European Commission

NWRM

Natural Water Retention Measures

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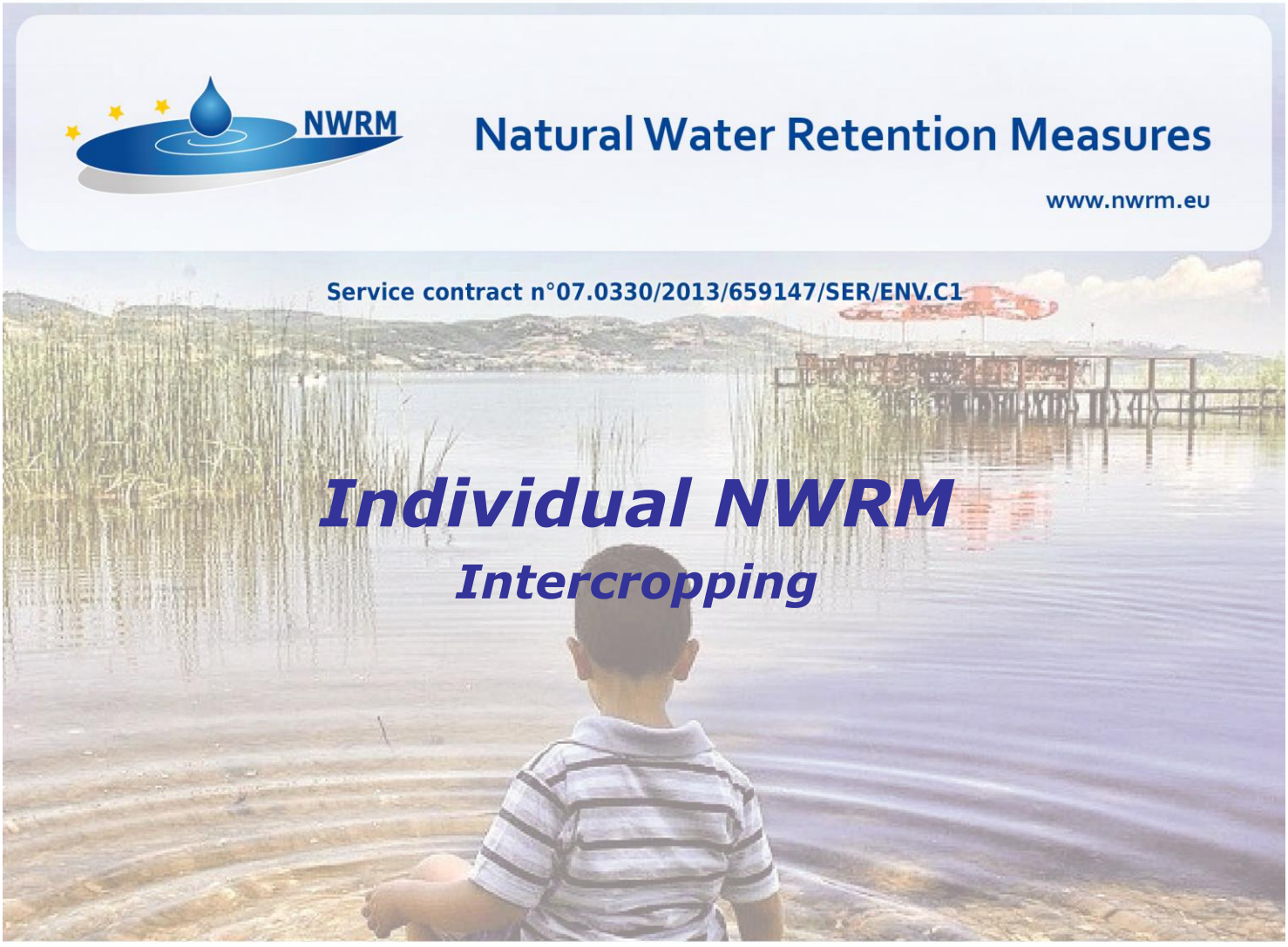

Individual NWRM

Intercropping

Environment

This report was prepared by the NWRM project, led by Office International de l'Eau (OIEau), in consortium with Actéon Environment (France), AMEC Foster Wheeler (United Kingdom), BEF (Baltic States), ENVECO (Sweden), IACO (Cyprus/Greece), IMDEA Water (Spain), REC (Hungary/Central & Eastern Europe), REKK inc. (Hungary), SLU (Sweden) and SRUC (UK) under contract 07.0330/2013/659147/SER/ENV.C1 for the Directorate-General for Environment of the European Commission. The information and views set out in this report represent NWRM project's views on the subject matter and do not necessarily reflect the official opinion of the Commission. The Commission does not guarantee the accuracy of the data included in this report. Neither the Commission nor any person acting on the Commission's behalf may be held responsible for the use which may be made of the information contained therein.

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I. NWRM Description

Intercropping is the practice of growing two or more crops in proximity. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop. Examples of intercropping strategies are planting a deep-rooted crop with a shallow-rooted crop, or planting a tall crop with a shorter crop that requires partial shade. Numerous types of intercropping, all of which vary the temporal and spatial mixture to some degree, have been identified: mixed intercropping, row cropping, relay cropping, etc.

II. Illustration

Illustration 1: Example of intercropped cereals with soybeans

Source: http://environmental.lilithezine.com/images/Intercropping-02.jpg

III. Geographic Applicability

Land Use	Applicability	Evidence
Artificial Surfaces	No	
Agricultural Areas	Yes	Intercropping concerns crops and is thus applicable in agricultural areas. Different types of intercropping strategies exist, which can involve annual or perennial crops.
Forests and Semi-Natural Areas	No	
Wetlands	No	

Region	Applicability	Evidence
Western Europe	Yes	According to Stella study (Stella consulting , 2012), intercropping is applicable in any climate zone of Europe. However, it depends on the acceptable slopes for mechanical systems.
Mediterranean	Yes	
Baltic Sea	Yes	
Eastern Europe and Danube	Yes	

IV. Scale

	0-0.1km^2	0.1-1.0km^2	1-10km^2	10-100km^2	100-1000km^2	>1000km^2
Upstream Drainage Area/Catchment Area	✓	✓				
Evidence	Intercropping concerns fields and is thus applicable at field scale. In terms of drainage, the concerned area is the field itself. In Europe, field size can vary a lot across states and agriculture types in each state; in France (Latruffe, 2013) and Denmark (Levin, 2006) for instance, mean field size is a bit more than 4ha.					

V. Biophysical Impacts

Biophysical Impacts		Rating	Evidence
Slowing & Storing Runoff	Store Runoff	None	
	Slow Runoff	High	Intercropping can slow runoff by up to 50% (Zougmore, 2000) and increased infiltration can reduce runoff by up to 4 times (OMERE, 2014).
	Store River Water	None	
	Slow River Water	None	
Reducing Runoff	Increase Evapotranspiration	None	
	Increase Infiltration and/or groundwater recharge	High	By implementing cover crops where the soil is otherwise left bare (under other crops, between rows…) intercropping contributes to reduce runoff and increase water infiltration (Battany, 2000). For instance, experiments in the Sahel region showed that runoff

			decreased by 20-30% with sorghum-cowpea intercropping compared to sorghum sole crop and by 45-55% compared to cowpea monoculture (Zougmore, 2000). OMERE (2014) showed that infiltration on Mediterranean vineyards in France can reach 20mm/hour with grass when it remains less than 5mm/hour without (bare soil under vines).
	Increase soil water retention	Low	According to Battany (2000), slowing runoff and increasing water infiltration improves water filling of the soil profile in winter and makes more water available for both crops during their growth.
Reducing Pollution	Reduce pollutant sources		
	Intercept pollution pathways		
Soil Conservation	Reduce erosion and/or sediment delivery	High	By covering bare soil areas with plants, intercropping reduce runoff (see above) thus erosion; it also reduces wind erosion compared to a bare soil. Shallow roots are effective in reducing erosion because they bind the soil at the surface. Zougmore calculated that intercropping reduced soil loss by more than 50% compared with sorghum and cowpea monocultures in Sahel (Zougmore, 2000).
	Improve soils	Medium	By introducing another type of plant next to the cultivated one, intercropping leads to a more stable plant system and a better soil structure (Stella consulting , 2012). Shallow roots help to aerate the soil (Zougmore, 2000). Moreover, soil fertility can benefit from intercropping particularly when it concerns legumes, which enrich the soil by fixing the atmospheric nitrogen and turning it into forms which can be taken up by plants. Legumes grown in intercropping are considered as an alternative and sustainable way of introducing N into lower input agro-ecosystems (Fustec, 2010).
Creating Habitat	Create aquatic habitat	None	
	Create riparian habitat	None	
	Create terrestrial habitat	None	
Climate Alteratio	Enhance precipitation	High	By implementing cover crops where the soil is otherwise left bare (under other crops, between rows…) intercropping contributes to reduce runoff and increase water infiltration (Battany, 2000). For instance,

			experiments in the Sahel region showed that runoff decreased by 20-30% with sorghum-cowpea intercropping compared to sorghum sole crop and by 45-55% compared to cowpea monoculture (Zougmore, 2000). OMERE (2014) showed that infiltration on Mediterranean vineyards in France can reach 20mm/hour with grass when it remains less than 5mm/hour without (bare soil under vines).
	Reduce peak temperature	None	
	Absorb and/or retain CO_2	None	

VI. Ecosystem Services Benefits

Ecosystem Services		Rating	Evidence
Provisioning	Food provision	High	Intercropping leads to a more efficient use of resources (light, water, nutrients...) and an increased productivity compared with each sole crop of the mixture (Lithourgidis, 2011). Research led in Zimbabwe showed that intercropped pigeonpea or cowpea can help to maintain maize yield when maize is grown without mineral fertilizer and in sandy soils (Waddington, 2007). Intercrops happen to increase light interception, reduce evaporation and improved conservation of the soil moisture (Ghanbari, 2010). This yield advantage can be observed when crops do not compete for the same ecological niches and when the interspecific competition for resources is weaker than the intraspecific competition.
	Water Storage	Low	According to Battany (2000), slowing runoff and increasing water infiltration improves water filling of the soil profile in winter and makes more water available for both crops during their growth.
	Fish stocks and recruiting	None	
	Natural biomass production	None	
Regulatory and Maintenance	Biodiversity preservation	Medium	Intercropping increases biodiversity into agrosystems by providing habitats for insects and soil organisms, which increase species richness (Lithourgidis, 2011).
	Climate change adaptation and mitigation	Low	

	Groundwater / aquifer recharge	None	
	Flood risk reduction	Medium	Intercropping increases infiltration: OMERE (2014) showed that infiltration on Mediterranean vineyards in France can reach 20mm/hour with grass when it remains less than 5mm/hour without (bare soil under vines). That contributes to groundwater/aquifer recharge.
	Erosion / sediment control	Medium	By covering bare soil areas with plants, intercropping reduce runoff (see above) thus erosion; it also reduces wind erosion compared to a bare soil. Shallow roots are effective in reducing erosion because they bind the soil at the surface. Zougmore calculated that intercropping reduced soil loss by more than 50% compared with sorghum and cowpea monocultures in Sahel (Zougmore, 2000)
	Filtration of pollutants	High	Intercropping is a way to increase biodiversity into agrosystems. Hauggard-Nielsen (2003) showed that increased biodiversity has a positive impact on limiting nutrients leaching losses.
Cultural	Recreational opportunities	None	
	Aesthetic / cultural value	None	
Abiotic	Navigation	None	
	Geological resources	None	
	Energy production	None	

VII. Policy Objectives

Policy Objective		Rating	Evidence
Water Framework Directive			
Achieve Good Surface Water Status	Improving status of biological quality elements	None	
	Improving status of physico-chemical quality elements	None	
	Improving status of hydromorphological quality elements	Medium	By covering the soil with plants and particularly shadow roots plants, intercropping contributes to stable the soil and reduce erosion (see above). Thus, sediments loss is reduced, which has a positive impact on hydromorphology status. Zougmore calculated that intercropping reduced soil loss by more than 50% compared with sorghum and cowpea monocultures in Sahel (Zougmore, 2000)
	Improving chemical status and priority substances	None	
Achieve Good GW Status	Improved quantitative status	None	
	Improved chemical status	None	
Prevent Deterioration	Prevent surface water status deterioration	Medium	Intercropping have a positive impact on filtrating pollutants and on reducing sediments loss (see above). Consequently, it has a beneficial impact on preventing surface water status deterioration.
	Prevent groundwater status deterioration	None	
Floods Directive			
Take adequate and co-ordinated measures to reduce flood risks		High	Given the positive impact of intercropping on reducing runoff (up to 4 time more infiltration (OMERE, 2014)) and slowing runoff (up to 50% according to Zougmore, 2000), intercropping contributes to reduce flood risk caused by drainage water from agricultural areas. It is thus one of the measures that can be implemented on agricultural lands to reduce flood risks.
Habitats and Birds Directives			

Policy Objective	Rating	Evidence
Protection of Important Habitats	None	
2020 Biodiversity Strategy		
Better protection for ecosystems and more use of Green Infrastructure	High	Intercropping provides more habitats in agro-systems (Lithourgidis, 2011). Moreover, increased biodiversity make crop systems more stable and resistant to pests (Lithourgidis, 2011). Intercropping is part of green infrastructures which can be implemented in order to reach policy objectives in Europe.
More sustainable agriculture and forestry	Medium	Intercropping is part of the measures increasing agriculture sustainability. Indeed, it enables maintaining good conditions for further cropping: soil fertility and structure preservation, agro-system resistance to pests and diseases. Intercropping also leads to improved efficiency in crops growing (Lithourgidis, 2011).
Better management of fish stocks	None	
Prevention of biodiversity loss	Medium	Strip cropping increases biodiversity into agrosystems by providing habitats (like hay), which can increase species richness.

VIII. Design Guidance

Design Parameters	Evidence
Dimensions	Intercropping dimension is the field one. Field dimensions can vary a lot across Europe; field size mean in France and Denmark is about 4ha (Latruffe, 2013) (Levin, 2006) but it can reach much more in some cases and much less in other countries or cases.
Space required	The required space corresponds to the dimension of the measure (field).
Location	Intercropping can be implemented on any field in any context (Stella consulting , 2012).
Site and slope stability	Slope constraints impact mostly on possibilities for mechanized agriculture. Conditions for intercropping depend on the type of crop (Stella consulting , 2012).
Soils and groundwater	Soil type can impact the choice for species introduced in the intercrop. Intercropping has been implemented on any soil depth.
Pre-treatment requirements	

Design Parameters	Evidence
Synergies with Other Measures	Intercropping is part of "soil conservation practices". It can be combined with soil management practices such as no tillage or reduced tillage. Combination of several agricultural measures related to soil conservation practices will enable reaching significant results on water status improvement and flood risk reduction.
Design recommendations	Mixtures have to be well thought in intercropping systems. Crops can gain or lose productivity depending on the companion crop. The main recommendation consists in choosing crops which will not compete for light, water, nutrients and space. For instance, efficient mixture can consist in deep-rooted and shallow-rooted plants, or tall with short crop. Efficient mixtures depend on the location and on the environmental conditions met. Cereals-legume association often happen to be energy-efficient due to legume capacity to fix nitrogen. Trees can also be part of intercropping systems (Lithourgidis, 2011).

IX. Cost

Cost Category	Cost Range	Evidence
Land Acquisition		
Investigations & Studies		
Capital Costs	Low	According to Stella Consulting (2012), capital cost for intercropping is low.
Maintenance Costs		
Additional Costs	110€/ha	Subsidies accorded for supporting intercropping development have been estimated to 110€/ha/year in Europe (Stella consulting , 2012).

X. Governance and Implementation

Requirement	Evidence
Efficiency demonstration: research and experimentation, exchanges, communication	Intercropping is implemented on private areas (fields) thus depends on farmers' strategy. Intercropping happens to have a positive or null impact on yields, but does not correspond to the common way of planning cropping in most part of Europe. Communication and diffusion of information, and demonstration, have an important role to play in convincing farmers to test intercropping and supporting them in choosing appropriate systems.
Coordination and animation	So as to be efficient on reaching some policy objectives, intercropping should be part of a wider program of measure and be considered at a sufficient scale. If implemented only on individual will and at field scale, the measure will not be sufficient to impact on water quality for instance. Coordination of measures and animation at a relevant scale (watershed) can make the implementation of the measure more efficient and relevant. Local authorities, local water or agricultural stakeholders (consular chambers, watershed agencies...) have a role to play.

XI. Incentives supporting the financing of the NWRM

Type	Evidence
CAP Pillar II: agri-environment-climate measures, organic farming	Intercropping is potential agri-environment and climate measure under article 28 of Regulation 1305/2013. It may also be encouraged under article 29 on organic farming.

XII. References

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A5: Intercropping

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