LANDSCAPE ELEMENTS FOR WATER RETENTION (LWR) IN A MOUNTAINOUS ENVIRONMENT
Case-Study Factsheet

Climate change is affecting water quantity and quality, posing challenges particularly for what regards agricultural production. The use of nature-based solutions to address these challenges is increasing. Natural water retention ponds have been identified as viable solutions for water management in agriculture. This paper aims to characterize water retention ponds, to quantify their effectiveness, their direct and indirect benefits, and costs. The paper analyses the case of the Lamone river catchment in Emilia Romagna Region (Italy), where water flow and availability show large seasonal variability. This is an area of important agricultural production (particularly for kiwi plantations) heavily relying on irrigation. Here water retention ponds are systematically applied to store water in winter that can be used during the dry summer season. They can play a strategic role in ensuring irrigation water availability while preserving the minimum environmental flow. The paper analyses both the benefits of ponds for the water balance at sub-catchment scale, and the environmental effects produced by ponds having an ecological functionality. We refer to a scenario of implementation of new ponds, and we appraise the contribution of new ponds whose siting is chosen in order to maximize landscape connectivity. The hydrological effects of the new ponds are evaluated under present and climate change scenarios. We show how water retention ponds may increase water availability for irrigation, while improving the river flow regime. More water for irrigation can be associated to additional agricultural production, while a more ecologically oriented design of ponds may lead to landscape ecological improvements. The investment costs of ponds are justified in economic terms, and the additional costs of improved design are expected to be balanced by the ecosystem services obtained. The business model required to operate this type of intervention is discussed, together with potential funding channels. In particular, we discuss two innovative incentive models based on compensation of land and production lost and on tradable development rights.

1. Photo Gallery

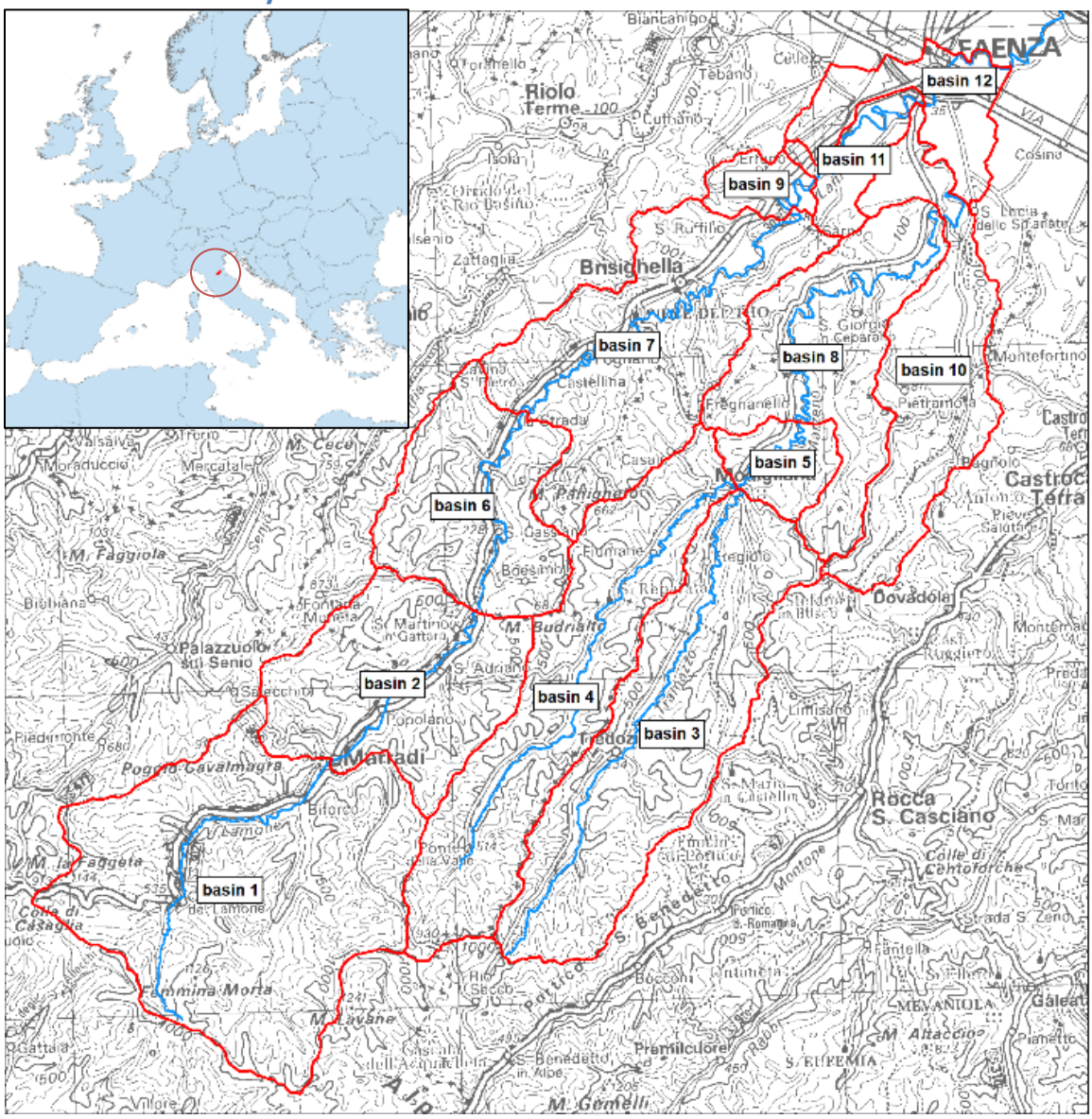

Figure 1- Map of Lamone river sub-catchments.

Source : GECOsistema Srl

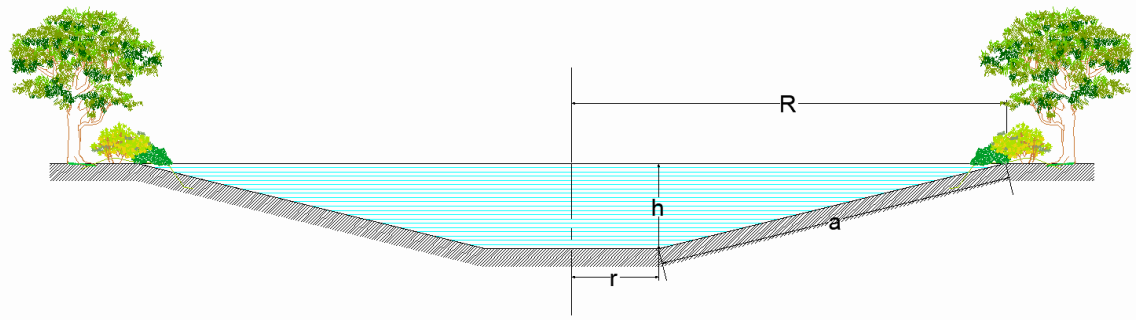

Figure 2 – Water retention pond – schematic . R is the top radius of ponds, while r is the base radius; h is the height and a refers to the bank slope.
Source : GECOsistema Srl

Figure 3 – an example of existing pond tin the rural areas in the region
Source : GECOsistema Srl

2. Basic information

Application ID *(Country_Numeric, e.g.: Greece_01)*	**Italy_01**			
Application Name *(provide a short name)*	**LWR IN A MOUNTAINOUS ENVIRONMENT**			
Application Location	Country: *(select from list in Annex 1)*	Italy	Country 2: *In case of transboundary applications*	
	NUTS2 Code *(select from list in Annex 1)*		*2*	
	River Basin District Code *(select from list in Annex 1)*		*Po district*	
	WFD Water Body Code *(select from list in Annex 1)*		*For the moment we have only the WFD GWsB in the Annex 1, since the SWBs is a huge list. You can leave out this matching for the moment, just provide the correct coordinates below and we can do all matchings afterwards.*	
	Description *(free text, short description of the location)*		*Nature based water retention ponds in upper Lamone River catchment in Emilia Romagna Region*	
Application Site Coordinates *(in ETRS89 or WGS84 the coordinate system)*	Latitude: 44.197909° *WGS84*		Longitude: 11.761707° *WGS84*	

Target Sector(s) *Possibility to select more than 1 sectors (primary vs. secondary)*	Primary:	Agriculture
	Secondary:	Nature
Implemented NWRM(s) *Possibility to select more than 1 NWRM. Link to NWRM catalogue and NWRM Factsheets, Select from list in Annex 1.*	Measure #1:	N1 Basins and Ponds
	Measure #2:	
	Measure #3:	
	Measure #4:	
Application short description	Developing new ponds and converting exiting grey ones to green to sustain agriculture and provide environmental benefits	

3. Policy Context and Design Targets

Brief description of the problem to be tackled	This case study aims to characterize water retention ponds, to quantify their effectiveness, their direct and indirect benefits, and costs.		
What were the primary & secondary targets when designing this application? *Select from the drop-down menu. The possibility for more than one target is provided. Additional info can be given in the "remark" field to address e.g. other targets not included in the list, and give some details*	Primary target #1:	Regulation of hydrological cycle and water flow	
	Primary target #2:	Choose an item.	
	Secondary target #1:	Biodiversity and gene-pool conservation in riparian areas	
	Secondary target #2:	Choose an item.	
	Remarks	Benefits also outside riparian areas due to increase ecological connectivity	
Which specific types of pressures did you aim at mitigating? *Select the relevant Directive (EU, non-EU) from the drop-down menu and type-in the related pressures. Different types of pressures as identified by EU-Directives (WFD, FD, etc.) are listed in the Annex 2*	Pressure #1:	WFD identified pressure	*Water balance*
	Pressure #2:	Choose an item.	*Type in the relevant pressure from the EU-Directives' lists in Annex 2*
	Pressure #3:	Choose an item.	*Type in the relevant pressure from the Directives' lists in Annex 2*
	Pressure #4:	Choose an item.	*Type in the relevant pressure from the Directives' lists in Annex 2*
	Remarks		
Which specific types of adverse impacts did you aim at mitigating? *Select the relevant Directive (EU, non-EU) from the drop-down menu and type-in the related impacts. Different types of adverse impacts as identified by EU-Directives (WFD, FD, etc.) are listed in the Annex 2*	Impact #1:	WFD identified impact	*Stress during dry season*
	Impact #2:	Choose an item.	*Type in the relevant impact from the Directives' lists in Annex 2*
	Impact #3:	Choose an item.	*Type in the relevant impact from the Directives' lists in Annex 2*
	Impact #4:	Choose an item.	*Type in the relevant impact from the Directives' lists in Annex 2*
	Remarks		
Which EU requirements and EU Directives were aimed at being addressed? *Select from the drop-down menu the different types of requirements as identified by EU-Directives (WFD, FD, etc.), and provide additional specification.*	Requirement #1:	WFD-mitigation of significant pressure	*Specify*
	Requirement #2:	WFD-achievement of good ecological status	*Specify*
	Requirement #3:	Choose an item.	*Specify*
	Requirement #4:	Choose an item.	*Specify*

	Remarks
Which national and/or regional policy challenges and/or requirements aimed to be addressed?	Text

4. Site Characteristics

Dominant Land Use type(s) *Select from the drop-down menu with the CORINE LU types and codes. Space of additional comments/remarks is provided*	Dominant land use	*311: Broad-leaved forest*
	Secondary land use	*222: Fruit trees and berry plantations*
	Other important land use	*Type in the relevant Code Level3*
	Remarks *Irrigated fruits*	
Climate zone *Select from the drop-down menu*	cool temperate moist	
Soil type *Select from the list with the FAO classes in Annex 3*	*Type in the relevant soil type (FAO class) from the list in Annex 3*	
Average Slope *Select from the drop-down menu*	sloping (5-10%)	
Mean Annual Rainfall *Select from the drop-down menu. Values are in mm,*	900 - 1200 mm	
Mean Annual Runoff *Select from the drop-down menu. Values are in mm.*	300 - 450 mm	
Average Runoff coefficient (or % imperviousness on site) *Select from the drop-down menu. Space of additional comments/remarks is provided*	0.3 - 0.5	40 - 60%
	Remarks	
Characterization of water quality status (prior to the implementation of the NWRMs) *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.)*	Text *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	Text *Positive way: water availability in winter*	
	Text *Negative way: land availability*	

5. Design & Implementation Parameters

Project scale *Select from the drop-down menu the relevant scale and specify.*	Small (e.g. farm, plot, building complex, block)	*Specify*

Time frame *NWRM(s) Installation date and lifespan*	Date of installation/construction (MM.YYYY)		*Specify*
	Expected average lifespan (life expectancy) of the application in years		*Specify*
Responsible authority and other stakeholders involved *List of all + Descriptive Text of roles, responsibilities, etc.*	*Name of responsible authority/ stakeholder*	*Role, responsibilities*	
	1. Land reclamation Authority	Technician	
	2. Farmers	Owners	
	3.		
	4.		
	5.		
The application was initiated and financed by	EC-JRC		
What were specific principles that were followed in the design of this application? *Examples provided: water-sensitivity, aesthetic benefit, functionality, usability, adaptability, integrative planning, integration of demands, acceptable costs, impact on public perception & acceptability, etc.*	water sensitivity, functionality, environmental benefits, costs		
Area (ha)	Number of hectares treated by the NWRM(s). *e.g. It could be the upstream drainage area in case of retention ponds*	*Number of ha: 1000 ha of fruits (kiwi) can be sustained by new ponds without compromising the water balance of the river*	
	Text to specify *(caution to differentiate between treated or target area vs. the application area occupied by the NWRM). In some cases treated area may not have a meaning (e.g. green walls). In other cases you may have a measure applied in an upstream forest but with the purpose of mitigate an impact in a downstream area*	*Specify: area covered by new ponds≈500 ha*	
Design capacity *Briefly describe the design capacity(ies) of the implemented NWRM(s), e.g. maximum volume of runoff water that can be retained per time step, maximum pollutant removal capacity in mg/l, etc.*	*Water storage capacity in the year round 5.3 Mm3*		
Reference to existing engineering standards, guidelines and manuals that have been used during the design phase *References: active links to specific documents or website(s), and if not available online, provided them on the collaborate platform in the library section and URL here*		*Reference*	*URL*
	1.	Regional price lists for soil defense works	https://territorio.regione.emilia-romagna.it/osservatorio/Elenco-regionale-prezzi
	2.		
	3.		
	4.		
	5.		
Main factors and/or constraints that influenced the selection and design of the NWRM(s) in this application? *List and describe specific factors that either guided or constrained the*	Ecological connectivity improvement, slope, distance from the river, land use, legal obligations for permitting		

selection and the design (e.g. land use constraints, cooperation issues with land owners, specific legislation, existing funding for specific priorities, private investments, legal obligations - EU requirements, etc.)	

6. 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 *and/or*	% change in parameter value as compared to the state prior to the implementation of the NWRM(s)
Runoff attenuation / control	*Describe the impact on runoff reduction and/or control*		
Peak flow rate reduction	*Describe the impact on the peak flow rate*		
Impact on groundwater	*Describe the impact on the groundwater, e.g. increased groundwater level, decreased depth to groundwater, increased infiltration/percolation and recharge*		
Impact on soil moisture and soil storage capacity	*Describe the impact on the soil moisture and soil retention capacity*		
Restoring hydraulic connection	*Describe the impact on river connectivity, surface-groundwater body interaction, etc.*		
Water quality Improvements	*Has the NWRM impacted the overall water quality? In which way? Please provide some explanatory text. Provide details on specific pollutants (N, P, TSS, Cu, Zn, E.coli, Fecal coliforms, etc.)*		
WFD Ecological Status and objectives	*Describe any impacts related to the improvement of the WFD ecological status, and/or environmental (the biophysical related ones) objectives*		
Reducing flood risks (Floods Directive)	*Describe any impacts related to the flood risk reduction and the objectives (the biophysical related ones) of the Floods Directive*		
Mitigation of other biophysical impacts in relation to other EU Directives (e.g. Habitats, UWWT, etc.)	*Describe any other biophysical impacts related to pressures and objectives (the biophysical related ones) of other EU Directives, e.g. Habitats Directive, UWWT Directive, etc.*		
Soil Quality Improvements	*Has the NWRM impacted the overall soil quality? In which way? Please provide some explanatory text. Provide details on specific pollutants (N, P, soil carbon/organic matter, physical properties-bulk density, etc.)*		
Other	*Water availability in summer*	*From 3.96 Mm3 to 4.95 Mm3 for downstream sub-catchment*	*+25%*

7. Socio-Economic Information

What are the benefits and co-benefits of NWRMs in this application? *Refer to the direct and ancillary benefits (including societal impacts). These are positive outcomes (or welfare gains) closely*	Direct benefits: Increased water availability in agricultural land for irrigation.

related to the implementation of the measure, through causal relationship. *What are the direct benefits of the effective implementation of the measure? Please specify the kind of direct benefits of the effective implementation of the measure.* *What are the additional indirect benefits of the effective implementation of the measure?*	Increased biodiversity and habitat quality (vegetation and fauna) around and within ponds Indirect benefits: Support ancillary social and economic activities (wood production and social/educational farms)		
Financial costs *Value in € (Total + possible breakdown)* *Suggested categories for the breakdown of costs: capital, land acquisition and value, operational, maintenance*	***Total extra-costs for green ponds construction:***	*140.000 €*	*Total cost including construction and yield loss for a green water retention pond of 50.000 m^3 of water volume over 20 years*
	Construction costs (grey ponds)	*12 €/m3*	*Costs include excavation, waterproofing of the bottom and perimeter fence.*
	Construction costs (green ponds)	*14 €/m3*	*Costs include excavation, waterproofing of the bottom and perimeter fence, cost of additional land, floating island.*
Were financial compensations required? What amount? *Describe if financial compensations were required, the compensation scheme (including units, beneficiaries, etc.), the total amount of money paid in €*	*Was financial compensation required: Yes (proposed)*		
	Total amount of money paid (in €):		
	Compensation schema: *Land swap* *Tradable Development rights*		
	Comments / Remarks: compensation scheme proposed to compensate the extra-cost of building ponds in a greener approach		
Economic costs *What is the actual income loss (in some economic sectors) due to the implementation of the measure? Please specify the kind of income loss.* *What are the additional costs that stem from the implementation of the measure and a result of it? Please specify the kind of additional costs.* *Are there any specific costs the measure brought about which cannot be assimilated to the above-mentioned categories? Please specify the kind of other opportunity costs.*	*Cost of kiwi production loss due to greener ponds (50.000 m^3): 0.03-0.05 €/m3/year*		
	Additional costs:		
	Other opportunity costs:		
	Comments / Remarks:		
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.*	Water provision for agriculture Water security (water availability in rivers) Food security (agricultural production support) Amenities (increased biodiversity, habitats, landscape quality)		

- *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.*	

8. Monitoring & Maintenance requirements

Monitoring requirements *Describe monitoring requirements: which parameters, how often, how many monitoring sites, location of these sites, etc.*	Water balance revision, 5 – 10 years
Maintenance requirements *Describe the maintenance scheme: requirements and intensity of, frequency of, responsible authorities, share or tasks, etc.*	Very limited, vegetation cleaning nearby ponds
What are the administrative costs? *These are expenses linked to information, monitoring and enforcement.* *What were/are the costs of monitoring the operation of the measure(s) or any other cost incurred by the administration of the measure(s)? Please specify on what the money has/is been spent.*	Very limited

9. Performance metrics and Assessment criteria

Which assessment methods and practices are used for assessing the biophysical impacts? *Please describe e.g.: comparison to, paired watershed, pre vs. post, etc.*	Landscape connectivity indexes
Which methods are used to assess costs, benefits and cost-effectiveness of measures?	Regional price lists for main cost voices applied to schematic ponds of different size
How cost-effective are NWRM's compared to "traditional / structural" measures?	Extra costs are limited to circa 10% of grey solutions
How do (if applicable) specific basin characteristics influence the effectiveness of measures? *This field is important and needs a good deal of thought. It seems that the success of NWRM may be very dependent on the biophysical regime in which they are implemented. It would be really helpful for any potential practitioner to have enough information to evaluate whether or not the biophysical preconditions for successful NWRM implementation exist before addressing the much more complex socioeconomic challenges.*	Topography, river distance, position compared to relevant areas for the ecological network (as forests) influence the effectiveness
What is the standard time delay for measuring the effects of the measures? *NWRM are multi-purpose and multi benefit measures but like other green infrastructures and on the contrary to grey infrastructure, their effects are not always immediately visible and need a certain time lapse to be fully operational and effective (free text allowed to enter the anticipated delay and the effective deviation from this finally found)*	Years to check effect on the water balance on average

10. Main risks, implications, enabling factors and preconditions

What were the main implementation barriers?	Land availability and additional costs to be covered, legislative restrictions

Were there delays in the implementation? Please describe the main implementation barriers (e.g. attitude of decision makers, stakeholders, public perception -e.g. NWRM perceived as part pf a problem, existing technical standards, physical constraints, conflicts of interests, legal restrictions, lack of expert knowledge and/or tools, limited financial resources and financing potential, wide dissemination of the project, etc.)	
What were the main enabling and success factors? *Please describe the main enabling and success factors (e.g. positive attitude of decision makers, willing stakeholders, positive public perception, solid governance and adequate institutional structures, fruitful public consultation, regulatory support, existing expert knowledge and/or tools, availability of financial resources and financing potential, etc.)*	Water need is high, and ponds can cope with it
Financing *What were the main funding sources, and what amount? Where different incentives and financial instruments used? Which ones? Has private investments been encouraged – how?*	Tow innovative incentive schemes have been elaborated, compensating farmers with land or in monetary terms
Flexibility & Adaptability *Is the current implementation flexible and adaptable to changing baseline conditions? What does the adaptation of these measures requires? What costs could be foreseen?*	*Nature based ponds are simple solutions to adapt to broad spectrum of contexts*
Transferability *When and where can a similar application be proposed, assessed and selected? What are the necessary preconditions?*	Fully transferrable, data to design and study effectiveness are available pan EU

11. Lessons learned

Key lessons	(nature based) ponds showed their beneficial role in agricultural landscape, (water availability and habitat quality) in present and future climate change scenarios. Farmers and experts confirmed the complementary environmental benefits related to water retention ponds, which act as stepping-stone across the landscape supporting biodiversity and habitat quality for wildlife. Additional costs to farmers (construction and agricultural production loss) shall nonetheless be compensated by new incentive schemes.

12. References

Note: Complete list of reference available in the report. Here, we reported some references supporting the main concepts and methods used.

Source Type *Select from the drop-down menu*	*Journal*
Source Author(s) *Provide the Name of the author(s)*	*Cassani Gabriele*
Source Title *Provide the Tile of the reference*	The Water balance: A methodology for evaluating the compatibility between surface water resources and environmental and anthropic requirements.
Year of publication *Provide the year in the format (YYYY)*	2009
Editor/Publisher *e.g. Journal/Volume/Issue*	L'Acqua, n.2, pag.45

Source Weblink *Direct weblink(s) of the reference*	https://www.idrotecnicaitaliana.it/sommari/il-bilancio-idrico-una-metodologia-per-la-valutazione-della-compatibilita-tra-risorsa-idrica-e-idroesigenze-ambientali-e-antropiche/		
Key People *List names, affiliation and contact details of key people who have communicated important information presented in this factsheet*		*Name / affiliation*	*Contact details*
	1.	*Franchini Marco*	
	2.	*Galeati Giorgio*	
	3.	*Mazzoli Paolo*	
	4.		
Source Type *Select from the drop-down menu*	*Journal*		
Source Author(s) *Provide the Name of the author(s)*	Maes Joachim		
Source Title *Provide the Tile of the reference*	More green infrastructure is required to maintain ecosystem services under current trends in land-use change in Europe.		
Year of publication *Provide the year in the format (YYYY)*	2015		
Editor/Publisher *e.g. Journal/Volume/Issue*	Landscape Ecology, 30, 517-432		
Source Weblink *Direct weblink(s) of the reference*	https://link.springer.com/article/10.1007/s10980-014-0083-2		
Key People *List names, affiliation and contact details of key people who have communicated important information presented in this factsheet*		*Name / affiliation*	*Contact details*
	1.	*Barbosa Ana*	
	2.	*Claudia Baranzelli*	
	3.	*Grazie Zulian*	
	4.	*Felipe Batista e Silva et.al*	
Source Type *Select from the drop-down menu*	*Journal*		
Source Author(s) *Provide the Name of the author(s)*	Renard Vincent		
Source Title *Provide the Tile of the reference*	Property rights and the 'transfer of development rights: questions of efficiency and equity		
Year of publication *Provide the year in the format (YYYY)*	2007		
Editor/Publisher *e.g. Journal/Volume/Issue*	The Town Planning Review, 78(1), 41-60		
Source Weblink *Direct weblink(s) of the reference*	https://www.jstor.org/stable/40112701?seq=1#metadata_info_tab_contents		
Key People		*Name / affiliation*	*Contact details*
	1.		

List names, affiliation and contact details of key people who have communicated important information presented in this factsheet	2.		
	3.		
	4.		