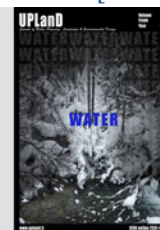


# UPLanD

*Journal of Urban Planning, Landscape & Environmental Design*



Research & experimentation  
Ricerca e sperimentazione

## BUILDING THE RESILIENT CITY. STRATEGIES AND TOOLS FOR THE CITY MASTERPLAN

Luca Barbarossa, Viviana Pappalardo, Francesco Martinico

*Department of Engineering and Architecture, University of Catania, IT*

### HIGHLIGHTS

- Climate change risks and resilience pose unprecedented challenges to urban planning.
- There is limited knowledge on how planning processes relate to the uptake of urban ecosystem services and resilience concepts in governance practices
- The Avola case study represents a first attempt in Sicily to put resilience into the practice of planning process and masterplan design
- Nature based solutions, such as sustainable urban drainage systems, are innovative design tools for addressing the mitigation of pluvial flood risk through the inclusion of ecosystem services into urban areas

### ABSTRACT

Urban risks and climate change mitigation and adaptation, are new challenges for enhancing the city resilience. City planning plays a fundamental role to cope with these challenges in new settlements design and urban renewal actions, taking into account the socio-ecological complexity of the city.

Catchment hydrologic response is influenced by several factors including land use choices and policy tools. Understanding potential effects of urban development is the basis for the implementation of storm-water control planning actions, along with appropriate mitigation and compensatory measures at the catchment scale.

This paper presents a land use planning experience conducted by the University of Catania (Lapta Lab). The focus is on the role of municipal land use planning, a key element of the resilient city.

The settlement system of city of Avola, in Sicily, is illustrated as well as the natural characteristics of the site, relevant for the hydrologic response. The main steps of the planning process are described, in order to explain how urban resilience issues were practically addressed.

The case presented stimulates several considerations about water sensitive urban planning and the opportunities for the inclusion of nature based solutions, such as sustainable urban drainage systems and regulating services, in land-use planning processes.

### ARTICLE HISTORY

Received: June 06, 2018  
Reviewed: July 01, 2018  
Accepted: July 31, 2018  
On line: September 21, 2018

### KEYWORDS

Urban risks  
Resilience  
Land use planning  
Water sensitive urban design

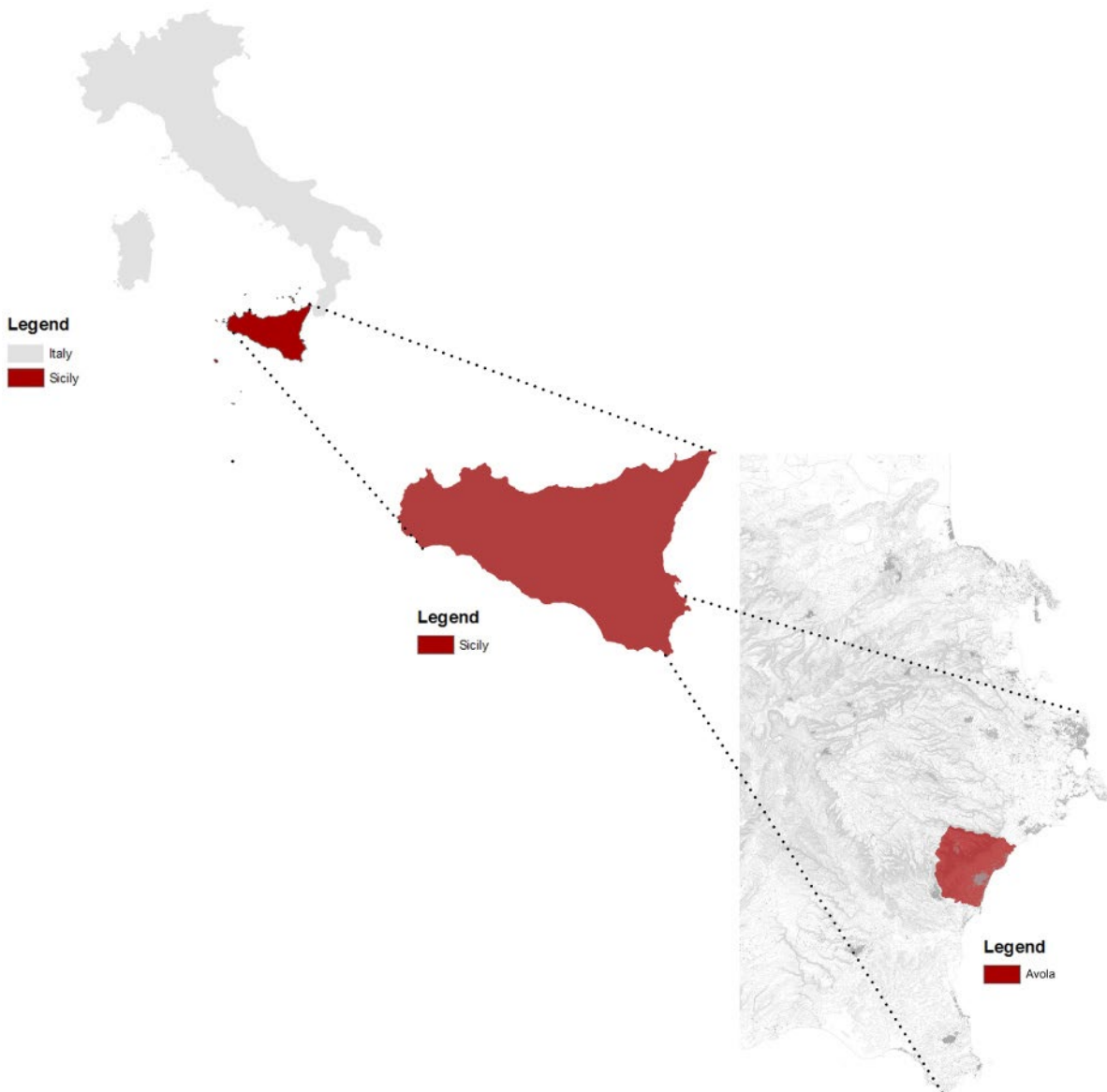
## 1. INTRODUCTORY REMARKS

Urban areas are critical components of global sustainability as well as hubs of progress and local drivers of world-wide transformation (McPhearson et al., 2015).

The rise of interest in sustainable development and resilience largely affects planning and design of urban areas, posing great challenges to the definition of sound urban policies and new tools for achieving objectives such as energy efficiency, containment of urban sprawl, mitigation and adaptation to risks, especially the ones associated to climate change.

At the heart of the resilience perspective in urban design is the focus on the capacity to equip an urban

system as a whole, including its socio-ecological and socio-technical networks across temporal and spatial scales, in order that it could maintain or rapidly return to desired functions in the face of a disturbance, adapting to change (Meerow et al., 2016). The generative metaphor of “resilient city” can be used in order to generate new forms of urban design, which share the model of cities as complex adaptive systems (Desouza et Flanery, 2013). Building a capacity for resilience might be a daunting task considering the multitude of components, processes, and interactions that take place within a city (Desouza et Flanery, 2013). Here planning is still the way to prioritize, recognize and account for innovative urban practices aimed at managing and designing for resilience.



**Figure 1:** City of Avola – Location. *Source: Authors' elaboration*

Currently, a challenging research question is related to understanding how planning processes, with their own timelines and path-dependencies as well as their context-dependent drivers and barriers, relate to the uptake of urban ecosystem services and resilience concepts in governance practices.

This paper analyses the case of a real urban planning process ending with the revision of the City of Avola masterplan. In 2013 the Lapta Lab of the University of Catania (Sustainable Planning and Design of Cities and Landscapes Lab - <http://www.lapta.dicar.unict.it>) was appointed as consultant to support the Planning Department of the Municipality in the preparation of the City master plan. This experience might help in understanding innovative approaches and methodologies for developing land use plan coping with resilience. The focus was on defining strategies for resilience that can produce effective planning practices.

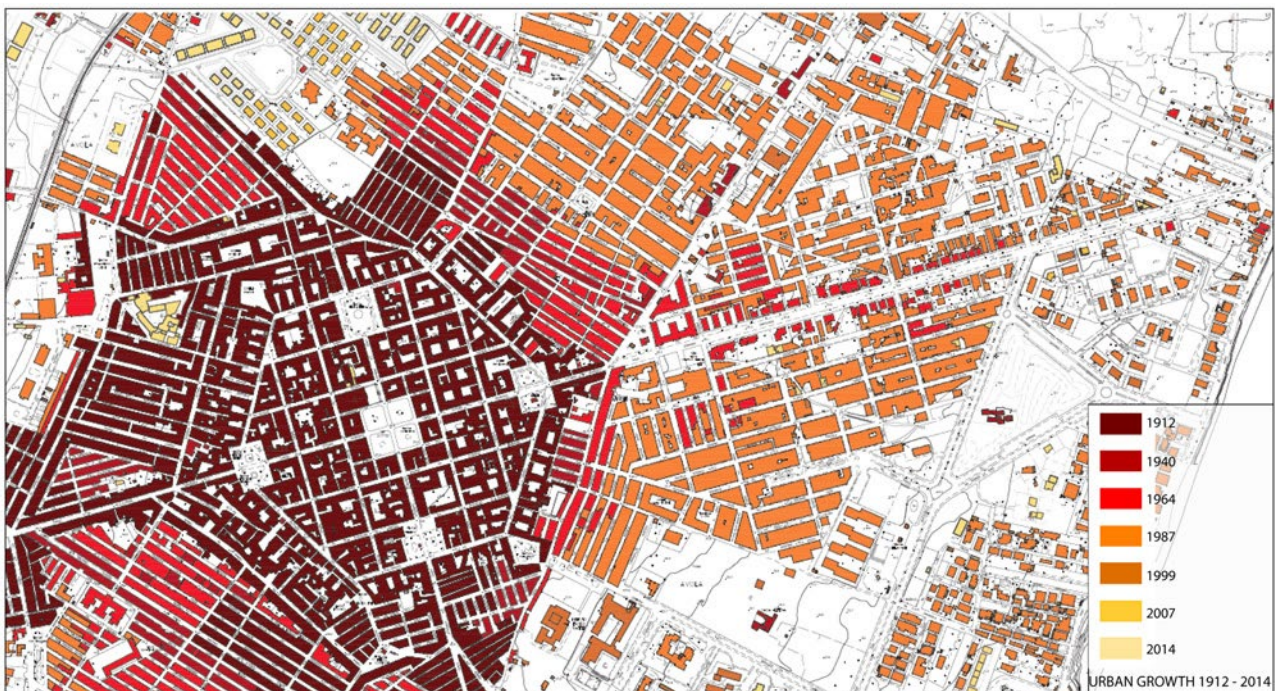
Resilience is informing each stage of the proposed planning process, from the preliminary strategic document to the detailed land use plans. This is needed to implement “specified resilience”, going beyond “general resilience”, (Walker B., Salt D., 2006). In this process the role of local authority was crucial for setting specific goals of mitigation and adaptation to climate change-related risks, as well as for bringing together different interests and approaches of stakeholders involved in the planning process.

## 2. THE AVOLA CASE STUDY

### 2.1 The settlement system

The city of Avola (31.576 inhabitants in 2016) is located along the southeastern coast of Sicily, the so-called Val di Noto, thirty kilometers south of Syracuse (Fig.1). It was completely destroyed in 1693 by a major earthquake that hit southeastern Sicily, causing thousands of victims. More than 45 cities were destroyed or severely damaged. This catastrophic event caused a complete change in the structure of the entire Val di Noto area, where a number of cities were rebuilt in new sites, closer to the coast.

After the earthquake, also the city of Avola was rebuilt in a new site in the coastal plain one kilometer far from the sea shore, according to a completely new layout. The urban structure is characterized by a grid of perpendicular streets within an hexagonal perimeter. A large main square with nearby minor ones marks the heart of town, according to a design inspired by the ideal cities plans from the Renaissance. Blocks inside the hexagon have a square shape with inner courtyards and small gardens. Until the end of 19th century, the urban growth around the original urban core was influenced by the hexagonal shape of the settlement. The settlement grew along a grid of streets that define perimeter built blocks without gardens or lanes. The pattern based on these compact and



**Figure 2:** City of Avola - Urban growth 1912 -2014. Source: Authors' elaboration

regular rectangular blocks repeats the model of the agro towns founded in Sicily from 15th to 17th century, especially during the Spanish domination. At the beginning, the regular grids were aligned to the sides of the hexagon and after their layout was oriented by the grid of existing long distance and rural roads. This phase fulfilled the relevant demand of urban growth between the 1940 and 1960, it produced a compact settlement that did not have a major impact on the environment and landscape. (Fig. 2)

Between 1970 and 1990, two new processes molded the shape of the settlement. The first was the expansion of extensive subdivisions, often illegal, built with detached single family holiday

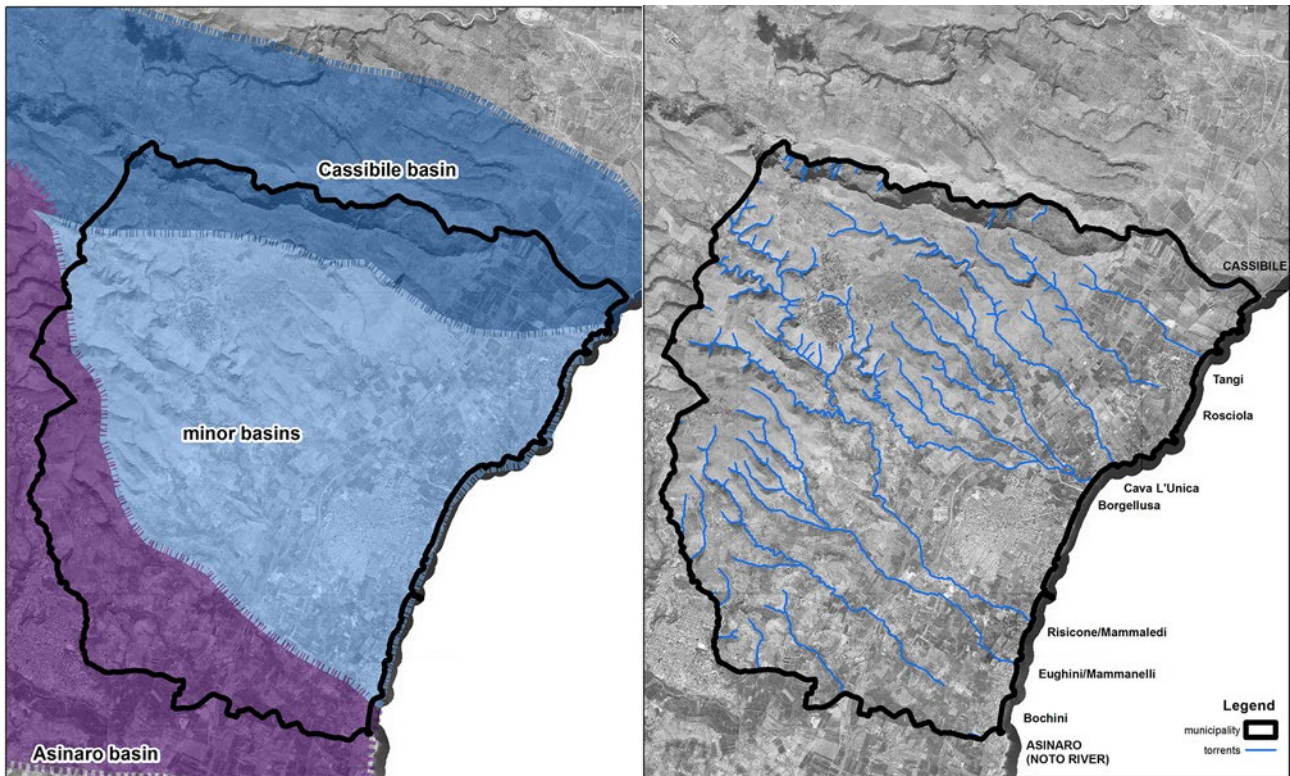
houses along the coastline, a phenomenon that overwhelmed the fragile coastal ecosystem. The second one was the low-density urbanization of peri-urban and rural areas where a considerable number of small and medium size houses have been built by the land owners for week-end or seasonal usage. (Barbarossa et al., 2017).

Legal urban growth in this period was governed by two rudimentary urban plans that did not take into account agricultural land protection and sustainability. These plans produced the new medium density settlements, developed close to the town center, following an awkward interpretation of the modernist planning models.

As a consequence, this settlement is the result of



**Figure 3:** City of Avola - Coastal settlements in a high hydraulic risk area. *Source: Regione Siciliana Aerial Map ATA 2007/2008*



**Figure 4:** City of Avola - Basins and torrents network. *Source: Authors' elaboration*

an uncontrolled and pervasive urbanization developed in agriculture areas characterized by a dense hydrographic network, as well as by relevant hydrogeological and hydraulic risks (Fig. 3). Between Cassibile and Asinaro, the rivers that mark the northern and southern municipal boundaries, a network of creeks flowing in the agricultural plane is producing a condition of high hydraulic risk, today worsened by climate change effects, particularly by recurrent heavy rainfalls (Fig. 4). The revision of the city master plan becomes an essential opportunity to readdress the city development and to set up adaptive strategies for climate change mitigation and adaptation, risks reduction, environmental and landscape protection.

## 2.2 The city masterplan

The preliminary strategic document of the planning process (Direttive Generali), approved by the City Council in January 2014, according to Regional Legislation, was the essential step to identify and frame social, economic, spatial and environmental challenges and to define general development scenarios for improving adaptive capacity and resilience to climate change.

Consequently, the development of the city masterplan, was focused on the implementation of a set of rules to address the theme of urban resilience. This was achieved according to two different strategies. The first is related to urban form and land use prevision while the second is concerned with the implementation of planning rules that include specific principles of urban regulation, useful to deal with climate change effects, and to control storm water run-off. Compensation and incentive policies, included in the zoning ordinance text (Norme Tecniche di Attuazione) will contribute to enhance the effectiveness of mitigation and adaptation policies and make urban resilience more real and effective. Land use regulations are oriented to enhance the ecological dimension of the entire city plan., the regulatory framework defined by a master plan must provide measures for ecological compensation and mechanisms to stimulate greening measures. These rules cannot be referred only to green spaces but they have to deal with the entire built environment. Development incentives are effective tools to promote the provision of green infrastructure and related mitigation measures, within the urban fabric (Martinico et al.2014). The proposed plan also provides new ecological standards, related to the quality of green areas, non-motorized mobility networks, urban agriculture and leisure areas.

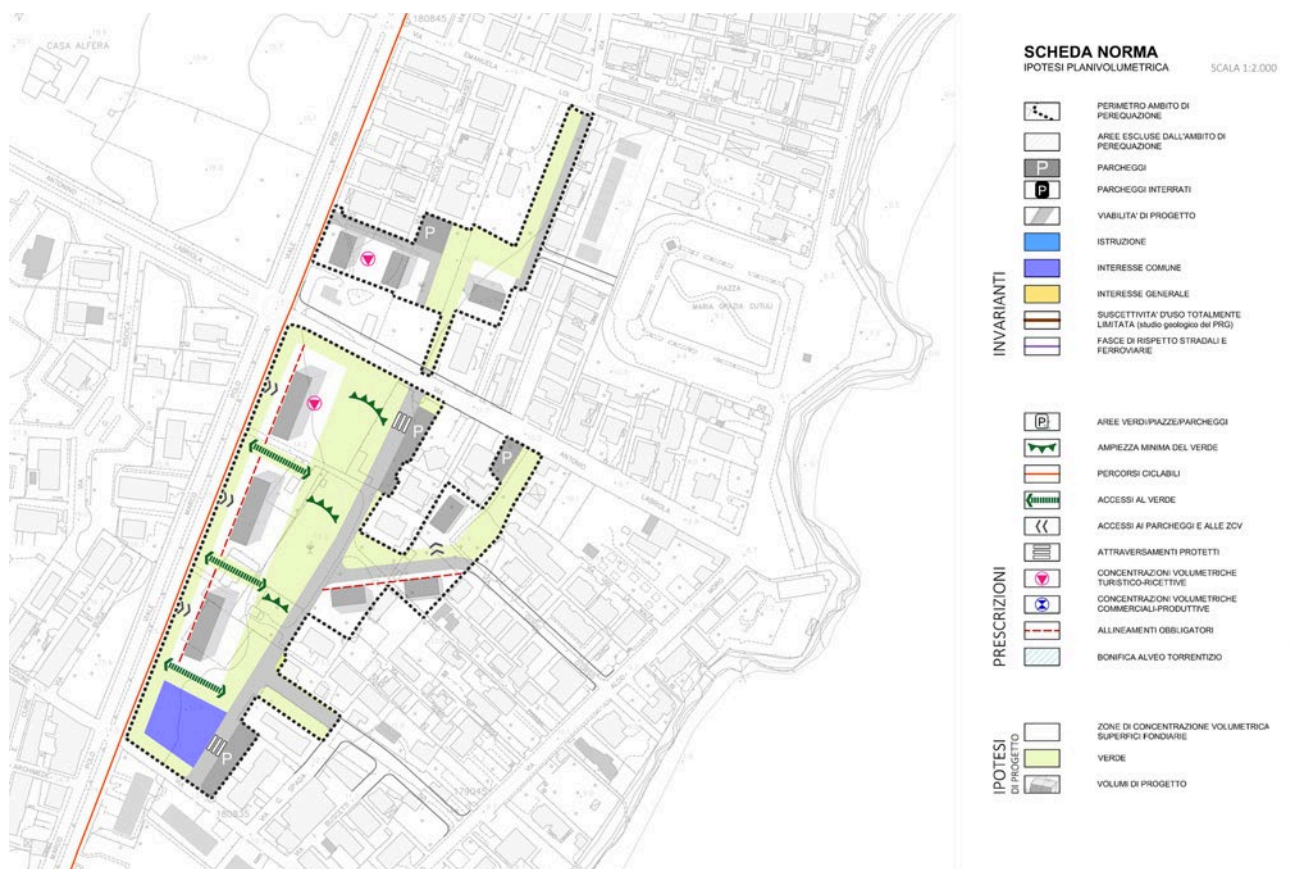
Among the land use prevision for non-urbanized areas, and in particular for farmland, river protection areas, are located close to the main riverbeds, in order to stop urbanization processes and to minimize soil sealing and hydraulic risk conditions, preserving the environmental characteristics of the areas at the same time. These areas feature environmental, agricultural and landscape values that are the backbone of the ecological network. They will complete and integrate a larger green infrastructure that include the outstanding area of the Cassibile river Natural Reserve, located along the northern municipal border with the city of Syracuse. For those areas, the plan provides land use destinations compatible with the objective of protection of creeks and rivers beds, aimed at minimizing hydraulic risk conditions. These regulations represent a radical change compared with the previous master plans which did not take into account hydraulic risk allowing any kind of development. Accordingly, the only limitation to development was the provision of the 1920's legislation that define an undevelopable buffer of only ten meters from the river bank.

The proposed land use regulation does not allow new buildings within the river buffer zones de-

finied by the Landscape Protection Plan recently approved (October, 2017), and where the Regional Hydrogeological Plan (PAI Sicilia, 2006) identifies areas classified as "Level 3", that is with high hydraulic hazard level. This is the first time that in this area a master plan imposes a clearly stated limitation to the uncontrolled development of farmland nearby rivers in order to minimize the exposition to flooding hazard.

According to the contents of preliminary strategic document related to urban resilience and mitigation and adaptation to climate change effects, the master plan introduces specific planning rules for the coastal areas burdened by a massive urbanization. The rules are referred to areas characterized by high levels of hydraulic and geomorphological risk. These coastal settlements very close to the shoreline are mostly made up of illegally built holiday houses.

In order to provide effective solutions for these areas, the masterplan identifies densely urbanized priority areas and proposes an action strategy based on the transfer of development rights (TDR) principle. In these areas the only development option allowed is the demolition of the exiting building and its relocation in identified hazard-free areas. The cost for the building owner will be compensated by a floor



**Figure 5:** City of Avola – Area Risorsa AR\_4, Viale M.Polo. *Source: Authors' elaboration*

area incentive to be applied to the new development in the identified relocation areas.

Delocalization can be carried out only after the demolition of the existing building and the plot property will be transferred to the municipal administration. Furthermore, in order to limit soil consumption and to give more effectiveness to this planning provision, part of the new floor area may be relocated in other residential areas identified by the Master Plan. The aim of this rule is not only to reduce current risk conditions, but also to improve the landscape quality severely damaged by the existing developments close to the coast and the rivers.

Another relevant provision for implementing the strategic principles of the city masterplan, is represented by the simplified detailed plans (Schede Norma) for the development of infill and regeneration areas, called Aree Risorsa (Resource Areas) (Fig. 5). These areas are located within or along the edge of the densely urbanized city. They are intended as a way for easing the acquisition of public land for green spaces and services both at the neighborhood and city scale as well as for improving the quality of the built up layout and increasing the diversity of urban functions.

The Resource Areas detailed plans are designed for addressing the redevelopment and infill of existing urban fabric, creating cycling and pedestrian facilities and improving urban ecosystems, through the creation of a set of interconnected green spaces, intertwined with the existing urban fabric. In this perspective, the urban design plays a key role in the construction of the green infrastructure. At the city and neighborhood scale, Resource Areas provide new green spaces within the urban fabric as a set of ecological connections, between the dense city, the coastal areas and the agricultural and natural areas around the city center. The proposed Resource Areas include the great part of the new developments comprised in the new Master Plan. They are conceived according to a planning approach that gives great priority to infill actions inside the built-up area. In this way, it will be possible to avoid as much as possible greenfield developments, protecting farmland and other natural areas around the existing settlement. Moreover, they are based on the TDR principle in order to increase the economic feasibility of the construction of a Green Infrastructure by the Municipal Authority. Development rights assigned to private owners by the Detailed Plans of each Resource Area are exchanged with the ownership of land zoned for public parks. The considerable amount of public land acquired by this implementation approach will become an essential component of the Green Infrastructure of the city.

The implementation of the Resource Areas is regulated by the zoning ordinance text which includes ecological compensation principles based on specific floor areas incentives that will be granted to the developers that adopt specific mitigation and adaptation planning actions.

According to the Regional Legislation on land use planning, the Master Plan was adopted by the City Council of Avola in April 2017 and it is currently (June 2018) under the approval procedure that will end with the Decree of the Planning Department of the Regional Government. Several amendments have been submitted, mainly by landowners and professionals, revealing the difficulty in accepting a new vision of the development, but the proposed overall framework has been acknowledged by the local government.

### 3. RESILIENCE TO URBAN PLUVIAL FLOODING RISK AND THE LAND USE MASTERPLAN

Among urban risky events, pluvial flooding is increasing as a consequence of growing impervious surfaces trends combined with extreme events. The increase of hydraulic is nowadays one of the most relevant climate change effects. Increasing complexity of the urban context is determining the need to manage rainfall and pluvial flood risk through integrated planning approaches and strategies based on combined mitigation and adaptation policies and practices.

Urbanization have a major effect on soil, compromising its capacity to provide for ecosystem services (EC, 2012) and affecting hydrological cycle (ISPRA, 2017; Chen et al, 2017), often pushing conventional stormwater systems beyond their drainage capacity. Sealing reduces the amount of rainfall that can be absorbed by the soil with resulting increased runoff volume and discharge (Bassan, Pozzer, 2011). Thus, it becomes more and more frequent that in urban areas the capacity of the sewage system might no longer be able to cope with the high runoff of water (Aronica et al, 2013) causing surface flooding.

Being aware of the huge risk that extreme events, combined with soil sealing, pose to urban settlements, planning strategies and actions have been adjusted addressing a more sustainable runoff drainage management and the maintenance of soil permeability. In particular, sustainable urban drainage systems (SuDS) aim at reducing runoff by integrating stormwater control techniques throughout the site. SuDS are used to drain surface

water by mimicking the natural drainage of a site prior to development. These systems capture the rainfall as close as possible to where it falls, reducing the volume, frequency and flow rate of surface water runoff. Not only SuDS objectives are to minimize the impacts from the development on the quantity and quality of the runoff, but also to maximize amenity and biodiversity (Kellagher et al., 2007). Thus, SuDS can deliver additional benefits to flood risk management such as improvements to aesthetics, health, biodiversity, thermal comfort, carbon reduction and sequestration, water availability, pollution control, wastewater treatment reduction and educational opportunities. SuDS contribute to the resilience of urban areas, being components of the green infrastructure.

Control of flow releases from transformed sub-catchments became a serious factor of concern consequently it was included as a key component of the Avola masterplan. In particular, the principle of “hydraulic invariance” (HI) was adopted, namely the condition for peak flow release from transformed areas to remain unvaried before and after land transformation (Pappalardo et al., 2017). The HI concept requires to set appropriate mitigation/compensatory measures at the catchment scale (Parikh et al., 2012). In this regard, the approach used by the plan was to charge the developer with the responsibility for the impacts due to the proposed development.

Basically, on-site retention rules place the responsibility of reducing runoff on the area generating the runoff by requiring the compliance for post-development conditions to meet the pre-development ones, along with the general reduction of impervious surfaces. To further stimulate sustainable and water sensitive individual behaviours, incentive-based policy instruments for areas of new development has been proposed, in combination with the previous command-and-control tools. Development incentives were conceived to be offered consist of density bonus incentive for installing SuDS in their properties or supporting retrofitting action in existing settlements within the urban catchment basin to which the property belongs.

Specifically, local authority would allow urban transformations only if they are compatible with the achievement of the condition of unvaried flow peak at specific outlet sections. In this regard, the assignment of the release restriction to the areas of transformation becomes an additional planning criteria at the implementation stage, namely the conditioning factor in order to receive and use the development permits. Each area where the plan allocates new projects or redevelopments is required to manage excess flow peak (peak differ-

ence between pre-development and post-development scenarios) created by impervious surfaces before leaving the site in order to comply with the hydraulic invariance principle, and preferably by using SuDS, where possible.

Moreover, development incentives (up to 20% of the floor area ratio allowed in each specific area according to plan provisions) are geared towards private property owners of the same areas to creatively encourage green infrastructure implementation according to three possible mechanisms. The first one sets the incentive proportionally to mitigation performances obtained by adopting sustainable site design and green building practices within areas of urban transformations in excess of to the achievement of hydraulic invariance. The second one sets the incentive proportionally to mitigation performances obtained by promoting retrofits of existing sites located outside of the area of transformation but within the urban catchment to which they belong to. The third one is based on the payment of a cash fee that will contribute to a dedicated “mitigation and adaptation fund”, in lieu of implementing SuDS, especially if their adoption is not feasible due to site-constraints.

#### 4. CONCLUSIONS

The Avola Masterplan experience is an attempt to deal with urban resilience into planning practice. It is a proposal based on an idea of resilience that overcome the traditional planning approach, usually oriented to urban redevelopment and sustainability. In the entire planning process, from the first strategic document to the simplified detailed plans, a multiscale approach was adopted, aimed at introducing sustainability principles in all the planning actions designed to fulfil the residual development needs of the city.

The Masterplan presented in this paper is based on accurate analyses of the urban system, this favour the provision of workable solutions, according to physical and social diversity that characterize the settlement, as well as the interaction of the built up area and the ecological and landscape features. The consulting experience conducted by an University research lab, highlights the role of field research related to urban risks management. Verifying in real planning processes, specific design and regulatory tools that incorporate sustainability and resilience can contribute to the advancement of knowledge in the efficacy of planning practice. The adopted approach can be useful to turn urban resilience from theory into practice, through the creation of new models for land use plans both



at the city and regional scale. This approach tries to change planning priorities and to drive urban plans towards a new and more successful ecological, cultural, social and environmental dimension. In particular, planning strategies concerning green infrastructure should play a key role in city plans, offering an effective means to operationalize the ecosystem service paradigm in spatial planning

and the ecological turn in theory and practice so that it would be possible to inform planning policies and processes (Lennon & Scott, 2014) The case presented can be considered a chance to develop critical considerations about water sensitive urban planning and inclusion of nature based solutions, such as sustainable urban drainage systems and regulating services, in land-use plans.

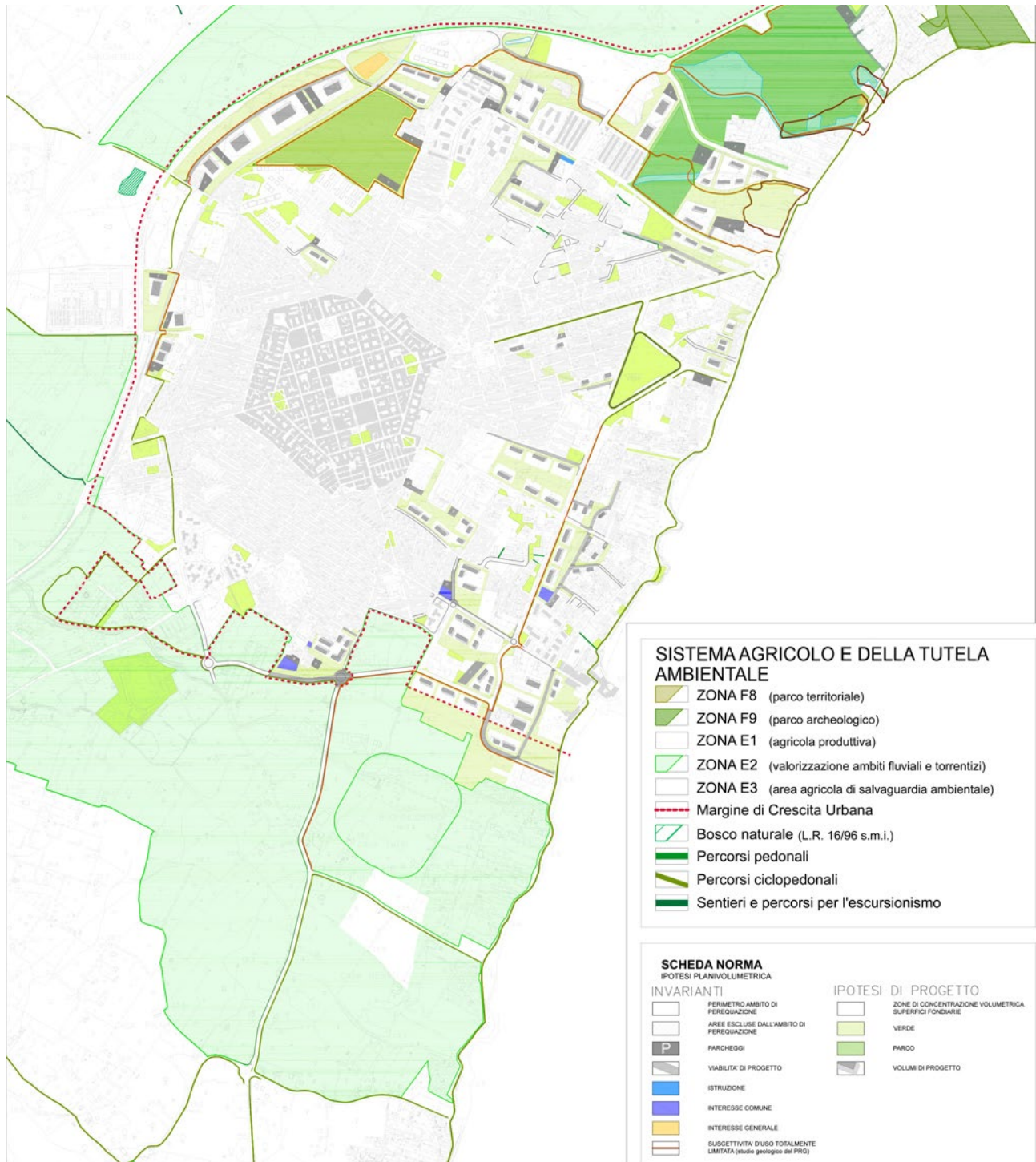


Figure 6: City of Avola – Urban green infrastructure. Source: Authors' elaboration

## REFERENCES

- Aronica, G.T., Palla, A., & Lanza, L.G. (2013). Drenaggio Delle Acque Meteoriche E Rischio Di Allagamento, in Area Urbana. *IX Rapporto Qualità dell'ambiente urbano. Focus su acque e ambiente urbano*, 46/2013, ISPRA.
- Barbarossa, L., Martinico, F., & Privitera, R. (2017). Insediamenti irregolari e rischi territoriali lungo i litorali del Val di Noto. Percorsi di progetto per la città costiera resiliente. *Atti della XIX Conferenza Nazionale SIU "Cambiamenti Responsabilità e strumenti per l'urbanistica al servizio del paese*. Catania 16-18 giugno 2016. Roma – Milano, IT: Planum Publisher.
- Bassan, L., & Pozzer, G. (2011), Vincolo di invarianza idraulica e pianificazione del territorio: prove di zonizzazione in provincia di Vicenza. In G. La Loggia, A. Paletti, G. Becciu, G. Freni, & U. Sanfilippo (Eds.), *Acqua e Città 2011 - Pianificazione, Protezione e Gestione* (pp. 75-76). Milano, IT: Centro Studi Idraulica Urbana
- Chen, J., Theller, R., Gitau, M.W., Engel, B.A., & Harbor, J.M. (2017). Urbanization impacts on surface runoff of the contiguous United States. *Journal of Environmental Management*, 187, 470-481. doi: 10.1016/j.jenvman.2016.11.017
- Desouza K.C., & Flanery T.H. (2013). Designing, planning and managing resilient cities: A conceptual framework. *Cities*, 35, 89-99. doi: 10.1016/j.cities.2013.06.003
- EC, European Commission Staff (2012). Guidelines on best practice to limit, mitigate or compensate soil sealing. Working document for information purposes. SWD (2012) 101. Retrieved from [http://ec.europa.eu/environment/soil/sealing\\_guidelines.htm](http://ec.europa.eu/environment/soil/sealing_guidelines.htm)
- ISPRA (2017). Il Consumo di suolo in Italia, Rapporto 266/2017. Retrieved from <http://www.isprambiente.gov.it/it/ispra-informa/area-stampa/dossier/consumo-di-suolo-2017>
- McPhearson, T., Andersson, E., Elmqvist, T., & Frantzeskaki, N. (2015). Resilience of and through urban ecosystem services. *Ecosystem Services*, 12, 152-156. doi: 10.1016/j.ecoser.2014.07.012
- Kellagher, R., Martin, P., Jefferies, C., Bray, R., Shaffer, P., Wallingford, H. R., & Wallingford, H. R. (2007). *The SuDS manual*. London, UK: CIRIA C697.
- Lennon, M., Scott, M., & O'Neill, E. (2014). Urban design and adapting to flood risk: the role of green infrastructure. *Journal of Urban Design*, 19(5), 745-758. doi: 10.1080/13574809.2014.944113
- Martinico, F., La Rosa, D., & Privitera, R. (2014). Green oriented urban development for urban ecosystem services provision in a medium sized city in Southern Italy. *iForest*, 7(7), 385-395. doi: 10.3832/ifer1171-007
- Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, 147, 38-49. doi: 10.1016/j.landurbplan.2015.11.011
- Dipartimento Regionale dell'Ambiente-Assessorato del Territorio e dell'Ambiente (2008). PAI- Piano Stralcio di Bacino per l'Assetto Idrogeologico. available from [www.sitr.regione.sicilia.it/pai/bacini.htm](http://www.sitr.regione.sicilia.it/pai/bacini.htm)
- Pappalardo, V., Campisano, A., Martinico, F., Modica, C., & Barbarossa, L. (2017). A hydraulic invariance-based methodology for the implementation of storm-water release restrictions in urban land use master plans. *Hydrological Processes*, 31(23), 4046-4055; doi: 10.1002/hyp.11318
- Parikh, P., Taylor, M.A., Hoagland, T., Thurston, H., & Shuster, W. (2012). At the intersection of Hydrology, Economics and Law: Application of Market Mechanisms and Incentives to Reduce Stormwater Runoff. In H. Thurston (Ed.), *Economic Incentives for Storm water Control* (pp. 168-192). Boca Raton, US: CRC Press.
- Walker, B., & Salt, D. (2006), *Resilience Thinking: Sustaining Ecosystem and people in a changing world*. Washington D.C., US: Island Press.