementation of terrace rehabilitation practices.[179]

Gibson (1995, 2001, 2015) identified various types of agricultural terraces including contour terraces built on steep hill slopes and check dam terraces constructed across gullies and in valleys. Contour terraces are composed of so-called dry retaining walls made of stones without any mortar. Constructed by backslope digging and foreslope filling, such terraces reach heights of 3–5 m (Gibson, 1995, 2001; Zgaier and Inbar, 2003). A great deal of human labour is required to construct such terraces. For example, it is estimated that 1500 donkey-loads of fill material are necessary to create a terrace 10 m long and 5 m high (Rozenson et al., 1994). According to Foxhall (1996), an extended family could build a terrace system with a size of 1000 m^2 (0.1 ha) during the course of one summer.[180] Posthumus et al (2004) also report that the major

[175] Global synthesis of the classifications, distributions, benefits and issues of terracing": https://www.sciencedirect.com/science/article/pii/S0012825216301313

[176] T.B. Yang, S.L. Wang, W.H. Yang Construction design and cost estimation on the machine building terraces
Soil Water Conserv. China, 1 (2014), pp. 25-27

[177] "Sustainability of modern land terracing for vineyard plantation in a Mediterranean mountain environment – The case of the Priorat region (NE Spain)": https://www.sciencedirect.com/science/article/pii/S0169555X06003114

[178] "Global synthesis of the classifications, distributions, benefits and issues of terracing": https://www.sciencedirect.com/science/article/pii/S0012825216301313

[179] "Hydro-geomorphological consequences of the abandonment of agricultural terraces in the Mediterranean region: Key controlling factors and landscape stability patterns": https://www.sciencedirect.com/science/article/pii/S0169555X19300480

[180] "Agricultural systems and terrace pattern distribution and preservation along climatic gradient: From sub-humid mediterranean to arid conditions": https://www.sciencedirect.com/science/article/pii/S1040618218305512

costs of terracing are labour inputs and that for bench terracing, on moderately steep slopes (about 30 per cent), requires about 700 man-days per ha. There are often additional construction costs of stone risers. Table 38 shows physical factors that under given climatic conditions, result in different effects, having either a positive or negative impact on the efficiency (cost-benefit relationship) of the terraces.[181]

Table 38: Physical factors determining the costs and benefits of terraces

Physical factor	Physical effects	Effects on costs	Effects on benefits
Slope	Earth movement per terrace width	Labour inputs	Net cultivatable area
Slope and soil type	Erosion rate	–	Productivity
	Earth movement per man-day	Labour inputs	–
Initial soil depth	Maximum slope of riser	–	Net cultivatable area
Watershed size	Maximum terrace width	–	Net cultivatable area
Field size	Waterways per terrace width	Material and labour inputs	–
Width of terrace	Waterways	Material and labour inputs	–
Distance to stones	Choice of crop and tool	–	Productivity increase
Type of riser	Means of transport	Stone transport costs	–
Water availability during dry season	Strength of terrace	Material and labour inputs	–
	Irrigation, enabling second crop		Productivity increase

Hussein et al (2015) showed that terraces built for water erosion control on sloping land are needed in areas with more than 600 mm of mean seasonal rainfall given that economic crops are grown to offset the cost of terrace building and maintenance. In areas with less than 600 mm of mean seasonal rainfall, terraces for water erosion control are generally not needed on land with level to rolling topography where wheat and barley are normally grown under rainfed conditions.[182]

5.2.10. Controlled traffic farming

Bochtis et al (2016) presented a targeted approach for the estimation of the operational machinery costs on an annual basis in controlled traffic farming (CTF) systems. Based on the results from two case study fields, it was shown that in the CTF the optimal rule for the driving direction to be parallel to the longest field edge does not apply. In the case of field A the two analysed directions (the one parallel to the longest edge of the field and the other perpendicular to it) resulted in approximately the same annual operational cost. In case of field B, the cost decreased by 9% when the direction of the traffic lines was changed from parallel to the longest edge of the field to parallel to the shortest one.[183] The results showed that annual operational costs are influenced by overlapping area for spraying, seeding, etc.

[181] Cost-benefit analysis of bench terraces,a case study in Peru: https://www.researchgate.net/publication/247992019_Cost-Benefit_Analysis_of_bench_terraces_a_case_study_in_Peru

[182] "Designing terraces for the rainfed farming region in Iraq using the RUSLE and hydraulic principles": https://www.sciencedirect.com/science/article/pii/S2095633915300642

[183] "Tramline establishment in controlled traffic farming based on operational machinery cost": https://www.sciencedirect.com/science/article/pii/S1537511010001777

Profitability of controlled traffic farming (CTF) in broadacre dryland agricultural systems in a major rural region of south-western Australia was analysed by the Kingwell et al (2011). The study reveals that CTF increases annual profits by between 51% and 67% across different farm types. Studies on crop improvements from adopting CTF indicate an average 10% increase in yield for wheat, barley and canola across different soil types (Li et al., 2007, Lorimer, 2008, Robertson et al., 2007a, Webb et al., 2004). Input savings from more precise application average 10% for fuel, seed, fertiliser and chemicals (Rainbow, 2004, Robertson, 2008, Robertson et al., 2007a, Stone, 2004, Webb et al., 2004). Casual labour costs were decreased from 16 €/h to 16 €/h from the base case, representing the ability to hire cheaper labour with less driving experience (Robertson et al., 2007a, Webb et al., 2004), for example backpackers, during seeding and harvest.[184] Here it must be noted that farm size plays an important part in the profitability of CTF.

How CTF affects costs:

- Improves the timeliness of sowing - lower capital replacement costs;
- Improves field efficiency;
- Reduces spraying costs by up to 10% (Robertson et al., 2007a, Webb et al., 2004).

The initial costs of setting up a CTF system in Australia are generally under 28,620 € (McHugh et al., 2004, Tullberg, 2008), including guidance technologies (GPS), modifications and adjustments to farm machinery (axle widths or machinery with adjustable tracks). Depending on the current machinery used, the desired level of accuracy and the area to be cropped, investments in CTF will vary between farmers.[185] According to Gains research and development cooperation (GRDC, Australian Government)[186] the conversion into CTF should be a gradual process in line with standard machinery replacement strategies. It can take anywhere from five to 10 years for growers to fully match their machinery for CTF, taking into account sound financial management to replace machinery when it is due and not any earlier. Growers should stage their machinery changeover for CTF with an easy first step being the boomspray, followed by the linkage spreader, then eventually the header or seeder subject to machinery replacement schedules and farm income. Additional cost for three-metre axle width compared to a standard two-metre axle are from 278 € with new machines (Boomspray, e.g. Goldacres 36m 6500L) and up to 14,311 € for front axle modification for tractors needing more strength for front weights or carrying implements (FWA tractor, e.e. Case Magnum 250hp).

GRDC[187] also proposes using a guide such as the ‘machinery income efficiency’ ratio (total machinery assets (clearing sale values) /farm income (past four years)) to determine the value of machinery relative to farm income. The ratio should fall between 0.7 and 1.2, relative to the role machinery plays in the business, with productivity, labour or debt considerations.

Northern Irish grower Richard Orr has put this theory into practice, cutting his establishment costs by 290[188] EUR/ha by switching from a traditional bed-till and destoner regime to a one-pass system using a TillerStar.[189]

[184] "The whole-farm benefits of controlled traffic farming: An Australian appraisal": https://www.sciencedirect.com/science/article/pii/S0308521X11000461

[185] "The whole-farm benefits of controlled traffic farming: An Australian appraisal": https://www.sciencedirect.com/science/article/pii/S0308521X11000461

[186] https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/02/controlled-traffic-farming-the-costs-and-benefits

[187] https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/02/controlled-traffic-farming-the-costs-and-benefits

[188] equivalent 2020 costs

[189] https://www.fwi.co.uk/arable/one-pass-potato-establishment-cuts-costs-and-improves-yields

The Controlled Traffic Farming (CTF)[190] Network promotes the following economic benefits:

- crop yields and N recovery increased by around 15%;
- fuel use for crop establishment drops by at least 35%;
- time and energy for crop establishment reduced by around 70%;
- machinery costs reduced through lighter machines needing less power;
- no under- or over-lap for all operations.

5.2.11. Reduced animal stocking density

NWRM platform states that there are no direct capital costs involved in reducing animal stocking density. But If reductions in stocking density are offseted by increased housing then capital costs may be incurred. For cattle these might range from €860 to €2,500 per head for a straw bedded solid floor house depending on space provision per animal (slurry and feed storage would be additional). Also, there are no direct maintenance costs. As with capital costs these would be indirect and depend on the management changes in response to reduced stocking density on pastures.[191]

The main problems are soil compaction and erosion, organic matter content decrease and crops productivity decrease, resulting in a higher cost production and natural resources degradation, mainly soil and water (Luciano et al., 2012; Freddi et al., 2017).[192] Livestock management including reduced stocking rate impact productivity cost. The benefits are improved animal health and mortality rates that outweigh the production losses.[193]

5.2.12. Mulching

Use of any kind of mulching proportionally reduces the evaporation and prevents the growth of weeds. These results in reducing the crop water requirement, and subsequently reduces the financial expenditure for water, especially where irrigation is involved. The fertilizer's efficiency use improves as well. Mulching can increase the yield of the next crop, especially in dry years. According to Pannel et al (2016)[194] economic model, mulching is more attractive for large farm types or over a longer time frame.

Where retaining adequate mulch over the non-crop period is possible, labour requirements for creating an adequate mulch prior to the next crop can be a further cost for farmers (Lahmar et al., 2012). Another important factor impacting costs is the viability of mulching. Where residues are used by the farmer for animal feed, the viability of mulching may be influenced by the volume of biomass produced.[195] Organic mulches are easily available as these are the crop residues of the cultivated crops. These are the cheap materials, so the cost of mulching is worth considering.

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[190] http://www.controlledtrafficfarming.com/downloads/CTF-A5-flyerWeb.PDF

[191] http://nwrm.eu/sites/default/files/nwrm_ressources/a12_-_reduced_stocking_density.pdf

[192] "Least limiting water as a soil indicator in an integrated crop-livestock systems of the Cerrado, Brazil": https://www.sciencedirect.com/science/article/pii/S235200941930032X

[193] "Impacts of climate change on livestock and possible adaptations: A case study of the United Kingdom": https://www.sciencedirect.com/science/article/pii/S0308521X18302555

[194] "The farm-level economics of conservation agriculture for resource-poor farmers": https://www.sciencedirect.com/science/article/pii/S016788091300354X

[195] "The farm-level economics of conservation agriculture for resource-poor farmers": https://www.sciencedirect.com/science/article/pii/S016788091300354X

Availability, durability and cost of the materials are the important issues to be taken into consideration for the selection of mulching materials. The main focus should be on the negative impacts of mulching. Organic mulching saves the labor cost and, after decomposing, adds plant nutrients to soils.[196]

Mulch cost can vary between 0.05 and 0.15€/m2 depending on thickness, mulch type and percentage of soil cover (Ministère de l'agriculture, de l'agroalimentaire et de la forêt, 2003).[197] Pannel et al (2016)[198] reports residue values of maize at 30 €/ton and legume at 60 €/ton if not mulched. Commercial average price (selled in bags for personal use) for pine/hay straw is from 0.9 € to 1.2 € per m^2 and for bark mulch from 1.2 € to 2.8 € per m^2 (2020 prices).[199]

4.2.13 Afforestation (forest sector)

As the measures are very similar in the forest sector, we have combined some measures in terms of investment, namely: forest riparian buffers, maintenance of forest cover in headwater areas, afforestation of reservoir catchments, urban forest parks, trees in urban areas, targeted planting for 'catching' precipitation, continuous cover forestry, land use conversion. All above mentioned measures have one thing in common – afforestation in a greater or lesser extent.

Afforestation is the creation of forests on land that did not have them for some amount of time, such as previous forests that were converted to ranges, though it is also the act of establishing forests on land that was not forested at all in the past. Locations require different approaches and measures which impact the needed extent of afforestation differently. Above mentioned measures can be divided into point, line and polygon measures. The vast majority of the measures are polygon measures, which require a lot of surface area. In most cases land for these measures does not need to be purchased because the measures already exist or they are being restored with afforestation. Rising cost are illustrated in Figure 12.

RISING COST

POINT	LINE	POLYGON
trees in urban areas	forest riparian buffers	urban forest parks
		targeted planting for 'catching' precipitation
		continuous cover forestry
		land use conversion
		afforestation of reservoir catchments
		maintenance of forest cover in headwater areas

RISING COST

Figure 12: Rising costs in the forest sector

Direct planting costs depend on the size and type of the buffer. Establishment cost can be broken down into site preparation, plant material, planting, replanting, and maintenance. Planting cost depends on geographic location, number of acres planted, number of trees planted per acre, species of trees, and

[196] Recent advances in mulching materials and methods for modifying soil environment": https://www.sciencedirect.com/science/article/pii/S0167198717300016

[197] http://nwrm.eu/sites/default/files/nwrm_ressources/a13_-_mulching_0.pdf

[198] "The farm-level economics of conservation agriculture for resource-poor farmers": https://www.sciencedirect.com/science/article/pii/S016788091300354X

[199] https://www.fixr.com/costs/mulching

whether or not the trees are in the form of bare root or container stock[200]. Trees can be planted either by machine or by hand. Machine-planted trees often have a higher survival rate. Machine planting can be less expensive compared to manual labour. Example of afforestation costs are presented in the Table 39.

Table 39: Afforestation cost in US for 436-550 trees per acre[201,202]

AFFORESTATION COST	EUR (2020)
Plant material	84.07-385.36 €
Plant by machine	105.1-182.2 €
Plant by hand	84.07-243.87 €
Site preparation (herbicides for grass control): • Band • Broadcast	50.30-70.06 € 112.11-168.16
Replanting	78.48-140.12 €
Maintenance: • Herbicides • Mowing	50.30-84.07 € 16.81-84.07 €
Total	**305.46-1020.81 €**

In general, in countries where bare and artificial restoration (mechanical or manual) is established, the cost of afforestation is approx. 1000 € ($) / ha, with seedlings and often including soil preparation.

4.2.14 'Water sensitive' driving

There can be increased capital costs for retrofitting forest harvesting equipment with GPS systems to link them with computerized maps of areas where driving damage is likely, or for modifying equipment by the addition of extra wheels or tracks to reduce compressing soil by the machinery[203].

Driving on frozen soil will also reduce the potential for compaction and damage. Driving parallel to contour lines of hill slopes will reduce the potential for rut formation and concentration of flow paths but may not always be feasible, especially in higher ground. Use of slash cover or specially designed logging mats for off road driving during forest logging operations may help to reduce soil compaction and rutting. Reduction of truck tire pressure on unpaved forest roads may also be considered as one aspect of this NWRM.

As an example of a logging mat we present here heavy equipment access mats and they cost from[204] 1,347.57-2,126.78 € (2020).

4.2.15 Coarse woody debris

Wooden parts of trees can be found in the surrounding area and are free of charge.

200 https://www.co.benton.or.us/sites/default/files/fileattachments/community_development/page/2516/willametteripcost030310.pdf

201 https://www.extension.umd.edu/sites/extension.umd.edu/files/_docs/programs/riparianbu ffers/FS774.pdf

202 http://www.malvern.org/wp-content/uploads/2013/03/Ripbufplant.pdf

203 http://nwrm.eu/sites/default/files/nwrm_ressources/f7_-_water_sensitive_driving_0.pdf

204 https://startsafety.com/heavy-equipment-mats-tufftrak-xl-xt

6. FINANCIAL ANALYSIS

6.1. Project`s time horizon

Considering the present costs or the expected costs for the next year, without considering how these will change in the future might result in an insufficient analysis[205] and can affect the decision-making process. It is important to understand the priorities.[206]

Projects can be evaluated in different time horizons and these affect the relative ranking of the projects. A single reference point for 20-25 years is the best practice for the time horizon for infrastructure projects.[207] In case of environmental management projects the time horizon is project specific, depending on the typology of the environment asset and the work included. Thus, it is difficult to establish benchmark values.[208]

For the purposes of calculating discounted net revenue for major projects, reference period applicable for the sector is set out in Annex 1 of Commission Delegated Regulation (EU) No 480/2014. The reference period includes the implementation period of the operation. SWRM does not comply with any sectoral reference period, thus estimated reference period is derived from design time horizon.

Table 40: Time horizon of NWRM

NWRM	Project`s time horizon
Structural NWRM (hydro-technical measures or engineered measures)	At least 30 years
Non-structural NWRM (soil conversation practices)	5 years or more - defined in the business plan

Source: Consultant`s estimates.

6.2. Revenues

Implementation of NWRM may generate revenue from natural resources (i.e. selling wood from afforestation activities) or services (for example, guided tours). Potential revenues should be included in the cash flow analysis. In general, revenues derived from NWRM can repay the investment, reduce O&M costs, support, or indicate a business model based on the context.

6.3. Net present value

Knowing the net present value (NPV) of the NWRM project is essential from affordability, financial and economic analysis aspects. Thus, NPV should be included among project performance indicators. The

[205] Weingarten, 1992; Sanders, 2017)
https://books.google.si/books?id=NH_EDwAAQBAJ&pg=PA67&lpg=PA67&dq=long-term+perspective+cost+analysis&source=bl&ots=oxZw4a_9xc&sig=ACfU3U2GRfrJJieYL4D4fN3kGkrilmwZg&hl=sl&sa=X&ved=2ahUKEwinscSHhdbmAhXkw8QBHQzHC_gQ6AEwAXoECAgQAQ#v=onepage&q=long-term%20perspective%20cost%20analysis&f=false

[206] https://books.google.si/books?id=NH_EDwAAQBAJ&pg=PA67&lpg=PA67&dq=long-term+perspective+cost+analysis&source=bl&ots=oxZw4a_9xc&sig=ACfU3U2GRfrJJieYL4D4fN3kGkrilmwZg&hl=sl&sa=X&ved=2ahUKEwinscSHhdbmAhXkw8QBHQzHC_gQ6AEwAXoECAgQAQ#v=onepage&q=long-term%20perspective%20cost%20analysis&f=false

[207] https://cadmus.eui.eu/handle/1814/29897

[208] https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

calculated value enables option ranking and selection of the most appropriate solution based on their financial and economic terms. Net present value (NPV) should take into account:

- The average economic life of the project assets (time horizon);
- Initial investment costs (capital costs);
- Operational and maintenance cost (opex costs);
- The real discount rate (e.g., 4%).

6.4. Return on investments (from cost-savings)

NWRM implementation can generate annual cost-savings (avoided costs) due to the transition from conventional to NWRM practices. Thus, it is crucial to forecast cost-savings throughout the life of the project and estimate in what time the investment in NWRM would repay through cost-savings mechanism. The potential revenues can be used for funding of NWRM capital costs.

7. CONCLUSIONS/SUMMARY

The Approach on how to calculate NWRM costs on a river basin scale is designed to provide the user with information on N(S)WRM costs and impacts of the overall investment. The Approach and its testing on selected pilot actions shows that is possible to assess cost based on limited information, but the results should be approached with caution. The cost assessment of N(S)WRMs investment costs demonstrated extreme vulnerability related to local (specific) conditions and expert judgment. Therefore, the cost assesment should only be done by an experienced expert (engineers or consultants experienced in NWRM design) in partnership with policy officials, planners, water managers, or other stakeholders and interest groups.

ANNEXES

Annex 1: Indicative pricing basis for assessment of capital expenditures of structural NWRM

Annex 2: Indicative pricing basis for assessment of operational expenditures of structural NWRM

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