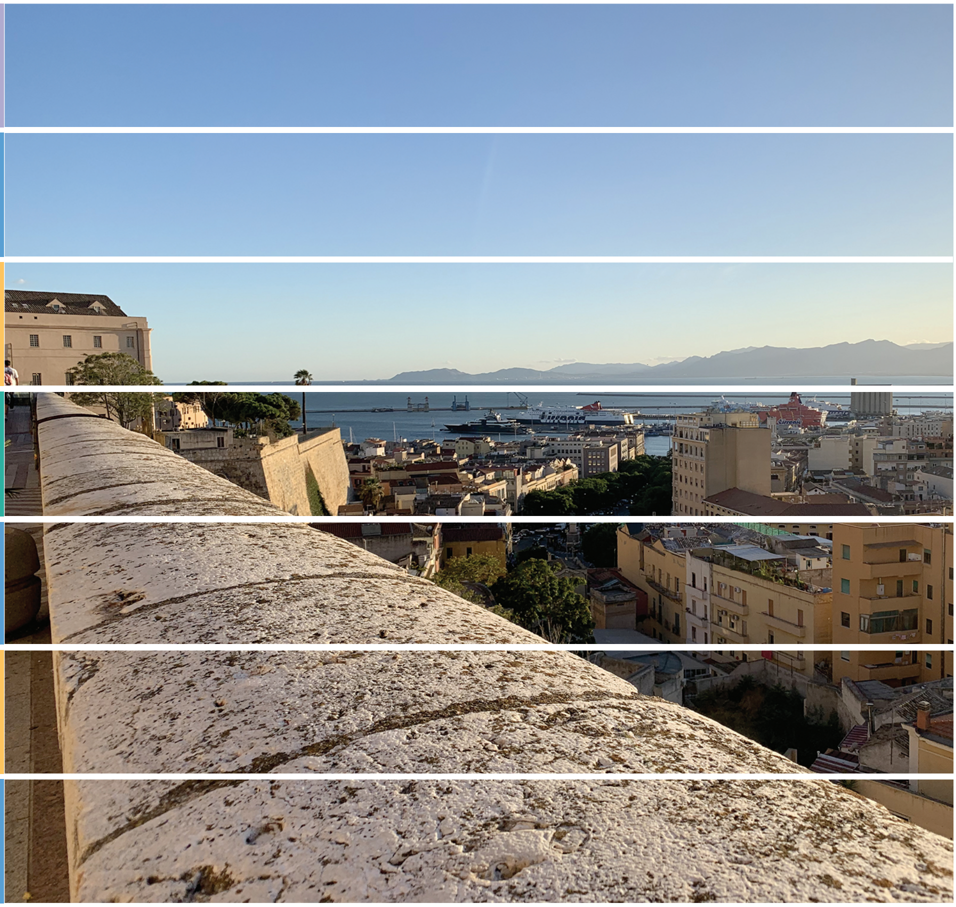
Carmela Gargiulo Corrado Zoppi
Editors

Planning, Nature and Ecosystem Services



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Smart City, Urban Planning for a Sustainable Future

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Carmela Gargiulo Corrado Zoppi

Editors

Planning, Nature and Ecosystem Services

INPUT aCAdemy 2019

Conference proceedings

Federico II Open Access University Press

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La cooperazione al cuore del Mediterraneo

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This book collects the papers presented at INPUT aCAdemy 2019, a special edition of the INPUT Conference hosted by the Department of Civil and Environmental Engineering, and Architecture (DICAAR) of the University of Cagliari.

INPUT aCAdemy Conference will focus on contemporary planning issues with particular attention to ecosystem services, green and blue infrastructure and governance and management of Natura 2000 sites and coastal marine areas.

INPUT aCAdemy 2019 is organized within the GIREPAM Project (Integrated Management of Ecological Networks through Parks and Marine Areas), co-funded by the European Regional Development Fund (ERDF) in relation to the 2014-2020 Interreg Italy – France (Maritime) Programme.

INPUT aCAdemy 2019 is supported by Società Italiana degli Urbanisti (SIU, the Italian Society of Spatial Planners), Istituto Nazionale di Urbanistica (INU, the Italian National Institute of Urban Planning), UrbIng Ricerca Scientifica (the Association of Spatial Planning Scholars of the Italian Schools of Engineering) and Ordine degli Ingegneri di Cagliari (OIC, Professional Association of Engineers of Cagliari).

This book is the most recent scientific contribution of the "Smart City, Urban Planning for a Sustainable Future" Book Series, dedicated to the collection of research e-books, published by FedOAPress - Federico II Open Access University Press. The volume contains the scientific contributions presented at the INPUT aCAdemy 2019 Conference. In detail, this publication, including 92 papers grouped in 11 sessions, for a total of 1056 pages, has been edited by some members of the Editorial Staff of "TeMA Journal", here listed in alphabetical order:

- Rosaria Battarra;
- Gerardo Carpentieri;
- Federica Gaglione;
- Carmen Guida;
- Rosa Morosini;
- Floriana Zucaro.

The most heartfelt thanks go to these young and more experienced colleagues for the hard work done in these months. A final word of thanks goes to Professor Roberto Delle Donne, Director of the CAB - Center for Libraries "Roberto Pettorino" of the University of Naples Federico II, for his active availability and the constant support also shown in this last publication.

Rocco Papa
Editor of the Smart City, Urban Planning for a Sustainable Future" Book Series
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Table of contents

Session: 2 - Integrated management of marine protected areas and Natura 2000 sites

ISBN: 978-88-6887-054-6
DOI: 10.6093/978-88-6887-054-6

Session 3 - Rural development and conservation of nature and natural resources

Session 4 - Geodesign, planning and urban regeneration

ISBN: 978-88-6887-054-6
DOI: 10.6093/978-88-6887-054-6

Session 5 - Green and blue infrastructure

Session 6 - Smart city planning

ISBN: 978-88-6887-054-6
DOI: 10.6093/978-88-6887-054-6

Session 7 - Water resources, ecosystem services and nature-based solutions in spatial planning

ISBN: 978-88-6887-054-6
DOI: 10.6093/978-88-6887-054-6

Session 8 - Conservation and valorisation of architectural and cultural heritage

Session 9 - Accessibility, mobility and spatial planning

ISBN: 978-88-6887-054-6
DOI: 10.6093/978-88-6887-054-6

Session 10 - Tourism and sustainability in the Sulcis area

Special session 1 - Ecological networks and landscape planning

ISBN: 978-88-6887-054-6
DOI: 10.6093/978-88-6887-054-6

ISBN: 978-88-6887-054-6
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A BLUE INFRASTRUCTURE: FROM HYDRAULIC PROTECTION TO LANDSCAPE DESIGN

THE CASE STUDY OF THE VILLAGE OF BALLAO IN THE FLUMENDOSA RIVER VALLEY

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ABSTRACT

The United States Environmental Protection Agency (EPA) provides an interesting definition of 'green/blue' infrastructure (GI): 'an approach to ecosystem management that relies on constructing landscape features that function similarly to natural systems thereby increasing the functionality of built or urbanized ecosystems. GI systems use vegetation, soils, and natural processes to manage storm water and maintain ecosystem functions. GI systems are intended to also provide social and economic benefits that enhance urban liveability. They typically operate alongside blue infrastructures, defined as all the systems which channel water, whether they are surface or underground streams, marine or inland waters. The synergy between green and blue infrastructures does not only produce strategic environmental value, but it also plays a central role in the management of rainwaters during floods, the collection and storage of water, the prevention of floods, the defense against sea-level rise, the mitigation of natural risks and the reduction of environmental temperature. Two aspects of green/blue parks are of notable interest: the first one consists in their potential in enhancing the resilience of territories affected by environmental critical phenomena, by limiting their impact and restoring rapidly their initial conditions with minimal damages. The second one consists in their dual value as infrastructures for the mitigation of hydraulic risk, designed to preserve communities that are vulnerable to that risk, and as a public space, exploitable in the time laps between the critical or disastrous events. The case study of Ballao (Sardinia) along the Flumendosa river offers the opportunity to test practically the approaches suggested by the international best practices.

KEYWORDS
Green Parks; Blue Parks; Flood; Resilient Landscape

* The other authors are: Davide Pisu, Francesco Marras, Giovanni Maria Sechi.

1 INTRODUCTION

This study gave rise to and was developed alongside the PROTERINA-3Évolution project, an evolution of the work realized during the EU 2007-2013 program, with the PROTERINA-Due, RESMAR and PROTERINA-C projects. That is, therefore, a project conceived to enhance the attitude of institutions in preventing and managing, jointly, the risk of flood. The general aim of the project is to reinforce the response capacity of territories to the risk of flood through the 'construction' of awareness among institutions and communities. The addressees -whether direct or indirect- are the competent authorities in the field of civic protection, soil conservation and cycle of waters, the agencies which are involved in forecasting and monitoring activities in regard to meteorological phenomena and the citizens actively engaged in the decisional processes. The specific aims of the PROTERINA-3Évolution project are:

- to promote actions of prevention and protection: to enhance the effectiveness of preventive measures -both structural and not- against the risk of floods, through the transfrontalier and transregional involvement of institutions and communities that are willing to be actively engaged in a process of awareness-raising within their territories (OB.1);
- to empower event forecasting and monitoring systems: to strengthen monitoring networks and integrate the acquired data with early-warning models, capitalizing the results of the former programs (OB.2);
- to develop resilient communities: to increase the transfrontalier capacity of adaptation to climatic change through the deployment of resilient communities (OB.3).

The activity of the DICAAR research group within the PROTERINA-3Évolution project is specifically aimed at the development of guidelines on the construction of blue infrastructure consisting of urban parks serving the scope of flood peak reduction, the drafting of guidelines on flood-proofing operations, consisting of micro-scale actions on public buildings such as state schools, libraries and social centres, with the purpose of mitigating flood risk and identifying safe spots and, finally, the exchange of expertise with the river basin authorities of the other regions taking part in the PROTERINA project (for Italy the river basin authorities of Liguria and Tuscany, and for French partners their competent authorities). In this context, an extremely relevant role is given to the analysis of the risk of flooding in the territory of the municipality of Ballao, which even for events having low return periods shows large areas, even urbanized, affected by flooding phenomena from the Flumendosa river, which overflows its banks. The development of a bi-dimensional hydraulic model will be shown below. It will be used, firstly, to analyse the hydraulic risk in the current state of the territory and, secondly,

ISBN: 978-88-6887-054-6
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as a support for the definition of actions which can enable the mitigation of river flooding, thus preventing it from affecting urbanized areas, as far as possible. Such actions have the dual purpose of serving as systems for the prevention and protection from hydraulic risk during disastrous events and as public spaces open to the collective use, for leisure and play time, during the rest of the year.
Designing a blue infrastructure entails a reflection on its dual nature of tool for the mitigation of hydraulic risk -which constitutes the main reason for its construction- and as a landscape design tool for the correct fruition of spaces throughout periods with no critical events. If, on one hand, measures concerning the ban on building in areas at hydraulic risk may sometimes be sufficient to limit the risks and the vulnerability of communities, on the other hand, such measures often preclude the collective use of large areas of the territory. Furthermore, this kind of approach has a tendency to marginalize these places that are rapidly subject to decay. For this reason, it is necessary to consider their dual use: these areas must be considered, on one side, as part of an hydraulic infrastructure, namely spaces destined to the protection and safeguarding of the built space and, on the other side, they act -in the longer run- as public spaces open to collective use.

2 METHODOLOGY

Through the study of best practices in the field of blue park design, once again intended as public recreational spaces designed to be flooded during heavy rains and inundations, it was possible to identify four common measures to mitigate the risk, the application of which we deem to be essential for the success of the project.
The authors in line with the premise have defined the following methodology:

- the creation of expansion basins: flow-storage reservoirs and retarding basins;
- the creation of embankments and the modelling of topography;
- the establishment of paths on higher ground and safe spots;
- the restoration of riparian vegetation.

2.1 THE CREATION OF EXPANSION BASINS: FLOW-STORAGE RESERVOIRS AND RETARDING BASINS

The analysed case studies highlighted that the management and control of water flows play a crucial role within the park, not only from a merely functional point of view in relation to the mitigation of the risk, but most importantly in terms of quality of the landscape and the public space open to citizens.

ISBN: 978-88-6887-054-6
DOI: 10.6093/978-88-6887-054-6

Best practices highlight, in particular, that the introduction of expansion basins as flooding areas along riverbanks may represent an effective measure for the mitigation of floods, being at the same time an opportunity to create new habitats or new public spaces. Expansion basins are areas designated for the temporary or permanent conservation of water flows during rain and flood events. These are generally designed in two forms: flow-storage reservoirs and retarding basins. The formers, typically retain water only during storms, releasing it lately at a controlled rate, until they are completely empty, or they reach a reserved volume. The latter, located along the river, have typically the possibility to receive amounts of water exceeding the river flow capacity, independently from heavy rainfall events. On a perspective strictly inherent to the design of blue parks, expansion basins as flooding areas along riverbanks are preferable, because they not only have a limited impact on a territorial scale, but they also may create the opportunity to use a multidisciplinary approach to the project, which may aim at multiple tasks: hydraulic risk mitigation, environmental restoration, management of water resources and public space. The retention of even modest quantities of water allows for the creation of a moist environment in which birdlife can thrive together with vegetation that can tolerate short periods underwater. On the other hand, expansion areas along river banks allow to create wetlands that not only contribute to the valorisation of ecological corridors and to the creation of new habitats in support of biodiversity, but also represent an opportunity to enhance the perception of the landscape, making it more attractive.

2.2 THE CREATION OF EMBANKMENTS AND THE MODELING OF TOPOGRAPHY

Embankments are infrastructures that allow for a passive protection of the territory. They prevent the overflowing of watercourses and hamper every connection between the river and the surrounding territory. They are normally constituted by soil barriers that may be located at a minimum distance from the riverbed or, where possible, they are located at a long distance from the riverbed (setback levee). The distance of the riverbank form the watercourse has a significant impact on the dynamics of the river, inasmuch as it will be consequently more or less free to invade the floodplain during flood events. The more the barrier is distant from the river, the more its freedom of movement increases, thus leading to a reduction of the hydric level and, consequently, to a slowdown of its flow. The enhancement of the flow capacity of the riverbed through the setback of embankments is not always possible, because often the river is located near urban areas or farmlands. From the point of view of landscape architecture, best practices show us that embankments can be imagined not only as defensive systems, but also as elements, which define the public space. Barriers, if modelled on the surrounding territory following the height required by the various hydric

ISBN: 978-88-6887-054-6
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levels provided for critical events having different return periods, allow for the establishment of a network of pathways which can be used even during flooding's.

2.3 THE ESTABLISHMENT OF PATHS ON HIGHER GROUND AND SAFE SPOTS

As best practices show, in the design of blue parks the definition of paths based on expected water levels has a central importance. The connective systems within the park must be designed, in fact, at a higher altitude than the one required for the maximum expected level, so that in any condition a way out is guaranteed in case of flood. Paths on higher ground, as well as safe spots located over critical levels, can be further preserved from floating materials and soil transported by water through vertical protection systems.

2.4 THE RESTORATION OF RIPARIAN VEGETATION

Riparian vegetation represents an important and delicate interface between water streams and the surrounding territory. The root system performs, in fact, a strong stabilizing action both with respect to soil erosion and to hydrodynamic stress. It is nonetheless necessary to consider also the flow resistance of vegetation. Equilibrium is reached when vegetation has a diversified structure, composed by shrubs capable of a certain degree of flexibility and capable of reducing the action of resistance to the water flow, while allowing for mitigation of erosion, and by an arboreal system composed of young trees having a balanced diameter/height ratio. As a matter of principle, the diameter should in any case be progressively lower while approaching the riverbed and when the width of the river decreases. Thus, during floodings, riparian wood performs an important flow modulation function, delaying the reaching of the maximum level by amplifying the retarding action of expansion basins. For this reason, the choice of vegetation types in expansion basins has an important role: in conjunction with the morphology of the territory, it can amplify the beneficial effects of lowering the level of water. Clearly, the collateral effect is the containment of the stream speed: the water that leaves the riverbed flows in the riparian wood where, thanks to the increased roughness determined by vegetation, it suffers a significant slowdown.

Starting from these intuitive elements concerning cause-effect relationships, rather than defining abstract lines of principle we chose to investigate a case study through a pilot project and, from this, we derived methodological statements as generalizable as possible. Through this methodological approach, the following project attempts to find a difficult balance between a hydraulic infrastructure project for risk mitigation and a landscape design project made by conceiving the design action as the most delicate act of modification, capable of integrating itself moderately among the topographic and orographic signs.

ISBN: 978-88-6887-054-6
DOI: 10.6093/978-88-6887-054-6

3 THE CASE STUDY

The case study of the municipality of Ballao (Sardinia) shows a series of particularly significant phenomena related to the risk of flood, but at the same time it shows considerable opportunities in terms of hydraulic infrastructure design and public space, integrated in a landscape system. The area is located between the 'RiuBintinoi' stream and the corresponding riverfront, the Flumendosariver in the North and Via Roma in the East. This area is occupied by a series of residential buildings, located between the urban streets 'Via PeppinoMereu', 'Via Raimondo Piras', 'Via BenvenutoLobina', 'Via Aldo Moro' and other streets accessible from 'Via Sassari'. The closing element of this urban system consists of an aggregation of neglected buildings, formerly the town's abattoir and a depot, still used by the municipality. The last fragment of urban continuum is represented by a parking lot -accessible from the 'RiuBintinoi' side-, at a height of 83 meters above the sea level. Globally, the area covers 4 ha, of which only 1.5 not urbanized. As mentioned above, the aim was to realize an embankment which may serve the function of defining an area for the controlled flooding, located on the right bank of the Flumendosa river, as shown in the previous images, that may be open to recreational and sports uses for the community of Ballao and of Sarrabus/Gerrei.

From a landscape point of view, the hypothesis of constructing a hydraulic bank widely oriented along the riverbed was rapidly excluded due to the clear impact on the environment that this would have generated. This would have constituted a physical and visual barrier between the town and the river and, furthermore, this approach would not have been consistent with the principles of blue park design previously described. For this reason, we decided to focus on a barrier for the protection of the urban area consisting of component in bulk materials over the bank. The total height would be lower than 2.2 meters, with a length of 125 meters starting from the intersection with via Roma and following parallel to the riverbed to reach via Sassari, thus extremely distant from the river (setback levee). The planimetric position of the hydraulic protection intervention is synthetically shown in Fig. 1. The intervention can be built in two phases with reference to events with a return period from 10 to 50 years. The embankment is sized for the containment of the 10 years return period flood, and its peak is in fact at the same height of the parking lot, 83 m above the sea level. In a second phase, for the protection of the 50 years return period flood we designed a series of precast concrete barriers, conveniently shaped and waterproofed to raise the elevation above the parking lot located in front of the old abattoir.

The track of the new topographic sign was chosen in such a way as to create a direct connection -currently only potential- with the opposite bank of the RiuBintinoi. In fact, in the northern boundary of the village is already operating the 'Parco intervacua's', which even though it is easily accessible through the secondary roads of the town, at the moment does

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not have any relationship with the area on which this study is focused. The two parts may, on the contrary, be easily connected through a walking/cycling bridge on the RiuBintinoi stream, thus operating a whole large river park along points of contact between the Flumendosa river and the town of Ballao. This system, which may be further investigated in a specific forthcoming study, may constitute a greater green/blue infrastructure within a territorial scale, not only capable of reorganizing the elements of the landscape in an harmonious continuum, but also capable of providing physical support for the attraction of events, activities and demonstrations of public interest to the benefit of the local community. On the top of the newly built embankment, new cycling and walking paths will be traced. These will allow for the closing of a circuit along the river and the edge of the village. The plan design of the hydraulic infrastructure has, therefore, a double reason. On one hand, it constitutes the necessary barrier for the protection of the urban area from floodings of the Flumendosa river and, on the other hand, the new topographic sign joins existing lines and elements of the landscape in order to constitute an organic system, even though it is made of different parts, investing it with meaning and public function. The main development of the embankment is parallel to the riverbed, but it bends at about two-thirds of its length to reach via Garibaldi. Here the track of the new embankment crosses the rural area defining an average height of 2.2 meters. In the point of junction between its two lines, the embankment bifurcates and, in that point, a narrow corridor consisting of a wooden pier extends itself towards the centre of the flooding area and descends to the lower point, with the purpose of measuring the terrain from the water level of the 10 years return period flood to the ground below. There, a stair and a wooden hut mark the end of the path. The stair will allow to descend to the ground when it is not flooded, whilst the hut will offer protection from the sun and the rain, allowing visitors to stay and enjoy the landscape. The width of embankments varies accordingly to ground altitude, but they have approximately the same section all along the river. The sides of the embankment will be covered with grass and shrubs having mostly superficial roots. The paths will be paved with stone chunks or self-locking blocks which may offer a safe support to the pedestrian and cycling traffic. As mentioned above, in the second phase, a series of precast concrete barriers -properly sized and waterproofed-will be installed on the top of the embankment in order to create a protection from the 50 years return period flood. Indeed, the desired height of the embankment, sized for the 50 years return period, is equal to 2.5 meters from the lowest point of the area object of this study. Through the concrete barrier, the height of the embankment is increased by 0.8 meters reaching a total of 3 meters from the lowest point and thus leaving 0.5 meters free on the 50 years return period.

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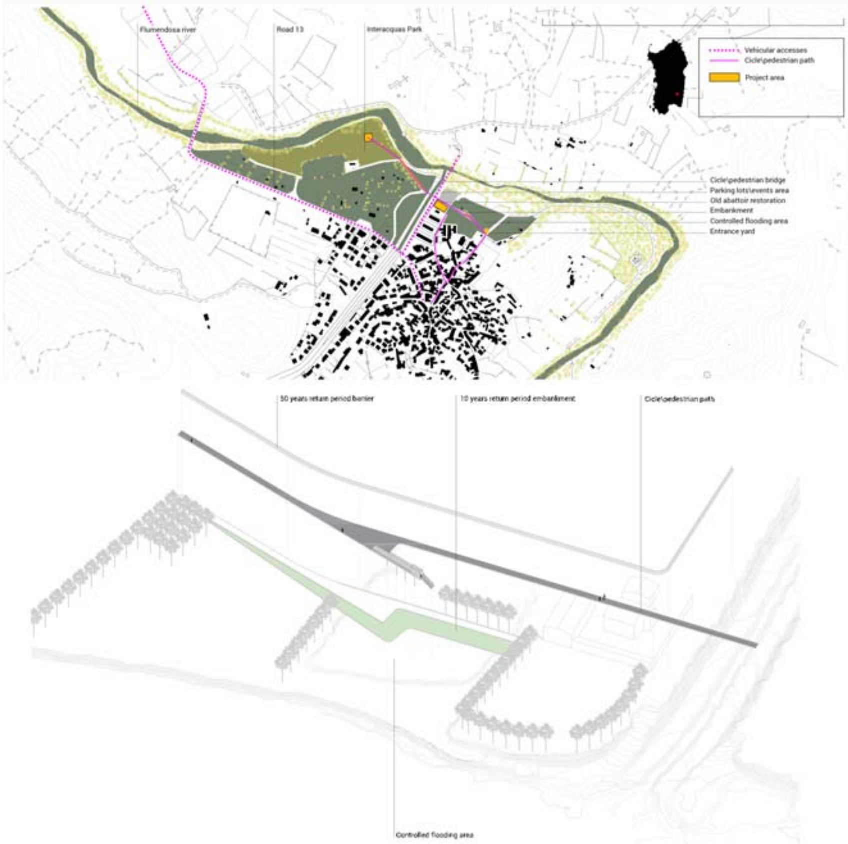

Fig. 1 General plan of the blue park and components of the landscape project

This element, which will be investigated in a separate detailed study, may be modelled in order to provide seats, bicycle racks, parapets and support for path lights. If the 10 years return period flood is taken into account, the area subject to critical events in case of flood consists of a depression comprised between the beginning of the embankment and the parking lot near the abattoir. Via Bintinoi is not subject to the 10 years return period flood. If we consider an event having 50 years return period, instead, the area subject to flood comprises all the area near the new embankment, the parking lot, and a portion of via Bintinoi until it reaches via Peppino Mereu. Finally, we must consider that, in order to complete the works of protection from 50 years return time period events, the current Hi4 -the maximum hydraulic hazard zone- could be redefined, allowing for the relocation of the old abattoir to public uses: this operation may constitute the last part of the project, allowing for the complete regeneration of the area comprised between the urban margins and the Flumendosa river.

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4 CONCLUSION

Drawing on a series of international best practices, the application of the methodology described above has allowed for the development of the project of a hydraulic protection system in close proximity to an urban settlement alongside two general goals: the first one consists in its potential in enhancing the resilience of territories affected by environmental critical phenomena (such as floods) by limiting their impact and restoring rapidly their initial conditions with minimal damages.

Fig. 2 Cross-section of the embankment

Fig. 3 Aerial view in normal conditions and during a 50 years return period

ISBN: 978-88-6887-054-6
DOI: 10.6093/978-88-6887-054-6

The second one consists in their dual value as infrastructures for the mitigation of hydraulic risk, designed to preserve communities that are vulnerable to that risk, and as a public space, exploitable in the time laps between the critical or disastrous events. The project for the Flumendosa valley in the town of Ballao (Sardinia), shows that the two aspects, strictly connected to the liveability and environmental quality of the territory, are not conflicting. Rather, in order for the project to have a positive impact on the environment and on the landscape, they should be combined and be designed to operate as hydraulic devices during disastrous events and as rural public spaces in the time between them.

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Pino Frau gained a First Class Honors Degree in Civil Engineering at the University of Cagliari, with a thesis entitled: 'Comparison of One-dimensional and Two-Dimensional modeling of flood events by using HEC-RAS - Application in the Posada river valley area". After graduating, he started his collaboration with the Civil and Environmental Engineering and Architecture Department (DICAAR) at the University of Cagliari. The internship focused on the use of Two-Dimensional modeling in the areas affected by river flooding as a consequence of flood events. During that internship, his areas of expertise included the application of the HEC-RAS modeling in both rural and urban areas in order to develop evacuation plans for the population, the valuation effects, in fluvial hydrodynamic, of the attribution of the roughness value based on the soil and the vegetative covering used. He won two research grants at the University of Cagliari entitled 'Analysis and Application of Two-Dimensional Models for the Assessment of Flood Risk and the Preparation of Emergency Plans downstream through large dams.' After winning two research grants at the University of Cagliari, he is currently collaborating with the Sarrabus Municipality Consortium and the Sardinian Regional Agency of Hydrographic District.

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Giovanni Maria Sechi is an Associate Professor of Hydraulic Constructions (ICAR/02). In February 1983 he was appointed university researcher at the same University and from October 2000 he has been Associate Professor of Hydraulic Construction Engineering. Winner of a research grant from the CNR -the Italian National Research Council- in 1984-85 he was a visiting researcher at the Civil Engineering Dept. of the Colorado State University. He is currently working at the DICAAR – UNICA - Hydraulic Engineering Section. From November 2004 to 2010 he was Director of the CINSA, the Interdepartmental Center for Environmental Science and Technology of UNICA.He is a member of the IAHR, International Association of Hydraulic Engineering and Research, of the EWRA, European Water Resources Association, the Italian Hydro-technical Association, the AIRO, Italian Association of Operations Research, and of the CSSA, Italian Center for Water Supply Systems.In September 2005 he was assigned to the Executive Committee of the EWRA, the European Water Resources Association.His research activity was focused in particular on the development of efficient algorithms for the optimization of large-sized water resource systems, also taking into account conditions of uncertainty and the use of non-conventional resources. He has also worked on probabilistic modelling of extreme hydrological events. He was coordinator of the research unit of the University of Cagliari in the VAPI project by GNDCI-CNR (Italian National Research Council).

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