PROLINE-CE

WORKPACKAGE T1, ACTIVITY T1.2

REVIEW OF BEST MANAGEMENT PRACTICES FOR DRINKING WATER SUPPLY ISSUES

D.T1.2.1 Country-specific best management practice reports

ITALY

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1. Introduction

The aim of this concept is to provide the review of best practices regarding different types of land use (agriculture, grassland, forestry) respectively vegetation cover (wetland), aiming at water protection and mitigating floods, resulting from several studies lined out in former projects . The Best Practice Catalogue is partially derived from the SEE project CC-WARE and further projects respectively studies.

Best management practices are divided into the three clusters according to WP T2 (Pilots) and contain a general description, Measure advantages and challenges of the respective measure. Each measure is evaluated due to its respective water protection functionality, costs, duration of implementation and time interval of sustainability.

The name of best practice measure is created by the first letters of the respective cluster and its subcategories (for example BP MF1 – Best practice for mountain region, subcategory forest). If the relevant measure also fits to another cluster the respective additional valid cluster is added with brackets.

2. Mountain sites

Forest

Within the Italian national to regional legislations, the practices for forest management must comply with different norms and restrictions.

In general, such norms and restrictions, even if to be updated and mostly under their revision phase, meet the main objective of preserving the forest heritage against unauthorized cuts or silvicultural interventions threatening the ecological and economic sustainability. Moreover, due to the orography of forested areas in Italy, such norms have also a key role in preserving hydrogeological stability and the quality and quantity of water resources.

Mountainous forests are mainly represented by: a) coppice stands, intended as forest formations originating by vegetative multiplication (agamic reproduction) and made of sprouts growing out of the stool after cutting; b) high stands, having a gamic origin due to natural or artificial renovation.

Both types of forest, if well managed, can have ecological and economic benefits. Identified good practices for Italy, and strongly related to the protection of water resources and hydrogeological stability, are listed below, as identified by the Task Force "Environment National Rural Network", Working Group "Forests" in the context of the National Framework for the Forestry Measures in the Rural Development 2014-2020 (http://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/14582).

2.0.1. BP MF1 Well scheduled cutting turns

Description of the measure

The turn (or return period) is the time interval between two successive cuttings over the same surface. The minimum turn length, both for final harvests and intermediate cuttings, is defined In Italy by laws and Forestry Regulations and Policies. Such norms, having the objective to reduce the overexploitation of the topsoil and aboveground vegetation, vary from one region to another, and could be specific for some species or groups of species.

With a coppice harvesting applied too often (i.e. at short intervals) there is the risk of tree depletion and an increase of soil erosion processes. Increasing the turn duration, while maintaining the management type, could be a good practice, coherently with the species and fertility of the site so to maintain the regeneration capacity of the tree. The maximum efficiency could be reached alternating intermediate cutting (thinning, clearance; see BP MF3) and sustainable utilization cuts.

For even-aged high stands, rarely (mainly in case of pests or for stimulating natural renovation) they are treated with clear-cutting (all trees over a given surface or in small patches – gaps -, sized according to regulations, are cut), more often they are managed with successive cuts, i.e. different small environments are created that favour renovation and the utilization occurs at successive phases (seed, secondary and final exploitation) according to the procedure and the site characteristics. Multi-aged high stands are interested by selection cutting, choosing trees with all diameter classes, but without altering the forest structure.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)
- Improvement of the environment and rural spaces
- Climate change mitigation
- Landscape and biodiversity preservation
- Conservation of health and services of ecosystems

Challenges:

- If the turn become too long, trees are more aged and lose their regeneration capacity also threatening the ecosystem's equilibrium

2.0.2. BP MF2 Optimal dimensioning of cutting areas

Description of the measure

The dimension and continuity of coppice and high stand cutting areas are defined by laws and Forestry Regulations and Policies. Such norms, having the objective to reduce the overexploitation of the topsoil and aboveground vegetation, vary from one region to another. In general, the dimension and continuity of cutting areas influences the topsoil ecological equilibrium (by erosion), the slope hydrological stability (by collapse of the surrounding aboveground elements), and the landscape impoverishment due to cutting operations. The optimal surface to be cut is a compromise between economic and ecological criteria. For protecting water resources (quality and quantity) and limit the hydrogeological instability, proper measures could be: a reduction of the maximum combined areas allowed in case of utilization cuts; maintaining, for a greater number of cutting years than foreseen by regulations, both horizontal and vertical strips (respecting geomorphological and ecological criteria) enough wide to separate and fractionate aggregated surfaces or surfaces larger than allowed (e.g. strips along the contour lines to interrupt the cutting areas), and also to reduce the visual appearance of cuts; preservation of strips, to be interested by cutting only after the upstream stand is well regenerated. Care should be paid in areas with slope > 25% and with high to very high landslide hazards.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)
- Improvement of the environment and rural spaces
- Climate change mitigation and adaptation
- Landscape and biodiversity preservation
- Improvement of the natural renovation capacity of forests
- Benefit for species attracted by shady environments (sciaphilous)

Challenges:

- Excessive reduction of cutting areas impacts on the utilization costs, increasing the wood hauling costs and reducing the possibility, for the forest utilization enterprises, to benefit of scale and scope economies.
- Excessive reduction of cutting areas limit the possibility to monitor the damages by wild fauna to favour natural regeneration renovation establishment.
- Shortcomings for species attracted by sunny environments (heliophilous)

2.0.3. BP MF3 Intermediate cuttings

Description of the measure

Intermediate cuttings (cuts between establishment and productive harvesting) are not mandatory. Regulations to execute intermediate cuttings have the objective to reduce the overexploitation of the topsoil and the aboveground vegetation, and vary from one region to another. Such cuttings are rarely applied as not economically convenient, characterized by negative stumpage (i.e. gains less than expenses). However, some intermediate cuttings are important to guarantee and improve the ecological efficiency of forests, to safeguard the environment and the biodiversity, and to prevent forest fires as well as the diffusion of phyto-pathological disturbances. Thinning and clearance for selection and maintenance of sprouts over the stump in case of coppice, as well as interventions to remove the dry biomass and weeds for both coppices and high stands, contribute to topsoil stabilization, limit the wildfire risk and create conditions for improved ecological function and production of stands, and a re-naturalization of those forest plantations with protection purposes. Moreover, it is possible to conduct a more efficient management of the best trees and species still present in coppice stands and produce an economic advantage complementary to that due to wood production. Similarly, interventions directed to single trees allow maintaining high species diversity in aged coppices or high stands.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)
- Improvement of the environment and rural spaces
- Climate change mitigation
- Landscape and biodiversity preservation
- Increase resilience of species and ecosystems to fires and natural hazards
- Phytosanitary conditions improvement and prevention
- Improvement of the natural renovation capacity of forests
- For single adult trees, intermediate cuttings can increase their value, production and stability, favouring biodiversity and resilience

Challenges:

- Not economically opportune because of: the obtained wood, especially for young trees, has low market value; low accessibility; inappropriate mechanization.

2.0.4. BP MF4 Selection of species for utilization

Description of the measure

The cutting turn for coppice usually follows economic principles and consist of a clear-cutting for simple coppices or of coppice with standards, preferring the cutting of one or more species economically more relevant. Using not only economic criteria to select the species will allow valorisation of the stands, guaranteeing on the long term a greater species diversity and thus a higher stability of the soil and the aboveground vegetation.

Also for high stands, species selection is driven by economic principles (trees of the most valuable species, of interest for the market, are cut) while, to preserve the ecological equilibrium and ecosystem stability, the maintenance also of the main species, together with those more valuable, sporadic and uncommon, is preferable.

Under usual management practices, as well as under regulations and regional norms, it is already expected the preservation of an appropriate minimum percentage of species/trees with lower economic value, but this could be not sufficient.

Many uncommon and sporadic species, not yet included in the national or regional lists of protected species whose extirpation, removal and damaging are prohibited, have valuable functions for the forest ecosystems and are a resource to preserve the biodiversity of flora and fauna.

Proper actions in selecting species could be:

- Preservation, management and care, to favour growth and renovation, of additional uncommon, less represented and ecologically valuable species, or of more trees for these species if already identified, with respect to what indicated by the Regional regulation;
- Limitation of the standards coverage (in case of coppices), but compliant with regulations;
- Removal of allochthonous species, especially if highly flammable, to favour autochthonous ones;
- Realization of buffer strips with varying width, to reduce the visual impact of cutting areas;
- Valorising those management practices that increase structural diversity;
- Preservation of species useful to feed wild and domestic fauna, and humans;
- Preservation of valuable trees with indefinite ageing;
- Management interventions during cutting operations.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)
- Improvement of the environment and rural spaces
- Climate change adaptation
- Landscape and biodiversity preservation
- Improvement of the natural renovation capacity of forests
- Increase resilience of species and ecosystems to fires and natural hazards
- Phytosanitary conditions improvement and prevention

Challenges:

- Cutting of species with low economic value
- Trade-off with BP MF5 (increase of standards dimensions/numbers)

2.0.5. BP MF5 Preservation and selection of trees (standards) in coppices

Description of the measure

In the context of coppice management, the preservation of standards (tree with age equal or greater than the turn) is crucial to maintain the soil and vegetation, as they are the responsible of the gamic renovation of the stumps to substitute in the future the depleted ones. Both the number and the species of standards to be preserved depend on silvicultural, ecological, phytosanitary and economic factors. In some regions, a higher number of standards and/or the maintenance of standards in groups improve the ecological and growth conditions of coppices. Regional laws regulate the minimum number of standards (in case of a uniform distribution of them) and the dimension and spatial arrangements of clusters (in case of groups of standards) to preserve, providing obligations where usually, for economic reasons, a very low number of standards is maintained, with a high risk for the coppice forest maintenance on the long term.

Although remaining in the context of coppice management, for specific conditions a higher number and types of standards, and a larger dimension of their clusters, is preferable to assure higher ecological stability on the long term and an economic improvement of the stand. Planning in this sense is recommended, as usually decision on standards to be maintained are made during cutting operations, following criteria and regulations in terms of quantity and characteristics, but without a preliminary identification of trees, thus prejudging the environmental and forest protection purposes.

Proper actions in selecting standards could be:

- Selecting standards based on individual tree quality and health, and not on the quantity, with localized selection, also for the not dominant species, with trees to be thus added to those selected for the dominant species;
- Maintaining wider groups, or larger number, of standards with respect to regulations, according to their ecological and hydrogeological functions;
- Studying appropriate standards arrangements according to tree/stand age, fertility, spatial distribution, local conditions, complementary local uses (e.g. for grazing);
- Preservation of "biodiversity islands" well representing the local forest complexity, without intervention for at least one turn;
- Identification of standards by experts and specialized technicians before cutting operations.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)
- Improvement of the environment and rural spaces
- Climate change mitigation
- Landscape and biodiversity preservation
- Improvement of the natural renovation capacity of forests
- Migrating from simple coppice to coppice with standards or compound

Challenges:

- More costly planning and cutting operations
- Trade-off with BP MF4 (limitation of standards coverage)

2.0.6. BP MF6 Intensity and ways of cutting in high stands

Description of the measure

The utilization rate follow economic efficiency criteria and vary among regions, also in function of species, group of species and site characteristics. For proper implementation of silvicultural operations, studying and measuring biomass increments influence the ways and intensity of cutting interventions. The utilization rate is important to increase, besides the mandatory

thresholds, the sustainability of forest resources, from an environmental and economic point of view.

Proper actions could be, for multi-aged forests, reducing the utilization rate with respect to the increment following specific ecological and silvicultural needs, and planning silvicultural practices during selection cutting. For even-aged stands, a diversification of forest structure, still based on specific ecological and silvicultural needs, is an option.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)
- Improvement of the environment and rural spaces
- Climate change mitigation
- Landscape and biodiversity preservation

Challenges:

- Lower utilization and thus economic benefit

2.0.7. BP MF7 Cleaning and mowing of shrub and grass in the forest

Description of the measure

The cleaning and mowing of shrub and grass vegetation within forest formation is made principally to prevent forest fires, to facilitate silvicultural operations and for the defence of hydrogeological stability. Also, the presence of clearing and marginal areas has a key role in preserving zones with high natural values and connected biological diversity. These areas also safeguard the structure, composition, mosaic and historical characteristics of the landscape. National to regional laws and norms regulate these interventions.

Proper interventions could be: cleaning and mowing in clearing, open and ecotone areas, along riparian strips, road borders, sites of wood storage after cuts, and fire roads, also to be implemented through controlled grazing.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)
- Improvement of the environment and rural spaces

- Climate change adaptation
- Landscape and biodiversity preservation
- Improvement of the natural renovation capacity of forests
- Increase resilience of species and ecosystems to fires and natural hazards

Challenges:

- Costs of operations

2.0.8. BP MF8 Optimization of cutting operations

Description of the measure

Techniques and methods adopted for organizing the cutting operations have a fundamental importance in terms of impacts on soil, shrubland vegetation and renovation. For that concerning cutting practices, the adoption of systems that preserve soil stability and do not damage the underlying vegetation, mainly for multi-aged high stands (subjected to selection cutting) is very important.

For operations' purposes, there are different equipments and preparation activities. The whole tree could be prepared, or only the floor where the short wood drops (fall substrate). The former foresees the hauling of the tree completed with branches that are successively organized at the wood storage site, the latter consists in organizing wood and then hauling it already sorted, and is characterized by lower productivity.

Good options are:

- to promote the use of techniques at low impact for wood hauling and concentration;
- preparation of dropped trees over the fall substrate as practice at low environmental impact that limits the effects on soil from wood dragging during concentration phase;
- temporal limitation of the forestry exploitation to reduce impacts on soils, as well as the negative effects over the wild fauna during the reproduction and migration period;
- limiting the forestry exploitation in reproduction areas for key animal species activities;
- extension of the cutting turns and creation of reserve areas not subjected to cutting within production forests.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)

- Improvement of the environment and rural spaces
- Landscape and biodiversity preservation
- Phytosanitary conditions improvement and prevention

Challenges:

- If the turn become too long, trees are more aged and lose their regeneration capacity also threatening the ecosystem's equilibrium
- Reduction of areas available for cutting
- More costly operations

2.0.9. BP MF9 Managing residues of cutting operations

Description of the measure

The management of cutting operation residues (brushwood, leaves, lops) could have positive or negative effects in function of site's environmental characteristics. Residues give nutrients to the soil creating a micro-habitat useful to sustain biodiversity, they reduce the rain drop impact over the surface and increase the runoff time limiting soil erosion. At the same time, leaving these residues on the soil can: in case of steep slopes and during intense meteorological events, cause relevant damages to the runoff by obstructing the bridges' spans or the filtering weirs of small watercourse; reduce the radiation reaching the soil so limiting the natural renovation of vegetation; limit carbon sequestration; make difficult the harvesting of non-wood products; obstacle the wild fauna; or cause fires triggering or propagation.

Proper management of operations' residues has benefits for the environments, in preventing fires and the diffusion of pathogens. Moreover, the wood chipping can foster the consumption of other fuels than fossil ones, and the development of short chains.

Good practices consist in:

- Removal of the residues to be used for energetic use.
- Chipping and/or grinding, distribution and spread on the soil to favour quick decomposition and organic inputs and reduction of windrow and heap size.
- Avoid burning of residues after above interventions.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)

- Improvement of the environment and rural spaces
- Climate change mitigation
- Increase resilience of species and ecosystems to fires and natural hazards
- Phytosanitary conditions improvement and prevention

Challenges:

- Costs of operations

2.0.10. BP MF10 Managing new-establishing forests

Description of the measure

New-establishing forests, with natural and autochthonous origin, recently (i.e. in the last 15 years) developed after the reduction of agricultural activities and the abandonment of grazing area in mountain sites; they are characterized by phyto-sociological uniformity.

Proper management of these forests could contribute to climate mitigation, biodiversity conservation and to the hydrogeological defence.

Moreover, in terms of production, if well managed since their sapling to pole stages, such formations could be in the medium to long terms an important economic resource, especially for mountainous areas with lower slope and with better soils with respect to the surroundings.

Usually the management of these forests is similar than for other forest types, so driven by economic purposes, and directed to the species with highest economic value.

Good additional options could be:

- Recovery of some antecedent conditions, as open areas and areas to control the forest advancement, or the reactivation of some agriculture and grazing;
- Removal of invasive species to valorise autochthonous valuable species, or sporadic species at risk of disappearing, also through silviculture directed to single trees;
- Planting of precious allochthonous species to increase phyto-sociological complexity, the biodiversity, the resilience to fires, the regulation of the water flow and slope stabilization;
- Favouring natural evolution with site-specific management toward reduction of hydrogeological instability and forest fires, and limiting grazing within new forest areas;
- Mycorrhization and inoculation with mycelium or symbiotic bacteria.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)
- Climate change adaptation and resilience
- Improvement of the environment and rural spaces
- Increase resilience of species and ecosystems to fires and natural hazards
- Landscape and biodiversity preservation
- Phytosanitary conditions improvement and prevention
- Improvement of ecosystem services as wood production
- Favouring of scale economy and short chain

Challenges:

- Interventions are highly site-specific and a right compromise among options is needed

Grassland

2.1.1. BP MG1 Soil management

Description of the measure

In steep slope zones with degraded grazing areas, even after fire burning, that under peculiar geomorphological conditions generate erosion, solifluction and landslide phenomena, transversal water-holding furrows and transversal to longitudinal ditches are useful in the short and medium term on the hillslope and hydrographic basins. However, grazing should be prohibited, in case of fires, for the five years after fire (http://www.isprambiente.gov.it/it/pubblicazioni/manuali-e-linee-guida/linee-guida-per-la-valutazione-del-dissesto-idrogeologico-e-la-sua-mitigazione-attraverso-misure-e-interventi-in-campo-agricolo-e-forestale).

Measure advantages:

- Water regulation, reduction of sheet and rill erosion
- Reduction of solifluction and landslides
- Reduction of floods thanks to longer concentration time (time from the rain dropping the soil to reaching the basin outlet)
- Higher edible surface for animals, thanks to the maintenance of organic matter
- Soil improvement (organic and mineral elements)
- Time for recovery of soil after fire.

Challenges:

- Not appropriate for some type of topography and soils (e.g. geo-mechanical characteristics of clays)
- Work risks and economic costs for operations

2.1.2. BP MG2 Plantation of tree-shrub lines

Description of the measure

Using appropriate and autochthonous species, permanent and visible field borders in steep slope areas could be established through lines of tree and shrubs. They could serve also to produce wood for energy purposes (estimated as 0-200 euro per km). It is estimated a maintenance of organic matter thanks to this practice of about 10t/ha/yr (http://www.isprambiente.gov.it/it/pubblicazioni/manuali-e-linee-guida/linee-guida-per-la-valutazione-del-dissesto-idrogeologico-e-la-sua-mitigazione-attraverso-misure-e-interventi-in-campo-agricolo-e-forestale).

Measure advantages:

- Reduction of sediment transport and of runoff
- Increase of infiltration on the hillslope
- Increase of the biodiversity for flora and fauna, providing opportunities for biological control, natural or anthropic
- Refuge for wild fauna
- Creation of ecological corridors and increase of the landscape value

Challenges:

- Loss of surface for grazing, however balanced by greening payments of the CAP

Agriculture

2.2.1. BP MA1 Optimized application of phytosanitary products

Description of the measure

Several studies have demonstrated that around 50% of contamination of superficial water bodies is due to an incorrect use of phytosanitary products during transportation, storage, application and waste management (http://www.topps-life.org/it---documents.html). Besides being careful in the moving and conservation of products, especially when planning field operations, it is crucial to identify vulnerable areas to pollution (e.g. if there are wells not appropriately protected or highly permeable soils), and it is recommended to not apply products in case of soil covered by ice, snow or water, or if weather forecasts predict heavy rains. Then, sprayers should be completed with sippy devices.

Measure advantages:

- Reduction of pollution risk for soil and superficial and underground water bodies

Challenges:

- More costly operations
- Not timely operations if weather and soil conditions do not recommend applications

2.2.2. BP MA2 Reducing runoff of phytosanitary products and fertilizers

Description of the measure

Three information are fundamental to estimate the risk of phytosanitary products distributed by runoff when infiltration capacity is reduced: the distance from the water body, soil permeability, slope. Briefly, according to the results of the LIFE project TOPPS (http://www.topps-life.org/it---documents.html), for fields close to the water bodies, the risk is high when: permeability is low and the slope is medium-high (>2%), or when permeability is medium but under high slope (>5%).

Some more information is needed when runoff generates from soil saturation, and the risk is high when, in absence of artificial drainage, there is a lower layer due to ploughing plus any other interruption of permeability along the vertical of the soil, for any value of water holding capacity.

In both cases, if runoff generates from soil reduced infiltration or increased saturation, if the field is not adjacent to water bodies the contamination risk is high if the runoff finds the way to reach the water body.

Best practices consist of: minimum tillage; tillage along the contour lines; conducting a cultivation with interrupted or alternated strips; establishing vegetated buffer strips within thalwegs; establishing hedges or forested strips; building retention or dispersion structures (thanks and constructed wetlands) or canals and vegetated ditches. These practices could be also combined. For icy soils, at risk of erosion during thawing or snow melting, the hillslope length could be reduced through cultivation arranged in bands, buffer strips and hedges in the fields. Buffer strips could be established also at the borders of water courses.

An experimental study in the Chienti basin in Italy, demonstrated that buffer strips of 5 m between the agricultural areas and water course reduced pollutants by 90% over 60% of the surface (http://www.isprambiente.gov.it/it/pubblicazioni/manuali-e-linee-guida/linee-guida-per-la-valutazione-del-dissesto-idrogeologico-e-la-sua-mitigazione-attraverso-misure-e-interventi-in-campo-agricolo-e-forestale).

No tillage or minimum tillage, also combined with cover crop and cultural rotation reduce also soil degradation (http://eusoils.jrc.ec.europa.eu/projects/soco-soil-conservation).

All that is applicable also to prevent pollution/contamination from fertilizers.

Measure advantages:

- Reduction of the risk of pollution and contamination of water bodies (ditches, rivers, lakes up to the sea)
- Increase of the deep infiltration capacity, reducing sediment transport and sheet erosion
- Increase of soil organic matter in the superficial soil layers allowing reducing the use of pesticides and herbicides, safeguard of the groundwater, and organic carbon stock
- Increase of the soil biomass, favouring macro-pores that increase water infiltration and resistance to compaction

Challenges:

- Costs of practices implementation, of mechanization and of training
- Practices occupy a surface no more devoted to cultivation, however the loss of surface is counterbalanced by CAP payments for greening

2.2.3. BP MA3 Soil management

Description of the measure

In steep slope areas with arable crops that, under peculiar geomorphological conditions generate erosion and landslide phenomena, transversal water-holding furrows (e.g. 30 cm depth) and transversal to longitudinal ditches (e.g. 50x50 cm), or ploughing according the contour line (over slope between 10-20%) or just over the surface (first 25-30 cm of soil) are useful in the short and medium terms on the hillslope and hydrographic basins. Some experimental data from the Research Center on Agrobiology and Soil of the Council for Agricultural Research and Agricultural Economics Analysis (CREA) show that without water furrow erosion is 33t/ha/yr, decreasing to 10t/ha/yr in case of furrows (-67%)(http://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/3984).

Measure advantages:

- Water regulation, reduction of sheet and rill erosion
- Reduction of solifluction and landslides
- Reduction of floods thanks to longer concentration time (time from the rain dropping the soil to reaching the basin outlet)
- Higher agricultural productivity, thanks to the maintenance of organic matter
- Soil improvement (organic and mineral elements)
- Minor need of mineral fertilizers
- Minor sediment deposition into reservoirs, improving water availability, less maintenance costs and higher hydropower production (cost saving estimated in about 120M euros).

Challenges:

- Not appropriate for some types of topography and soils (e.g. geo-mechanical characteristics of clays)
- Risks and economic costs for operations

2.2.4. BP MA4 Plantation of tree-shrub lines

Description of the measure

Using appropriate and autochthonous species, permanent and visible field borders in steep slope areas could be established through lines of tree and shrubs. They could serve also to produce wood for energy purposes (estimated as 0-200 euro per km). It is estimated a maintenance of organic matter thanks to this practice of about 10t/ha/yr (http://www.isprambiente.gov.it/it/pubblicazioni/manuali-e-linee-guida/linee-guida-per-la-valutazione-del-dissesto-idrogeologico-e-la-sua-mitigazione-attraverso-misure-e-interventi-in-campo-agricolo-e-forestale).

Measure advantages:

- Reduction of sediment transport and of runoff
- Increase of infiltration on the hillslope
- Increase of the biodiversity for flora and fauna, providing opportunities for biological control, natural or anthropic
- Refuge for wild fauna
- Creation of ecological corridors and increase of the landscape value

Challenges:

- Loss of surface for the cultivation, however balanced by greening payments of the CAP

2.2.5. BP MA5 Maintenance of terraced agricultural areas

Description of the measure

Concerning permanent crops over terraced hillslopes, it is fundamental here to guarantee function of walls and embankments with grassy slope to avoid instability and loss of soil. Soil erosion can be reduced of 10-40 t/ha/yr (-200/-500%) (http://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/3984).

The main practices consist in removing weeds from walls, recovering drainage systems and crown of the drywall, and in placing grass among tree lines (in general for olive and vineyards and citrus groves) or grass or shrubs over terrace cliffs. More invasive practices are the recovery of the walls in their more instable parts. Ordinary maintenance should be every 2 years.

This allows recovery or maintaining PDO and PGI cultivations, together with landscape improvements also favouring tourism.

Measure advantages:

- Recovery of historical agricultural activities with high added value
- Reduction of soil erosion, landslide and hillslope instability
- Improvement of hydrological, ecological and structural efficiency
- Landscape safeguarding also for touristic purposes

Challenges:

- Risks and economic costs for operations

Table 1. Mountain sites - Relevance of measures

Mountains	Water protection functionality	Cost of the measure	Duration of implementation	Time interval of sustainability
BP MF1	Medium	Low	Short periodically	High
BP MF2	Medium	Medium	Short periodically	High
BP MF3	Medium	Medium	Short periodically	High
BP MF4	Medium	Medium	Short periodically	High
BP MF5	Medium	Medium	Short periodically	High
BP MF6	Medium	Medium	Short periodically	High
BP MF7	High	High	Short periodically	High
BP MF8	High	High	Short periodically	High
BP MF9	High	High	Short periodically	High
BP MF10	High	Low	Medium	Medium
BP MG1	High	High	Medium	Medium
BP MG2	High	High	Short	Medium
BP MA1	High	Medium	Short periodically	Medium
BP MA2	High	High	Medium	Medium
BP MA3	High	High	Medium	Medium
BP MA4	High	High	Short	Medium
BP MA5	High	High	Medium	Medium

3. Plain sites

Agriculture

3.0.1. BP PA1 Optimized application of phytosanitary products

Description of the measure

Several studies have demonstrated that around 50% of contamination of superficial water bodies is due to an incorrect use of phytosanitary products during transportation, storage, application and waste management (http://www.topps-life.org/it---documents.html). Besides being careful in the moving and conservation of products, especially when planning field operations, it is crucial to identify vulnerable areas to pollution (e.g. if there are wells not appropriately protected or highly permeable soils), and it is recommended to not apply products in case of soil covered by ice, snow or water, or if weather forecasts predict heavy rains. Then, sprayers should be completed with sippy devices.

Measure advantages:

- Reduction of pollution risk for soil and superficial and underground water bodies

Challenges:

- More costly operations
- Not timely operations if weather and soil conditions do not recommend applications

3.0.2. BP PA2 Reducing runoff of phytosanitary products and fertilizers

Description of the measure

According to the results of the LIFE project TOPPS (http://www.topps-life.org/it---documents.html), in low lying agricultural fields, the risk of runoff for phytosanitary products is high when soil saturates, in particular when, in absence of artificial drainage, there is a lower layer due to ploughing or any other interruption of permeability along the soil, and water holding capacity is < 120 mm, or when lower ploughing surface is combined with additional impermeable layers within the soil for any value of water holding capacity.

If the field is not adjacent to water bodies, the contamination risk is high if the runoff finds the way to reach the water body.

Best practices consist in: minimum tillage; tillage along the contour lines; conducting a cultivation with interrupted or alternated strips; establishing vegetated buffer strips within thalwegs; establishing hedges or forested strips; building retention or dispersion structures (thanks and constructed wetlands) or canals and vegetated ditches. For icy soils, at risk of erosion during thawing or snow melting, the hillslope length could be reduced through cultivation arranged in bands, buffer strips and hedges in the fields. Buffer strips could be established also at the borders of water courses.

An experimental study in the Chienti basin in Italy, demonstrated that buffer strips of 5 m between the agricultural areas and water course reduced pollutants by 90% over 60% of the surface (http://www.isprambiente.gov.it/it/pubblicazioni/manuali-e-linee-guida/linee-guida-per-la-valutazione-del-dissesto-idrogeologico-e-la-sua-mitigazione-attraverso-misure-e-interventi-in-campo-agricolo-e-forestale). In addition, low lying fields could suffer from concentrated runoff generated from upstream fields or in the filed itself.

In this case best practices could be: the interception of the runoff from the upstream through buffer strips and retention structures; the appropriate orientation and width of operations' roads; reduce soil compaction in the access area to the field; double seedling, buffer strips or retention thanks (or other structures as hedges or small wetlands) at the border of the field, along channels and thalweg; establishing buffer strips also inside the field to interrupt the dimension of the cultivation area; adopting minimum tillage; filling erosion furrow.

No tillage or minimum tillage, also combined with cover crop and cultural rotation, contribute to reduce also degradation (http://eusoils.jrc.ec.europa.eu/projects/soco-soil-conservation).

All the above practices could be also combined and applied to prevent pollution/contamination from fertilizers.

Measure advantages:

- Reduction of the risk of pollution and contamination of water bodies (ditches, rivers, lakes up to the sea)
- Increase of the deep infiltration capacity, reducing sediment transport and sheet erosion
- Increase of soil organic matter in the superficial soil layers allowing reducing the use of pesticides and herbicides, safeguard of the groundwater, and organic carbon stock
- Increase of the soil biomass, favouring macro-pores that increase water infiltration and resistance to compaction

Challenges:

- Costs of practices implementation, of mechanization and of training
- Practices occupy a surface no more devoted to cultivation, however the loss of surface is counterbalanced by CAP payments for greening.

3.0.3. BP PA3 Crop diversification

Description of the measure

Within cultivated lands, diversification of crops, by increasing perimeters among fields, could be useful. This allows various scheduling of sowing, cultivation and harvesting, due to different phenological phases of the crops, reducing time between clod breaking and sowing.

Measure advantages:

- Increase of biodiversity in the area, for general fauna and insect, fundamental for the defence from biotic disturbances.
- Reduction of erosion and increase of infiltration, both from direct rainfall and from runoff.
- Natural control of weeds, reducing use of herbicides

Challenges:

- More complex operations in the field because of spatial and temporal diversification

Wetland

3.1.1. BP PW1 Technical measures, defence measures

Description of the measure

Measures for reducing the risks of climate change to the wetlands have traditionally based on supply-side options (Rilasciati & Clini 2002[1]). For instance, the implementation of coastal defence measures, including artificial reefs (shore parallel rock mound structures), near shore breakwaters, artificial channelling and drainage, and feeding (generally in high-profit touristic areas) (OrientGate 2014[2]). For the delta parts, this measure is implemented by the construction of new dams, reservoirs and pipelines. These engineering designs are based on knowledge of wide range of scientists such as hydrologists, civil engineers, water planners, and water managers. Practically, each engineering work is designed to protected human and ecosystem, within its lifetime, from extreme events based on the recorded historical data (e.g. climate and hydrological data).

Measure advantages:

- These interventions increase the the steadiness of shores and touristic attractiveness;
- These kinds of constructions usually affect immediately in term of mitigation in the short time horizon;
- High protection degree in selected location and designed site.

Challenges:

- These measures contribute to reduce their resilience to coastal erosion and increase marine/coast habitat vulnerability as well as environmental degradation;
- Climate changes are likely to produce – in some places and at some times – hydrologic conditions and extremes of a different nature than current systems were designed to manage;
- Climate changes may produce similar kinds of variability but outside of the range for which current infrastructure was designed and built;
- This approach assumes that no special efforts or plans are required to protect against surprises or uncertainties;

[1] Rilasciati, L.V. & Clini, C., 2002. Italy country base line study water, wetlands, and climate change. , (December).
[2] OrientGate, W., 2014. State of art on mitigation and adaptation plans and identification of cross sectoral links.

- The climate change impacts could turn out to be different from that expected, then investments in these measures could have been wasted (Rilasciati & Clini 2002).
- Highly require investment and civil work;
- Require operating rules, contingency plans, and water allocation policies under a wider range of climate conditions.

3.1.2. BP PW2 Enlarging wetland areas

Description of the measure

This measure can be implemented by creating artificial lakes, lagoons and retention areas or enlarge current wetland areas in order to storage runoff, regulate water resources for flood control, irrigation and hydropower, and maintain the quality of water (OrientGate 2014). Sometimes, the designed and operated human-made wetlands may provide a range of services well beyond the primary aim for their construction. For instance, provision of habitat and wildlife diversity, support of recreational activities such as walking, bird- and wildlife watching, water storage during periods of shortage and excess, and aesthetic value in urban environments (Bergh et al. 2009[3]). The researchers recommended a four-step process. Firstly, there should be clarification of the local requirements and limitations of the wetland and secondly, a definition of the spatial scale of the project. Thirdly, if more than one objective is pursued then conflicts and compatibilities should be identified and investigated before finally defining a strategy (ENV 2012[4]).

Measure advantages:

- Storage and regulate water resources, e.g. enhancement of recharge to groundwater, flood control during flood season, ensure water regime during dry season;
- Water quality improvements: reduction of nutrient load, sediment and purify water;
- High potential for landscape and waterscape;
- Provide recreational areas for local residents.

Challenges:

[3] Bergh, V. Den et al., 2009. The Values of Natural and Constructed Wetlands: A Meta-Analysis., (Ivm)

[4] ENV, E.C.D., 2012. Natural Water Retention Measures. Science for Environment Policy newsletter, (32).

- This measure possibly changes the natural hydrological condition such as flow rate, velocity and component of flow. Therefore, applying this technical measure requires a careful consideration and provision as well as accurate regulation plan;
- Highly required investment and civil work.

3.1.3. BP PW3 Behavioural strategies

Description of the measure

This measure encompasses actions that promote awareness for the altered conditions under climate change and adaptation. For instance, changing location of recreational facilities, infrastructure and related things far from vulnerable and dangerous areas such as costal line and flooded areas (OrientGate 2014). Awareness raising, or climate change awareness raising, plays an important component of this adaptation process to manage the impacts of climate change, enhance adaptive capacity, and reduce overall vulnerability. Awareness raising addresses the knowledge of individuals and organisations. It aims to ensure that all relevant regional and sub-regional bodies understand the impacts of, and take actions to respond to certain climate impacts. Awareness raising can be delivered through various form of media, for instance through television, internet, and newspapers.

Measure advantages:

- This strategy has Measure advantages in the reduction of receptors (exposure elements) exposing to hazards, thus leading to reduction of economically substantial losses;
- Require low investment cost in which places have not been invested;
- Strengthen awareness raising among communities;
- Have long-term effects on mitigating the impacts of climate change.

Challenges:

- The implementation of this measure requires huge investment for moving the existence infrastructure;
- Strongly require political decisions;
- It does not work in some particular places such as heritage sites, reserved sites, traditional infrastructure and habitats;
- Required long-term campaign for implementation, monitoring and assessment.

3.1.4. BP PW4 Political decisions

Description of the measure

Guidelines for the protection of wetlands have been defined, it based on integration of both Ramsar and CBD Convention with the Bird and Habitat Directives, Water Framework Directive and the Marine Strategy Framework Directive. Other possible option can be the land use planning (e.g. Regional Coastal Plan of Puglia, 2011).

Measure advantages:

- This guideline has been considered one of the case studies of the working group set up by the European Commission dealing with the integration of European Directives;
- No need to involve large investments of public resources.

Challenges:

- There is a difficulty in the practical application of these legislation due to the difficulty in interpretation, sometimes contradictions, financial and/or technical gaps and insufficient control;
- Monitoring exists, but there are some gaps about measured components, spatial density of the monitoring points and the frequency of measurements.

3.1.5. BP PW5 Capacity buiding

Description of the measure

Many activities of education, communication and information on environmental issues and on climate change for citizens and schools are carried out in coordination by different structures: the Provincial Agency for Environmental Protection, the network of environmental educators for sustainable development, the Science Museum of Trento, the Adamello Brenta Natural Park. Other activities undertook in such sense are the organization of periodic events of information with public lectures, scientific conferences, workshops and theatre performances, to discuss the issues of climate change and their implications such as: “Trentino Clima 2008“ (Trento 20-24 february 2008); “Climatica…mente cambiando – Trentino Clima 2011” (Trento, 5-10 september 2011).

Measure advantages:

- This measure captures wide range of participants from administration to civils, thus, has influence to a huge range of subjects;

- No need to involve large investments of public resources.

Challenges:

- Participants, both at the waterworks and administration, are required a sufficient professional experience and knowledge to comply with new challenges in term of new practices and new technologies;
- The short-term economic gains of this strategy are relative low and they could be easily dissipated by the impact of future climate events.

3.1.6. BP PW Recreation plans

Description of the measure

The recreation plan consists of two parts: (i) reshaping the site's morphology, and (ii) providing infrastructures for recreational goals. The first part for all the wetlands consists of placement of vegetation to improve water quality by trapping nutrients and to increase the attractiveness of the site, as well as opening opportunities for wildlife. Also, in those sites in which water quality has worsened because water circulation is compromised, reshaping must include moderate excavation to restore earlier hydraulic conditions in this respect (Bodini et al. 2000).

Measure advantages:

- The creation of a natural reserve does not cost much as no intervention is planned to restore environmental quality in those sites. This is justified by the fact that only wetlands that are not severely degraded will occupy the best positions in the multicriteria scheme, and good environmental conditions will be restored simply by prohibiting human access. Thus, the only financial requirement for natural reserves is for surveillance;
- Water quality improvement;
- Creation of land for local habitats.

Challenges:

- Since different wetland areas have different characteristics, the implementation of this measure requires a careful analysis (e.g. economic analysis, multi-criteria analysis, and stability analysis) with wide range of participants and stakeholders;
- Modify morphological conditions and hydrological conditions.

3.1.7. BP PW Wetland restoration

Description of the measure

Wetlands perform multiple essential functions including flood and erosion management, climate and water regulation. Wetlands induce wave and tidal energy dissipation and act as a sediment trap for materials, thus helping to build land seawards. The dense root mats of wetland vegetation also help to stabilise soil and sediments, thus reducing erosion. Wetland restoration means re-establishes these advantageous functions for the benefits of floods, erosion and water protection. Restoration of existing wetland ecosystems and their services is required as they have been increasingly degraded by both natural and human activities. Different kinds of techniques can be used to reintroduce wetlands in areas where they previously existed depending on the habitat type and the level of degradation. In terms of flood and water quality protection, the main benefit of wetland restoration is related with their function to act as "buffer zone", improving flooding and erosion protection by reducing incoming wave and tidal energy. This is achieved by increasing the roughness of the surface over which incoming waves and tides travel (Nicholls et al., 2007b). In contrast to hard defences, wetlands are capable of undergoing 'autonomous' adaptation to increase sea levels, through increased accumulation of sediments to allow the elevation of the wetland to keep pace with changes in sea level (Nicholls & Klein, 2005). In this way, coastal wetlands also provide a natural barrier to salt water intrusion into coastal aquifers, which can be maintained without additional investiments. Restored wetlands also provide a number of additional ecosystem services including water quality and climate regulation, representing valuable accumulation sites for sediment, contaminants, carbon and nutrients coming from productive activities located upstream.

Challenges of wetland restoration are minimal if compared with benefits provided.

Measure advantages:

- Improve surface and ground water quality by collecting and filtering sediment, nutrients and pesticides in runoff;
- Reduce soil erosion and downstream floods by slowing overland flow and storing runoff water;
- Wetland plants and ponded conditions utilize trapped nutrients, restore soil organic matter and promote carbon sequestration;
- Provide food, shelter and habitat for many species and enable the recovery of rare or threatened plant communities;
- May significantly reduce sea water intrusion into coastal aquifers;
- Improve groundwater supply recharge by slowly releasing water into the ground;
- Provide recreational and aesthetical functions.

Challenges:

- Require large surfarce to be implemented which is likely to create conflicts with alternative land uses (i.e. agriculture, forestry);
- Require a degree of expertise, especially in locations where wetland re-colonisation has to be encouraged by transplanting wetland plants.

3.1.8. BP PW Artificial wetlands for water treatment

Description of the measure

Implementation of artificial or constructed wetlands with the purpose of treating anthropogenic discharge such as municipal or industrial wastewater, stormwater or agricultural runoffs.They may also be created for land reclamation after mining, refineries, or other ecological disturbances which required mitigation. Constructed wetlands are engineered systems that use the natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist in treating and purify waters. They are designed to take Measure advantages of the same processes that occur in natural wetlands, but within a more controlled environment. Although these processes are slower, comparing with the high-rate processes held in conventional treatment systems, they treat wastewaters reliably and continuously if properly designed and without additional costs. Constructed wetlands have been implemented and tested in pilot sites at national level while a considerable record of experience and design practice has been documented all over Europe demostrating their efficiency in removing nutrients (i.e. phospouros and nitrogen), metals and metalloids from wastewaters. Specifically, some of these systems are designed with the sole purpose of treating wastewater while others are implemented with multiple-use objectives in mind, such as using treated wastewater effluent as a water source for the creation and restoration of wetland habitat for wildlife use, environmental and biodiversity enhancement.

Measure advantages:

- Less expensive than other wastewater treatment systems, regarding construction and maintenance cost;
- Provide effective and reliable water treatment under fluctuating hydraulic and contaminant loading rates;
- Treated wastewater can be finally reused for irrigation and/or other purposes;
- Provide flood regulation and aesthetic functions as they can become suitable habitat for terrestrial and aquatic wildlife;
- Cost-effective and environmentally friendly treatment.

Challenges:

- Require high land area to be implemented;
- High water retention time may cause problems with pest and pathogens diffusion.

Forest

3.2.1. BP PF1 Intermediate cuttings (high stands)

Description of the measure

Intermediate cuttings (cuts between establishment and productive harvesting) are not mandatory. Regulations to execute intermediate cuttings have the objective to reduce the overexploitation of the topsoil and the aboveground vegetation, and vary from one region to another.

Such cuttings are rarely applied as not economically convenient, characterized by negative stumpage (i.e. gains less than expenses). However, some intermediate cuttings are important to guarantee and improve the ecological efficiency of forests, to safeguard the environment and the biodiversity, and to prevent forest fires as well as the diffusion of phyto-pathological disturbances.

Interventions to remove the dry biomass and weeds for high stands contribute to topsoil stabilization, limit the wildfire risk and create conditions for improved ecological function and production of stands, and a re-naturalization of forest plantations with protection purposes. Moreover, it is possible to conduct a more efficient management of the best trees and species and produce an economic advantage complementary to that due to wood production. Similarly, interventions directed to single trees allow maintaining high species diversity in high stands.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)
- Improvement of the environment and rural spaces
- Climate change mitigation
- Landscape and biodiversity preservation
- Increase resilience of species and ecosystems to fires and natural hazards
- Phytosanitary conditions improvement and prevention
- Improvement of the natural renovation capacity of forests
- For single adult trees, intermediate cuttings can increase their value, production and stability, favouring biodiversity and resilience

Challenges:

- Not economically opportune because of: the obtained wood, especially for young tree, has low market value; low accessibility; inappropriate mechanization.

3.2.2. BP PF2 Tree farming for wood

Description of the measure

A special case to consider is the farming of trees to sustain industrial and energetic use of wood. Tree farming is not considered "agriculture" but "forestry", but as it is conducted over agricultural areas, it is subjected to both forestry and agricultural practices, and falls in between the extensive managed forests and the intensive agriculture in terms of impacts.

Tree farming could consist in:

- Plantations with medium-long cycle (20-40 years) to produce wood valuable for the industry. These plantations could be pure or mixed with prevalence of autochthonous needleleaves, with or without accessories species, possibly subjected to more cycles;
- Plantations with short cycles (8-15 years) to produce wood valuable for the industry, with single species and usually monoclonal (poplar plantations);
- Plantation with very short cycles (less than 8 years) to produce biomass for panel industry or for energetic production, single species and usually monoclonal.

Tree farming is important also for the environment: it represents a landscape peculiarity and a cultural asset of some areas in the country; it fixes CO2, contributing to climate mitigation; it is a unique habitat for animal biodiversity, and a refuge and ecological corridor in agricultural areas. Tree farming provides many positive externalities: phytoremediation, absorption of heavy metals and pollutants, stabilization of riparian banks and protection strips etc.

Intensive tree farming in Italy is located in Lombardia, Piemonte, Veneto, Emilia Romagna and Friuli Venezia Giulia and consists of monoclonal plantations, as poplars, mixed to numerous traditional agricultural activities and many external inputs due to application of fertilizers, pesticides and phytosanitary products, or because of an inappropriate re-input of nutrient removed from the soil (for short rotation forestry, e.g. willows, eucalyptus, locusts) which causes a loss of fertility and a reduction in productivity.

Regional to local regulations fix minimum turns and in some case the re-planting is mandatory to preserve the landscape, but without giving instructions on the size of cutting, on how preserving natural vegetation, on the use of fertilizers and pesticides, or on the use of multi-clonal elements.

Good practices could be:

- Multi-species or multi-clonal (at least two) and multi-cycle plantations, to differentiate the stand composition and increasing the resilience to biotic and abiotic disturbances.

- Maintaining clonal species and hybrid poplars for at least 12 years, with the possibility to prune a least 90 poplars/ha during the commitment period.
- Planting permanent hedges at the plantation borders, made of autochthonous trees or shrubs, to increase the vegetation complexity, the plantation biodiversity, and to create semi-natural environments favourable for the animal fauna (with distance among hedges that do not threaten the principal cultivation).
- To favour the recovery of riparian forest environments and the management of fluvial areas, thanks to permanent multi-cycle plantations associating on the same area clonal species (poplar), or mixtures of genotypes, and valuable needleleaves, so alternating production cycles and never fully removing the tree cover so assuring ecological value and permanent tree corridors;
- Establishment and management of natural grass between tree lines to favour rainwater harvesting, but in quantity that does not favour fire propagation.
- Soil tillage under dry farming and/or close to trunks, to increase carbon sequestration in the soil and mitigate climate change;
- Better use of chemical inputs (fertilizers, phytosanitary products, pesticides) in line with soil fertility and also promoting fertirrigation with waste water. The reduction of phytosanitary products and of water could be enhanced by multi-cycle plantations, where more species could also limit diffusion of pathogens, without altering wood quality and quantity;
- Limiting the cutting of tree (especially high poplars), avoiding cutting in the period of nidification for some important species.

Measure advantages:

- Water cycle (water and quality) regulation
- Hydrogeological stability (against erosion, landslide)
- Climate change adaptation and resilience
- Improvement of the environment and rural spaces
- Increase resilience of species and ecosystems to fires and natural hazards
- Landscape and biodiversity preservation
- Phytosanitary conditions improvement and prevention
- Improvement of ecosystem services as wood production
- Favouring of scale economy and short chain

Challenges:

- Costs of farming practices
- Risk of triggering new under-investigated dynamics counterproductive for the main cultivation.

Table 2. Plain sites - Relevance of measures

	Water protection functionality	Cost of the measure	Duration of implementation	Time interval of sustainability
BP PA1	**High**	**Medium**	**Short periodically**	**Medium**
BP PA2	**High**	**High**	**Medium**	**Medium**
BP PA3	**Medium**	**Medium**	**Medium**	**Medium**
BP PF1	**Medium**	**Medium**	**Short periodically**	**High**
BP PF2	**Medium**	**Medium**	**Medium**	**Medium**
BP PW1	**High**	**High**	**Medium**	**Medium**
BP PW2	**Medium**	**Medium**	**Medium**	**High**
BP PW3	**Low**	**Low**	**High**	**High**
BP PW4	**Medium**	**Low**	**High**	**High**
BP PW5	**Medium**	**Low**	**Medium**	**High**
BP PW6	**Medium**	**Medium**	**Medium**	**High**
BP PW7	**Medium**	**Low**	**High**	**High**
BP PW8	**Medium**	**Medium**	**Medium**	**Medium**

4. Special sites

4.1. Riparian strips

4.1.1. BP SR1 Integrated hydraulic-environmental restoration of water streams within the piedmont belt

Description of the measure

The best practice originates from the results of LIFE 11 ENV/IT/000243 RII ("Integrates hydraulic -environmental restoration of water streams within the piedmont belt of the Emilia-Romagna region", http://ambiente.regione.emilia-romagna.it/life-rii). The LIFE RII project is designed to enhance the environmental conditions and hydraulic safety of some minor water streams within the piedmont belt and high plains in the province of Reggio-Emilia. More specifically, it points out that the key concepts underlying the Water Framework Directive 2000/60/EC and the Floods Directive 2007/60/EC, on the need to reduce the flooding risk by improving the ecological status of rivers, can also be applied on the minor water streams network.

A first feasibility study was developed in 2009 to secure waterways, which envisaged the construction of a series of dams to decrease the slope in the mountain stretches. Yet, this solution would have caused a significant deterioration of the ecological status of the watercourses, thus resulting into a disruption of the biological continuity and blocking the natural dynamics of river beds. With the LIFE RII project it has instead been decided to apply experimental alternative technical solutions, based on "river restoration" principles, on the minor watercourse network.

To retain water in the upstream stretch of towns at most, the river section was expanded, wherever possible, to recover the stream bed width lost over the years due to human intervention. In the mountain stretches, due to steep slopes, simple riverside enlargements were not sufficient to "retain water". Hence, stream bed enlargements, "closed" downstream by pebble narrowings, were developed, replenishing green-belt vegetation, in order to retain water during floods. The creation of large floodplains upstream from narrowings, which would be often flooded, encouraged the development of wetlands, characterized by the temporary presence of water, being rather rare habitats in that local context.

Furthermore, in mountain stretches the water outflow was slowed down by creating natural differences in elevation by means of pebbles and timber by fastening trunks with roots to the river banks. It should be highlighted that these works, besides reducing the steepness of the stream bed slope locally, contribute to an environmental enhancement both due to the diversification introduced in the stream bed itself but also thanks to the creation of new natural habitats. To reconnect existing floodplains to the stream bed, making them periodically floodable, alternative solutions were implemented by rising the stream bed elevation to make streams more easily floodable during floods, also allowing morphology and habitat diversification.

Finally, environmental and natural enhancement measures were implemented in all streams. In particular, the continuity of riparian vegetation strips was improved by planting native hardwoods species and by replenishing green-belt vegetation in barren stretches. Locally sourced indigenous selective plant species cuts were carried out to promote the regrowth of plants and to enhance natural vegetation along the most deteriorated stretches. In all plant management actions a special attention was paid to preventing the proliferation of invasive species.

Measure advantages:

- positive impacts on both river flood protection and hydromorphological quality
- decreased diffused discharge of nutrients (e.g. nitrate)

Challenges:

- availability of strips of territory facing the river beds to be allocated to riverine/floodable areas
- implementation costs

4.1.2. BP SR2 Naturalistic restoration for the integrated hydraulic-environmental sustainability of the canals

Description of the measure

The best practice originates from the results of the project LIFE13 ENV/IT/000169 RINASCE ("Naturalistic Restoration for the integrated hydraulic-environmental Sustainability of the Emilian Canals", http://ambiente.regione.emilia-romagna.it/life-rinasce). The project proposes to realize for demonstrative purposes the hydraulic-environmental restoration of some drainage canals in the Emilia-Romagna region and aims to show that the key concepts of the "floods" (2007/60/EC) and "water framework" 2000/60/EC directives, concerning the need to reduce flood risk, at the same time improving the ecological status of the water courses, can also be applied to the artificial water network.

The emilian plain is crossed by a dense network of artificial canals, built by man in the course of centuries for the hydraulic drainage: in the artificial network, waters flow not only because of gravity, but also thanks to pumping stations. Therefore malfunctions of a system so distinctly artificial can cause catastrophic damages, thus is essential to increase the levels of flood safety. At the same time, the ecological restoration of the drainage canals represents an important opportunity for the joining of the ecologic network and the improvement of the quality of the environment. The canals selected for the interventions suffer in similar degree of environmental and hydraulic problems: they characterize themselves for a rectilinear course and a geometrical section of trapezoidal shape and there are no floodable areas linked to them. It is important not

to forget that the development of urban settlements of the last decades, has further increased runoff outflow, leading to an efficiency crisis of the various hydraulic networks. Add to this the problems of discharge of polluting substances, thus worsening the quality of the waters.

On the whole, the interventions consist of the requalification of canals, by creating floodable naturalistic areas along the banks, the forestation of banks and the creation of an expansion area destined to become a naturalistic humid zone for the accumulation of flood and the phyto-depuration of the water.

Measure advantages:

- positive impacts on both river flood protection and hydromorphological quality
- decreased diffused discharge of nutrients (e.g. nitrate)

Challenges:

- availability of strips of territory facing the canals to be allocated to riverine/floodable areas
- implementation and maintenance costs

4.1.3. BP SR3 Guidelines for integrated requalification of natural watercourses

Description of the measure

The Emilia-Romagna Region is pursuing strategies aimed at mitigating the adverse consequences of floods and of morphological dynamics of the watercourses, which may occur to human health, properties, cultural heritage, economic and social activities, territory and environment. The territory is potentially subject to flooding of lowland areas caused by disruption or overlap of defence levees or hydraulic failure; in the mountainous-hilly areas the prevailing phenomena are linked to hydro-morphological dynamics of river beds and are expressed by local floods and, especially, by intense erosive processes in river beds, which can lead to destabilization of the infrastructure close or overlying the rivers. The causes are partly natural, however are due to a large extent to the change of land use, and to the progressive artificiality of the hydrographic network, who removed part of the areas naturally appointed to the morphological evolution of riverbeds and floods restraint.

The Guidelines, approved by the Regional Council of Emilia-Romagna in 2015 (Bollettino Ufficiale della Regione Emilia-Romagna n.301 del 20.11.2015 (Parte Seconda), http://bur.regione.emilia-romagna.it/), aim to develop a territorial defence strategy that addresses toward an approach to the management of the watercourses more in accordance with their natural processes, aiming at a synergy between the river ecosystem objectives and at decreasing the risk from floods and morphological dynamics, as indicated by the EU, which requires to a joint implementation of the

directives "Water" (2000/60/EC) and "Flood" (2007/60/EC). The guidelines are directed to the natural hydrographical network, and focus specifically on innovative interventions of "land protection" that allow to reach the objectives of the "Water" Directive by improving the ecological status of rivers.

The guidelines deal specifically with those interventions of morphological requalification which can bring positive effects on flood and morphological dynamics risk mitigation. The measures suggested are intended to reduce the danger of the areas potentially subject to flooding and are designed to be a tool that aims to clarify what are the possible alternatives, the related areas of application, the relevant variables involved, the expected effects.

Measure advantages:

- positive impacts on both river flood protection and hydromorphological quality enhancement

Challenges:

- compatibility with current land uses and infrastructures in the territory near the riverbeds
- implementation and maintenance costs.

4.1.4. BP SR4 Guidelines for integrated rehabilitation of drainage canals

Description of the measure

The Emilia-Romagna Region in 2003 has created, within the European project LIFE Econet, the activity entitled "The canals and waterways of the provinces of Modena and Bologna - Towards the creation of lowland ecological network ". This work has identified a first set of operating procedures relevant to the establishment of the ecological network substantiated in the first "Guidelines for the rehabilitation of drainage canals" and 17 project sheets for redevelopment feasible in situations and specific sites. The Region, after 5 years away from the first interventions, decided to integrate and further develop the 2003 document by using, as a starting point, an analysis of the redevelopment projects of canals is made under the LIFE Econet.

The Guidelines, approved by the Regional Council of Emilia-Romagna in 2012 (Bollettino Ufficiale della Regione Emilia-Romagna n. 52 del 28.03.2012 periodico (Parte Seconda), http://bur.regione.emilia-romagna.it/),, are the result of this study and represent an initial list of usable techniques for environmental rehabilitation of the canals; these are to be meant not so much as a technical-design manual, but rather as a tool to address operators in the address of project types and "environmental management" of canals.

Each type of intervention described in the Guidelines is accompanied by a brief description of the suggested technique and problems that it intends to deal with, the precautions that must be taken in its implementation and possible need for future research; there are also "Project Box" related to interventions on the Italian territory, which show a possible practical application.

Similar Guidelines/Manuals exist in Lombardia region ("Linee guida per la Riqualificazione dei Canali Agricoli" (LIRICA) funded by Piano per la Ricerca e lo Sviluppo 2006, Delibera n. 2216 del 29 marzo 2006,http://www.lavoro.regione.lombardia.it/shared/ccurl/365/422/QdR_92_completo.pdf) and Veneto region ("Manuale per la gestione ambientale dei corsi d'acqua a supporto dei Consorzi di bonifica" edited by Veneto Agricoltura under the agreement signed with Region of Veneto, Regional Council Decision no. 3759 of December 9, 2009, http://www.venetoagricoltura.org/basic.php?ID=3394).

Measure advantages:

- positive impacts on both river flood protection and hydromorphological quality enhancement

Challenges:

- compatibility with current land uses and infrastructures in the territory near the channels
- implementation and maintenance costs.

4.1.5. BP SR5 Implementation of the Technical regulations for the maintenance of natural and artificial watercourses in the RN2000 sites

Description of the measure

The "Habitats" Directive 92/43/EC provides for the establishment of the European ecological network Natura 2000, requiring conservation / restoring of the related habitats. This means that even the maintenance of the watercourses, must take into account, among other things, the possible presence of habitats and animal and plant species of conservation interest.

The Technical Regulations for the maintenance of natural and artificial watercourses in the RN2000 sites, approved by the Regional Council of Emilia-Romagna in 2009, contains provisions that identify the types and methods of intervention in river areas and environmentally compatible costs, trying to combine the preservation of biodiversity in the areas included in the Natura 2000 sites with hydraulic safety criteria and water management which are the basis of the routine maintenance of the waterways, natural and artificial.

The Disciplinary (http://ambiente.regione.emilia-romagna.it/parchi-natura2000/rete-natura-2000/siti/fotorete/disciplinaretecnico.jpg/view) has the main purpose to regulate the

maintenance of natural and artificial waterways that can be considered to low environmental impact and that, consequently, if located in the Natura 2000 network sites, are exempt from the execution of the incidence evaluation or pre-assessment, if the works are compliant with the conditions, the types and the execution times indicated.

Measure advantages:

- positive impacts on both river flood protection and riverine habitats quality

Challenges:

- implementation and maintenance costs.

4.1.6. BP SR6 Guidelines for programming and implementation of maintenance operations on vegetation and riparian forests

Description of the measure

In the operative management of the territory emerge the needs to combine the hydraulic safety requirements with the need to protect biodiversity and landscape, to define process of information and participation in the definition of the programs, to establish the procedures of transparency and efficiency in the allocation of works and control their execution.

The guidelines help to ensure the coordination of measures aimed at hydraulic risk reduction with the need for protection and enhancement of forests and tree and shrub vegetation in the riparian areas, through managing modes of programming and control of the activities of maintenance of the vegetation.

The guidelines propose, in relation to the different requirements of securing intervention (insufficient maximum hydraulic discharge flow, need to laminate the flood flow, etc.), the type of action on vegetation riparian and of river bed more consistent with the environmental quality objectives of the water course his critical issues highlighted (macrobenthos, diatoms, fish communities, etc).

Beyond Emilia romagna Region, similar Guidelines exist for Provincia di Trento ("Linee guida per la gestione della vegetazione lungo i corsi d'acqua in Provincia di Trento" produced within the project T.E.N. Trentino Ecological Network: a focal point for a Pan-Alpine Ecological Network, LIFE11 NAT/IT/000187, http://www.lifeten.tn.it/) and Regione Marche ("Linee guida per l'elaborazione dei progetti generali di gestione dei corsi d'acqua", Deliberazione n. 100 del 29 Aprile 2014, http://www.consiglio.marche.it/banche_dati_e_documentazione/iter_degli_atti/paa/pdf/d_am73_9.pdf)

Measure advantages:

- positive impacts on both river flood protection and riverine ecological quality
- decreased diffused discharge of nutrients (e.g. nitrate)

Challenges:

- compatibility with current land uses and infrastructures in riparian strips
- implementation and maintenance costs

4.1.7. BP SR7 Creation of buffer strips and wetland basins

Description of the measure

EU legislation related to the Common Agricultural Policy (CAP) from 2014 to 2020, confirms that farmers, in order to qualify for economical subisdes, are required to comply to conditionality (basic rules on the environment, climate change, good agricultural and environmental conditions land, public health, animal health, plant health and animal welfare). Conditionality applies through a set of Management Criteria Required (SMRs) and standards of Good Agricultural and Environmental (BCAA), identified in Annex II to Regulation (EU) No. 1306/2013, and adopted annually by a Decree Mipaaf. BCAA1- Establishment of buffer strips along water courses is a conditionality aimed to protect surface and groundwater pollution resulting from agricultural activities.

For example, in Emilia-Romagna the realization of buffer strips and wetland basins is the Submeasure 4.4 - support for non-productive investments linked to the achievements of agri-environment-climate targets of the Rural Development Plan of the Emilia-Romagna Region (PSR 2014-2020).

The Emilia-Romagna region has large areas vulnerable to nitrates and areas at risk of erosion to which is associated transport of nutrients in sediments. The measure of PSR is designed to mitigate the impacts resulting from the use of fertilizers, but also to control the pollution associated with the sediment transport through a farm scale creation of buffer strips and wetland basins.

The term "buffer zone" identify linear formations of herbaceous vegetation, tree and / or shrub interposed between the crops and the stream/channel which intercept surface and sub-surface runoff water, acting effectively as a filter against pollutants / sediments carried by water. The efficacy of nitrogen removal is variable in function of the selected type of buffer strip and, in particular, varies in function of its complexity.

The PSR envisages three types of interventions (Operazione 4.4.03 - Realizzazione di fasce tampone e bacini di fitodepurazione di contrasto ai nitrati, http://agricoltura.regione.emilia-romagna.it/psr-2014-2020/temi/tipi-di-operazioni):

- buffer strip with herbaceous band and single-strand arboreal and / or shrubby: farmland band 4 m wide, adjacent to the cultivated field, sown with a mixture of long life forage species and single-strand arboreal and / or shrubby of 1 meter wide interposed between the grassy strip and the drainage water body;

- buffer strip with herbaceous band and single-strand arboreal and / or shrubby, with load ditch: load ditch parallel to the channel/stream that collects the waters, with higher water levels to facilitate a subsurface flow between the ditch and the canal/stream; strip of land between the load ditch and the channel/stream consisting of grassy band of 3 m width seeded with a mixture of long life forage species and single-strand arboreal and / or shrubby 1 m wide;

- basin for the phytoremediation of farm land runoff waters: basin, not waterproofed, of area equal to 1-5% of the UAA, buffer strip surrounding the basin of at least 5 m covered with vegetation, main entrance ditch, outflow ditch able to ensure the maintenance of a 50 cm average level in the basin, depressions of 0.50 and 2 m on at least a third of the surface of the basin.

Similar measures exist in other Regions, e.g. Veneto (https://www.regione.veneto.it/web/agricoltura-e-foreste/bandi-finanziamenti, http://www.lamiaterravale.it/files/veneto), Lombardia (http://www.lamiaterravale.it/files/lombardia), Piemonte (http://www.lamiaterravale.it/files/piemonte), where it is possible that technical characteristics required for the realization of buffer strips are a little different.

Measure advantages:

- decreased soil erosion
- decreased diffused discharge of sediments and nutrients (e.g. nitrate, phosphorus)
- reduction of flood discharge (wetland basins)

Challenges:

- compatibility with current land uses and infrastructures in riparian strips
- reduction of extension of productive farmland
- implementation and maintenance costs

4.1.8. BP SR8 Wooded Buffer Strips in rural areas (LIFE99 ENV/IT/000083)

Description of the measure

The pollution of water resources is one of the main problems connected with agricultural activities. The main polluting agents (nitrates, phosphates, chemical residues and insoluble mineral particles) are generated by excessive application of fertilisers to crop fields, by use of fertilisers not adapted to crop cycles and by inappropriate tillage or irrigation practices. The transfer of polluting agents is linked to water flows: for substances with lesser absorbance by soil particles (e.g. nitrates) the transfer happens mainly through surface flowing or deep percolation of solutions; for highly absorbed substances, (phosphorus compounds), erosion and sedimentation are the main transfer systems. The Woody Buffer Strips (WBS) are an effective means to retain, assimilate and remove the nutrients coming from agricultural fields.

The LIFE project (http://www.acquerisorgive.it/ambiente/inquinamento-diffuso/il-progetto-life-fascie-tampone-boscate-ftb/) aimed to demonstrate that WBS offered an efficient method for reducing nutrients-leaching from agricultural field, and also could provide an interesting economic opportunity for farmers, by enabling the production of wooden biomass for energetic use and giving economic support through financial subsides (Structural Funds).

A cost-benefit analysis quantified the results in terms of Measure advantages for the environment and opportunity for the farmers. The environmental benefits were clearly quantified with an analysis of the conditions that make the investment convenient for farmers, with or without public incentives. The main results of such assessment are:

- water quality and nitrogen retention: young WBS are able to reduce up to 50% the amount of total fluid nitrogen that percolates through them by the sub-superficial layer;

- in terms of % retention no appreciable difference was observed between 5 and 15 meters wide WBS, confirming the key role of the first 5 meters of the hedge as the main area where waters enriched with nitric nitrogen meet favourable conditions for denitrification; retention capacity of a 100 meters long and 5 meters wide WBS was 6.3 kg per year of total fluid nitrogen;

- the most evident effects were a decrease in the releasing of nitric nitrogen and an increase in the releasing of organic nitrogen;

- the main factor limiting denitrification processes is carbon, energy source for bacteria; this leads to the assumption that trees growth with a higher biomass production will support an increase in nitrate-reducing bacteria's activity;

- when WBS is intended mainly for environmental purposes or where the wood production is meant for construction purposes it's not profitable; WBS that partially uses species aimed at producing wooden biomass for energy purposes, shows profitability only when there are public incentives, it's clearly profitable in those cases in which plants are used to produce wood biomass, even without public incentive.

Similar experiences have been obtained in central Italy with the projects REWETLAND (Widespread introduction of constructed wetlands for a wastewater treatment of Agro Pontino,

LIFE+08 ENV/IT/000406, http://www.rewetland.eu/) and RIPARI (Reduction of impacts of agricultural pressures on water resource, funded by Regione Toscana, POR FESR 2007-2013, http://www.hydrogeavision.it/services).

Measure advantages:

- decreased soil erosion
- decreased diffused discharge of sediments and nutrients (e.g. nitrate, phosphorus)

Challenges:

- compatibility with current land uses and infrastructures in riparian strips
- reduction of extension of productive farmland
- implementation and maintenance costs

4.1.9. BP SR9 Saltwater barriers

Saltwater barriers are weirs located at waterways end sections, just before the sea mouth, to prevent the intrusion of marine waters.

The rise of marine waters upstream the rivers can occour where the river's bed is lower than the sea level and when the discharge flow is very low. In absence of anthropic alterations to the hydrology and morphology of rivers, the rise of marine waters does not constitute an critical environmental issue, since it is a natural phenomenon. The reduction of low flows caused by water abstractions and/or alterations of waterways morphology (river bed lowering) and/or land subsidence may strongly amplify the phenomenon. The upstream rise of marine waters may affect stretches of the order of ten kilometers or even more (up to 30 km during recent extreme drought in the Po river), and trigger phenomena of salinisation of the soils and acquifers surrounding the rivers. The problems concern environment (impairment of ecosystems that do not tolerate brackish/marine waters), water supply (brackish water is unsuitable for irrigation, drinking and industrial uses), and agricolture (soil salinisation can damage agricultural productions).

Saltwater barriers are set near the sea mouth with the aim of upholding the rise of marine waters in the case of low river streamflow, and consist of fixed or mobile weirs that artificially raise the bottom of the riverbed or which are permeable only in the downstream direction (by means of clapet openings). It is to be underlined that the functionality of the barriers is related to the designed streamflow rates, below which the hydraulic system loses functionality. Usually there the presence of movable devices, as clapets or gates, require constant maintenance to assure full functionality of the system and hydraulic safety in the event of floods.

On the delta of Po river in last decades of the past century have been built salt barriers on the branches of Po di Tolle and Po of Gnocca, designed for a minimum streamflow operating capacity of 450 m^3/s (at Pontelagoscuro); the recent past years drought events frequently entail the fall of river streamflow under the 450 m^3/s threshold, impairing the saltwater barriers functionality.

Measure advantages:

- saltwater barriers, if properly built and maintained, are effective, in the range of designed river streamflows, to stop the intrusion of marine waters

Challenges:

- saltwater barriers are an element of disruption for river ecosystems and an obstacle to navigation
- below the designed operative minimum river streamflow (which can never be extremely low) the effectiveness of the barriers is lost
- construction costs are relevant and expensive constant maintenance is required

Table 3. Special sites: Riparian strips - Relevance of measures

	Water protection functionality	Cost of the measure	Duration of implementation	Time interval of sustainability
BP SR1	**High**	**Medium**	**Medium**	**Medium**
BP SR2	**High**	**High**	**Medium**	**Medium**
BP SR3	**Medium**	**Medium**	**High**	**Medium**
BP SR4	**Medium**	**Medium**	**High**	**Medium**
BP SR5	**Low/Medium**	**Low/Medium**	**Low**	**Medium**
BP SR6	**Low/Medium**	**Low/Medium**	**Low/Medium**	**Medium**
BP SR7	**High**	**High**	**Medium**	**Medium**
BP SR8	**High**	**High**	**Medium**	**Medium**
BP SR9	**High**	**High**	**Medium**	**Medium**