European Commission

NWRM

Natural Water Retention Measures

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Case Study

Water retention management in the broader area of Ancient Olympia, Elia, Greece

ACTeon environment research & consultancy

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BEF LATVIA

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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 Key words: Biophysical impact, runoff, water retention, effectiveness - Please consult the NWRM glossary for more information.

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I. Basic Information

Application ID *(Country_Numeric, e.g.: Greece_01)*	*Greece_01*			
Application Name *(provide a short name)*	*Water retention management in the broader area of Ancient Olympia, Elia, Greece*			
Application Location	Country: *(select from list in Annex 1)*	Greece	Country 2: *In case of transboundary applications*	
	NUTS2 Code *(select from list in Annex 1)*		*EL23*	
	River Basin District Code *(select from list in Annex 1)*		*GR01*	
	WFD Water Body Code *(select from list in Annex 1)*		*GR0129R000215044H (Alpheos Water Body)*	
	Description *(free text, short description of the location)*		*The study area is located in Ancient Olympia, Elia, Peloponnese, Greece.*	
Application Site Coordinates *(in ETRS89 or WGS84 the coordinate system)*	Latitude: *37,3835085 (φ)*		Longitude: *21,378061 (λ)*	
Target Sector(s)	Primary:	Forest		
Implemented NWRM(s)	Measure #1:	Afforestation of mountain areas (F2)		
Application short description	*The measures include the temporary installation of structures utilizing locally available timber in order to increase water retention. The installation of the timber structures has been fixed parallel to the contours of the hills slopes in order to retain water. They were constructed from the cutting trunks of burned Aleppo Pine (Pinus helepensis) and Cypress (Supressus semprervirens) and they were secured on wooden stakes without any metal supports. This construction method was selected to avoid major landscape intervention and to preserve the ecological balance of the ecosystem. Their distances were determined according to log characteristics and also to topographic and hydro-meteorological conditions of each site they secure. They were also placed in a "mosaic design" consisting from single or double in high logs according to the gradient of the slopes.* *Additionally, the occurrence of soil erosion and overland flow contributed to severe flooding problems. These measures retained a total of 7.5 mm of fertile soil and the total soil material that was retained is estimated about 2.500 m3/30 ha. The flood events mainly affected the archaeological sites and the surrounding areas.* *An additional intervention refers to targeted planting of forests in mountain areas that can help stabilize hill slopes, thereby reduce erosion and potentially leading to greater water retention in the mountain areas. Afforestation may have beneficial impact on the hydrograph by reducing peak flows and enabling the maintenance of base flows. The potential for water retention must be balanced against the increased ET and pollutant trapping that may be associated with forests.*			

II. Policy context and design targets

Brief description of the problem to be tackled	*The specific interventions aim at tackling the environmental impacts of the significant wildfires of the study area in 2007. The principal aim of the works includes reduction of soil erosion and flood management. The interventions also include burned trees harvesting and restoration actions on the existing vegetation and on the tree crops.*		
What were the primary & secondary targets when designing this application?	Primary target #1:	Flood control and flood risk mitigation	
	Primary target #2:	Mass stabilisation and control of erosion rates	
	Secondary target #1:	Biodiversity and gene-pool conservation in riparian areas	
	Remarks	*The primary targets when designing this application were soil erosion management, flood control and flood risk mitigation in the context of restoring the fire affected area.*	
Which specific types of pressures did you aim at mitigating?	Pressure #1:	Floods Directive indetified pressure	*Other pressure contributing to flooding /flood risk*
	Pressure #2:	WFD indentified pressure	*Other hydromorphological alterations*
	Remarks		
Which specific types of adverse impacts did you aim at mitigating?	Impact #1:	Floods Directive indetified impact	*Other Environmental impacts*
	Impact #2:	WFD indentified impact	*Altered habitats due to hydrological changes*
	Remarks		
Which EU requirements and EU Directives were aimed at being addressed?	Requirement #1:	Floods Directive-mitigating Flood Risk	*Flood risk management and flood impacts mitigation*
	Requirement #2:	WFD-mitigation of significant pressure	*Mitigation of hydromorphological alterations e.g. soil erosion*
	Remarks		
Which national and/or regional policy challenges and/or requirements aimed to be addressed?	*Law 3199/2003 &Presidential Decree (P.D.) No. 51/2007 (protection of water resources)* *Fire protection laws (Law 998/1979, P.D. 86/69, 2612/1998, 3013/2002, 3208/2003, 3511/2006 (protection of forest ecosystems, reorganization of fire department & upgrade of its mission). In terms of water policies these laws (esp. 3208/2003) are addressing the protection of the forest ecosystem including water resources.*		

III. Site characteristics

Dominant Land Use type(s) *Select from the drop-down menu with the CORINE LU types and codes.*	Dominant land use	*313*
	Secondary land use	*211*
	Other important land use	
	The land use has changed from forests and other wooded land to arable land.	
Climate zone	warm temperate moist	

Soil type	*Luvisols*
Average Slope	very steep (>60%)
Mean Annual Rainfall	300 - 900 mm
Mean Annual Runoff	600 - 750 mm
Average Runoff coefficient (or % imperviousness on site)	
	The measures to prevent soil erosion and flood events have positive impact on the reduction of runoff and the increase of vegetation in the burned area.
Characterization of water quality status (prior to the implementation of the NWRMs)	*Prior to the NWs and after the wildfires the water quality was poor. Regarding groundwater quality, due to decreased water retention, the rainwater did not infiltrate the soil and did not enrich the aquifers. As far as surface water is concerned, the wildfires have deteriorated the vegetation quality; thus the quality of water runoff was decreased.* *Please link to the WFD water quality parameters (nutrients N,P; organic pollution; chemical pollution, Cu, Zn; saline pollution; TSS; acidification, elevated temperatures; E.coli, Fecal coliforms, etc.)*
Comment on any specific site characteristic that influences the effectiveness of the applied NWRM(s) in a positive or negative way	

IV. Design & implementation parameters

Project scale	Medium (eg. public park, new development district)	*It is a medium scale project as it involves the 4 hills around the Ancient Olympia*
Time frame	Date of installation/construction	*The installation / construction period was planned between 11/2007 and 02/2008.*
	Expected average lifespan (life expectancy) of the application in years	*The designed lifespan of the application NWRM is 4-5 years as after this time the vegetation itself will take over the erosion and flood risk.*
Responsible authority and other stakeholders involved	*Name of responsible authority/ stakeholder*	*Role, responsibilities*
	1. *Hellenic Ministry of Culture and Sports*	Beneficiary
	2. *Z' Ephorate of Prehistoric and Classical Antiquities.*	Responsible for monitoring the work progress
	3. *Institute of Mediterranean and Forest Ecosystems*	Scientific responsible
	4. *Forest Products Technology of the National Agricultural Research Foundation (NAGREF)*	Scientific responsible
	5.	
The application was initiated and financed by	*The application was initiated by the Institute of Mediterranean and Forest Ecosystems and Forest Products Technology of the National Agricultural Research Foundation (NAGREF) and funded by donations of the Latsis J. Public Benefit Foundation.*	

<table>
<tr><td>What were specific principles that were followed in the design of this application?</td><td colspan="3">The specific principles that were followed in the design of this application include aesthetic benefit, functionality, integrative planning, impact on public perception & acceptability, etc.</td></tr>
<tr><td rowspan="2">Area (ha)</td><td colspan="2">Number of hectares treated by the NWRM(s).</td><td>49.5</td></tr>
<tr><td colspan="3">49.5 ha are the area affected by the fires and restored. In particular, Kronios Hill, International Olympic Academy – Zone A, International Olympic Academy – Zone B, Zouni Hill, Kolosaka Hill.
In these areas 80-100% of the vegetation has been burned.</td></tr>
<tr><td>Design capacity</td><td colspan="3">The temporary structures utilizing locally available timber have been designed to reduce the hill slopes thus attenuate the surface runoff as well as the sentiment volume. This measure enables the increase of soil moisture, water absorption, and infiltration. Additionally, it creates suitable sites for natural regeneration or technical afforestation of the burned area.
The maximum volume of runoff water that can be retained has not been assessed as this was not originally a water retention application but the restoration of the surrounding of the archaeological site</td></tr>
<tr><td rowspan="6">Reference to existing engineering standards, guidelines and manuals that have been used during the design phase</td><td colspan="2">Reference</td><td>URL</td></tr>
<tr><td>1.</td><td>Non available information</td><td>Non available information</td></tr>
<tr><td>2.</td><td></td><td></td></tr>
<tr><td>3.</td><td></td><td></td></tr>
<tr><td>4.</td><td></td><td></td></tr>
<tr><td>5.</td><td></td><td></td></tr>
<tr><td>Main factors and/or constraints that influenced the selection and design of the NWRM(s) in this application?</td><td colspan="3">The factors that influence the selection and design of the NWRM are morphology, vegetation, climate and geology of the area. The morphology of the area (large slopes), increases surface runoff, leading to soil erosion and increased risk of landslides as well as increased flood events. To address this, the use of geotextile had to be implemented in most sloping and vulnerable positions. The vegetation (after the fires) has eliminated and a hydrophobic layer in the soil has been created by the combustion of organic matterwhich increases surface runoff and flood risk. The local climate, with an annual precipitation of over 1,000 mm and often intense events, also tends to increase the intensity of flood events.
The soils of the study area are also very loose and corrodible; thus vulnerable to the rainfall.
A high challenge for the temporary small structures is the hydraulic undercut.
Improving the condition of existing rainwater drainage system e.g. cleaning of the rainwater drainage system to avoid filling the road network with logging waste and increasing the flood risk.</td></tr>
</table>

V. Biophysical impacts

Impact category (short name) Select from the **drop-down menu** below:	**Impact description** (Text, approx. 200 words)	**Impact quantification** (specifying units)	
		Parameter value; units	% change in parameter value as compared to the state prior to the implementation of the NWRM(s)
Runoff attenuation / control	*The installation of temporary structures utilizing locally available timber have been designed to reduce the hill slopes thus control the surface runoff. This measures reduces the velocity of water volume leading to decreasing the intensity and frequency of floods. Also the timber structures retain water for longer period enabling the infiltration/percolation and recharge of aquifers.*		
Peak flow rate reduction	*The peak flow rate is reduced due to the obstacle of the timber structures. This measures reduces the velocity of water volume resulting in the decrease of floods intensity.*		
Impact on groundwater	*These measures have an impact on the increase of the groundwater level due to the increased infiltration, percolation and recharge that is achieved through the slowing down of water velocity. Also vegetation succeeded in eliminating the hydrophobic layer that was created in the soil after the fires and enables the water absorption towards the aquifers.*		
Impact on soil moisture and soil storage capacity	*These measures have a direct impact on soil moisture as the temporary timber structures enable to retain water for a longer period and inhibit the volume of runoff. Additionally, the area afforestation succeeds in eliminating the hydrophobic layer that was created in the soil after the fires and thus increased soil storage capacity.*	The rating for hydro-seeding was 60% "excellent". The rating for the log erosion barriers was "excellent" or "good" in 70% of the measurements.	
Restoring hydraulic connection			
Water quality Improvements			
WFD Ecological Status and objectives	*These measures have an impact on the ecological status of the water bodies of the specific river basin as they improve the quality of the surface water (improved water quality standards due to vegetation) and the quality and quantity of the groundwater (increased soil infiltration)*		
Reducing flood risks (Floods Directive)	*These measures reduce the flood risks as the timber structures function as a water retainer that slows down the velocity of water volume thus the surface runoff resulting in the decrease of floods frequency and intensity.*		
Mitigation of other biophysical			

impacts in relation to other EU Directives (e.g. Habitats, UWWT, etc.)			
Soil Quality Improvements	*These measures have a direct impact on the overall soil quality as afforestation of the area succeeds in eliminating the hydrophobic layer that was created in the soil after the fires and thus increase soil storage capacity. The fires have created the porosity of the soil to decrease, thus the restoration has positive impact on the soil infiltration capacity. Also the soil is improved due to the increase of the moisture.*	*The total estimated soil material w/30 ha or retention of a total 7.5 mm of fertile soil*	
Other			

VI. Socio-Economic Information

What are the benefits and co-benefits of NWRMs in this application?	*The direct benefits include the reduction of the flood risk, the improvement of the micro-environment as well as the aesthetic restoration of the affected area.* *Additional indirect benefits of the measures in this application include the increase of groundwater quantity of the river basin in order to be used for different uses as well as for ecosystem services.*		
Financial costs	***Total:***	*2,762,500 €*	*In terms of breakdown, the cost for the log barriers is not assessed in the provided information.*
	Capital:	*Value in €*	*The irrigation system for the four hills was 464.658 € plus VAT.*
	Land acquisition and value:	*1,500,000 €*	*The cost for land compensations was about 1.500.000 € due to the overpriced value of the properties around the archeological site.*
	Operational:	*Value in €*	*The operational cost for irrigation as well as for pruning and fertilizer application was not assessed.*
	Maintenance:	*Value in €*	
	Other:	*Value in €*	
Were financial compensations required? What amount?	*Was financial compensation required: Yes*		
	Total amount of money paid (in €): 1,500,000		
	Compensation schema: The financial compensations were for 5-6 beneficiaries-fields with a total area of 10 hectares each.		
	Comments / Remarks: The cost per hectare for this high value area was about 20,000-30,000 €; thus the total cost for land compensations was about 1,000,000 €.		

Economic costs	*Actual income loss: The actual income loss for the implementation of the measures was not assessed in the relevant studies. The kind of income loss is related to the limited agricultural activity.*
	Additional costs: The additional cost that stem from the implementation of the measure is related to the log barriers and wood-made check dams as well as the jute geotextile application and the hydro-seeding technique.
	Other opportunity costs: Also the cost of the plants that were used for the afforestation of the area is included in the economic cost.
Which link can be made to the ecosystem services approach? *Hint: The actual benefits of improving nature's water storage capacity are essentially linked to an improved provision of some of the following ecosystem goods and services:* - *Freshwater for drinking.* - *Water provision to deliver water services to the economy both for drinking and non-drinking purposes.* - *Water security (reliability of supply and resilience to drought).* - *Health security (control of waterborne diseases).* - *Flood security and protection.* - *Storm surge protection.* - *Biomass production.* - *Amenities (associated to habitat protection): fish and plants, tourism, recreation, and others.* - *Benefits of improved coastal water quality and ecological status for a sustainable commercial production of shellfish with human health and welfare values.*	*The actual benefits of improving nature's water storage capacity are essentially linked to an improved provision of some of the following ecosystem goods and services:* - *Water provision to deliver water services to the economy both for drinking and non-drinking purposes.* - *Water security (reliability of supply and resilience to drought).* - *Flood security and protection.* - *Storm surge protection.* - *Amenities (associated to habitat protection): fish and plants, tourism, recreation, and others.*

VII. Monitoring & maintenance requirements

Monitoring requirements	*A permanent automatic meteorological monitoring station is necessary to be installed, in order to predict of the progress of the wildfire risk in the area as well as to inform the public in real time for the plant development.*
Maintenance requirements	*The maintenance requirements include the plants irrigation, clearing and pruning as well as bio-fertilizer application. The intensity and the frequency of the maintenance activities are related to the season the plant and the meteorological conditions in the specific area. The local authorities are responsible for the maintenance.*
What are the administrative costs?	*The expenses linked to maintenance are not assessed in the provided studies, however it is estimated that the responsible local authorities adequately cover them from their internal budgets. Additionally the cost for monitoring is considered relevantly affordable.*

VIII. Performance metrics and assessment criteria

Which assessment methods and practices are used for assessing the biophysical impacts?	The performance of the interventions was evaluated with the use of qualitative criteria on a scale of four grades "excellent", "good", "moderate" and "poor".
Which methods are used to assess costs, benefits and cost-effectiveness of measures?	The performance of the interventions was evaluated with the use of qualitative criteria on a scale of four grades "excellent", "good", "moderate" and "poor".
How cost-effective are NWRM's compared to "traditional / structural" measures?	The evaluation of the installation of the timber structures was excellent or good in a percentage of 70%. The evaluation of hydro-seeding was excellent at a percentage of 60%. For the geo-textile (jude) the evaluation was good or moderate at a percentage of 60%, due to the difficulty of the steep slopes. As far as the vegetation interventions are concerned it is estimated that the effectiveness was good or excellent at a percentage of 70%. The traditional /structural measures would include the construction of reservoirs or water retaining installations (e.g. small dams), as well as soil retention measures. These interventions would apparently need more expensive materials (e.g. concrete) and would have a greater impact on the environment. Thus the NWRM measures seem to be more cost-effective compared to the traditional/structural measures.
How do (if applicable) specific basin characteristics influence the effectiveness of measures?	*As water is retained to the ground for longer period, water absorption and infiltration were increased with a positive impact on the groundwater and the aquifers of the specific basin.*
What is the standard time delay for measuring the effects of the measures?	*The standard time delay for measuring the effects of measures are 1-2 years as by then the natural environment has started to be restored. After 4-5 years the ecosystem is expected to be fully restored and the retention is conducted naturally by the improved properties of the soil.*

IX. Main risks, implications, enabling factors and preconditions

What were the main implementation barriers?	*Generally there were not significant delays in the implementation of the measures as the risks were associated with flood risk and landslides. The main implementation barriers were physical constraints such as the high slopes.*
What were the main enabling and success factors?	*The main enabling and success factors was the positive attitude of decision makers, the willing stakeholders and the positive public perception and the existing expert knowledge and tools*
Financing	*The main funding sources were donations by the Latsis J. Public Benefit Foundation as well as by EU-funds: Rural development funds (Agricultural Development Programme)* *The total* expenses linked to the measure installation is 2.762.500 €.
Flexibility & Adaptability	*The current implementation is flexible and adaptable to changing baseline conditions as the log barriers can be easily removed when the vegetation is adequately restored. The cost to for adaptation is limited.*
Transferability	*A similar application can be proposed, assessed and selected in respective wildfires that occur in steep hills that result in increased surface runoff. The necessary preconditions are the climate conditions and the soil properties and characteristics.*

X. Lessons learned

Key lessons	*The measures are based on changing the morphology of the area as well as the soil composition. Thus, the length of the slopes was shortened, the surface roughness and the soil infiltration rates were increased, the surface runoff and sentiments were delayed and the soil humidity was increased.*

XI. References

Source Type	Project Report		
Source Author(s)	Bourletsikas Athanasios		
Source Title	*Post-fire water retention management : The case study of Ancient Olympia, Greece*		
Year of publication	2014		
Editor/Publisher	-		
Source Weblink	-		
Key People		*Name / affiliation*	*Contact details*
	1.		
	2.		
	3.		
	4.		

Source Type	Other (specify)

Source Author(s)	Lyrintzis Georgios		
Source Title	*Restoration of the archeological and the broader landscape of Olympia*		
Year of publication	2011		
Editor/Publisher	*National Agricultural Research Foundation (N.AG.RE.F)*		
Source Weblink	*www.nagref.gr/journals/publications/arxaia_olympia.pdf*		
Key People		*Name / affiliation*	*Contact details*
	1.		
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XII. Photos Gallery

Picture 1: Kronios Hill after the implementation of the measures, Continuous Lines (Bourletsikas Athanasios, 2014)

Picture 2: Olympic Academy Hill after the implementation of the measures, Empty Space Lines, (Bourletsikas Athanasios, 2014)

Picture 3: Detail of the timber structures (26-11-2007) (Lyrintzis Georgios, 2011)