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*Article*

# The Economic Valuation of Flood Damage to Support the Proactive Policies in Sicily †

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**Abstract:** Although floods, as well as other natural disasters, can be considered relevant causes of *intra*-generational inequalities, the frequent catastrophes and the resulting damages to territory reflect the generalized indifference about *inter*-generational justice. Societal concerns, such as land protection, typically involve the administrative system performing proactive policies in the perspective of inter-generational solidarity, but subsidiarity has made more and more independent the local communities. As a consequence, the attention toward the long run effects – typically concerning the territorial system, as a whole, at the geographical scale – has been dispersed, and the proactive policies coming from the central government has became more ineffective. Regarding the case of the flood happened in 2009 in the Fiumedinisi-Capo Peloro hydraulic basin, in the northeastern part of Sicily, Italy, we propose an economic valuation – carried out by performing the method of the imputed preferences – in order to compare the expenses incurred by the public authorities responsible for protecting the territory to the costs of the rehabilitation of the damaged areas. Some considerations about the economic significance of the proactive policies for the arrangement of territory are addressed according to the role played by the social discount rate in the inter-temporal economic calculation.

**Keywords:** proactive policies; land protection; inter-generational solidarity; land sustainability; economic valuation; imputed preferences; imputed expenses; gis; cost-benefit analysis, social discount rate

## 1. Introduction. Is it worth it?

According to the general definition of risk, the damaging effects of the natural disasters, as well as flood damages, can be considered the result of three converging determinants: 1. the global climate change and the consequent local effects in terms of climatic disorder, as responsible for the natural *hazard*; 2. the progressive modification of the equilibrium of natural system carrying capacity and the and urbanization, as responsible for *vulnerability*; 3. the progressive growth of

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population, the consequent increase in built volume and real estate value, and the development of the infrastructures, as responsible for *exposition*.

Climate change cannot be faced even in the long run, as it would require the transition to a different development pattern from the whole human community, so that adaptation has become the only possible perspective; as a consequence, major efforts are needed to deliver a significant reduction of vulnerability especially in the more exposed areas; the structural scarcity of funding imposes a programming pattern ranking the different interventions basing to their contribution to the safeguard of the most strategic and valuable territorial resources ant contexts.

To date, many approaches, methods and tools have been developed and performed in the monetary appraisal and qualitative assessment [1-3] in the field of prevention; among them, the approach to the “avoided damage” [4], that is the cost to prevent a community from being affected by a damage of equal value at least. In the particular, Pimentel *et al*. [5] assume it referring to the benefit of biodiversity estimated as a percentage (5%) of the GDP, the monetary value of the protection services; Kremen *et al*. [6] apply the opportunity cost to incentive the preservation of the rain forests in Madagascar and criticize the larger financial benefits from industrial logging than the conservation ones as the reason of the deforestation exacerbation; Merlo and Croitoru [7] approach the Total Economic Value (TEV) of the Mediterranean forests by including in the estimate of their economic value the public goods and externalities they provide [8-10]; finally, Hansoon *et al*. [11] propose an original perspective, somehow contrary to the concept of exposition and overcoming the “avoided damage” approach, as “the impact of disasters on society depends on the affected country's economic strength prior to the disaster. The larger the disaster and the smaller the economy, the more significant is the impact. This is clearest seen in developing countries, where weak economies become even weaker afterwards”; this approach suggests to overestimate the mere economic value of buildings and infrastructures in order to prevent the affected community from definitively falling into the trap of poverty, so including in the estimates the social value. Kramer *et al*. [12], as well, integrate the ecological value in the economic estimate of the park projects aimed to prevent flooding damage in Madagascar, by comparing “with” and “without park” cases.

Territory is a complex of private goods, public goods and common goods with different "local-global" characterization; the literature on economic evaluation of the territory has highlighted different dimensions of its economic value [13]. The latter relate to the system of individual and aggregate preferences, regardless of the need for assessments to be expressed in monetary terms.

Now, despite how limited monetary measurements might appear, economic valuation shouldn’t be underrated as an effective tool for policy making. “Monetary language”, in fact, overcomes the mere accounting practice, as money measurement is relevant in both intra-temporal and inter-temporal value comparisons.

In the experiment carried out here, monetary measurement has been used to perform the opportunity-cost approach in order to compare the value of the territory protection to the cost of rehabilitation of the territory affected by the

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natural disaster. Furthermore, some different scenarios have been outlined according to the different time preferences as represented by the social discount rate typically used in the Cost-Benefit Analyses (CBA) [14].

The case study concerns the flood that in 2009 affected the Fiumedinisi-Capo Peloro hydraulic basin in the north-eastern part of Sicily, Italy [15].

The economic valuation was carried out by performing the method of the imputed preferences in order to provide the most objective (in the social and political sense) measurement of the economic value; the latter, in fact, is a property of the economic goods, and results as effect of a social, cultural and conventional communication process based on the "consensual behavioral coordination" making society as a unitary subject. In such a vision, objectiveness should to be assumed as inter-subjectiveness, according to the articulation of the social system as suggested by N. [16]. According to the social pattern he proposed, social system is divided in sub-systems communicating within themselves and excluding from such communication the others by means of a specific code, by performing which they select just what is able to consolidate the differentiation from the other sub-system and the environment; as a consequence, each subsystem makes the others for "human environment".

The reduction of the autopoietic enclosure of each sub-system helps to share codes (values, perspectives, programs), then improving the internal communication in order the social system as a whole the pressure from environment. Such premises are the conditions to enact environmental proactive policies.

In this sense we try to place the environmental economic valuation issue within the broad context of the social-economic and politic communication as it occurs at the level of the coordination of the activities performed by the entities responsible for land protection and improvement.

## 2. Materials

### *2.1 Territorial framework*

The province of Messina occupies an area of 3,247 sq.km in the northeast of Sicily, bordering to the south with the province of Catania and to the west with the province of Palermo. Its territory stretches from the Peloritani mountain chain to the Nebrodi one, and is bathed by the Tyrrhenian (north) and the Ionian (east) seas. The latter shoreline, including the municipalities of Messina, Scaletta Zanclea and Giardini Naxos, was affected on October 1$^{st}$ 2009 by a violent cloudburst hitting the villages of Giampilieri, Giampilieri Superiore, Giampilieri Marina, Molino, Altolia, Briga, Briga Superiore, Briga Marina, Pezzolo, Santa Margherita Marina comprised within the municipality of Messina, the villages of Scaletta Marina, Scaletta Superiore, Guidomandri Marina, Guidomandri Superiore, in the Municipality of Scaletta Zanclea, and the villages of Itala Marina, Itala Centro, Borgo, Mannello, Croce, in the Municipality of Itala, the municipalities of Alì and Alì Terme. The flood caused landslides, floods of rivers and streams, floods of residential, commercial and industrial settlements, the interruption of the transportation

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infrastructures (roads, highway and railway), including 31 dead, 6 missing, 122 injured and 2019 evacuated people.

*2.2 East Sicily from the climatic point of view*

The rainfall and thermometric data detected by the capillary network of stations present throughout Sicily allows to characterize the climate of the Sicilian Region, which can be considered in general as temperate Mediterranean climate, or more precisely as warm temperate with a prolonged summer season and mild winter.

The average winter temperatures are higher than 5 degrees centigrade, while the minimum temperatures rarely reach below 0 degrees.

Sicily has the characteristic hill climate with an average temperature of 16 degrees, where the warmer month is August and the coldest January.

The sunniest month is June (14.6 hours), while the annual minimum is in December (9.4 hours). Precipitation is minimal in July (with minimum water flow of the courses of water in August) and maximum in December.

Rainfall ranges from 0 mm falling rainfall in July to over 76 mm dropped in December with an annual average of 540 mm, lower than the national average of 970 mm annually. With 70 rainy days a year, Central Sicily can be considered a medium-intensity rain zone. The characterization of drought conditions, whose persistence affects the deterioration of soil characteristics, is an important aspect of climatology.

In order to study the drought conditions, it is necessary to build drought indices, including the De Martonne Classification and the Index of Aridity (Ia), where the magnitudes considered are average annual rainfall (mm) and average annual temperature (°C) (Figure 1) [17].

The 2009 Messina flood was a natural disaster that occurred in a restricted area of north eastern Sicily caused by a violent cloudburst, which began on the evening of October 1, 2009 and lasted all night until the morning of the next day. The cloudburst caused flooding of watercourses and various landslides, followed by sliding downstream of mud flows and debris.

The event struck an area immediately south of the city of Messina along the Ionian coast, which, despite the articulated geography of the terrain, is a heavily urbanized area. The most affected centers were Scaletta Marina, in the municipality of Scaletta Zanclea and several locations in the commune of Messina: Giampilieri Superiore, Giampilieri Marina, Altolia, Molino, Santo Stefano di Briga, Briga Superiore and Pezzolo. There have also been major damages in the hamlet of Guidomandri Superiore and in other areas in the municipality of Scaletta Zanclea and in the municipality of Itala.

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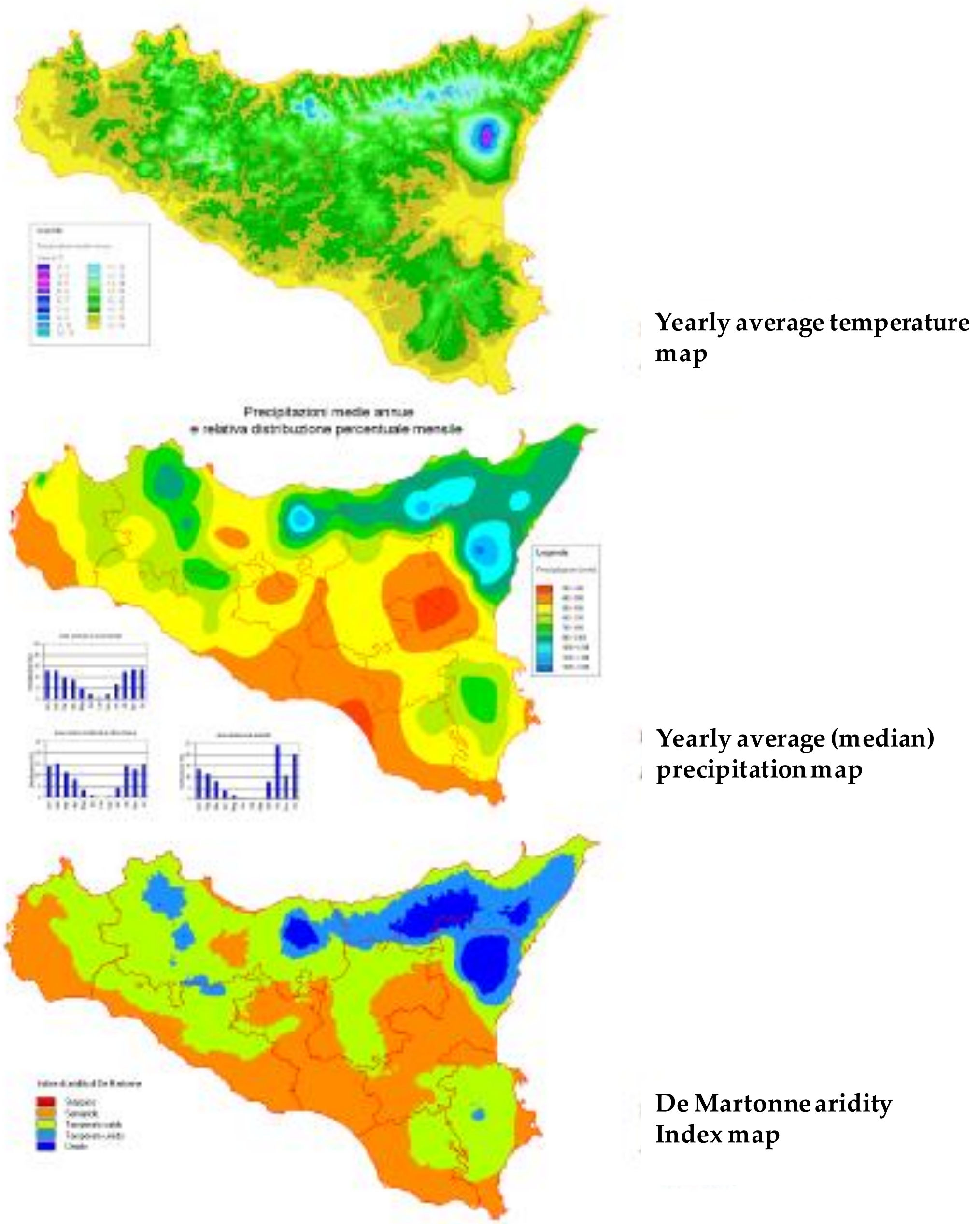


**Figure 1.** Yearly average temperature – Yearly average precipitation map – De Martonne aridity index map.

The disaster occurred in a high-risk hydrogeological area, already affected by landslides and floods. According to the Civil Protection Department, in some of the affected areas have fallen 220/230 mm of precipitation within 3-4 hours.

The cumulative deviation from the average long-term rainfall in Sicily in 2008 was negative (Figure 2 A), while the one in 2009 was positive (Figure 2 B).

Precipitations in Sicily for the years 2008-2009 compared to the long run show an average monthly rainfall for 2008/2009 higher than the average reference value for the period 1921/2005 (Figure 3 C), and an even greater rainfall than the monthly average of precipitation in Sicily 2009 is compared with the long-term (Figure 2 D), so the event of October 2009 was an exceptional event.

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The isohyets reported in September 2009 show that in Sicily the area of the province of Messina was the most affected by precipitation, with a characterization of the isohyets with significant values compared to those for the same area but referring to the year (Figure 3).

The exceptional events can't be expected, but the proactive policies can certainly promote actions aimed at reducing the devastating effects of such events on the territory.

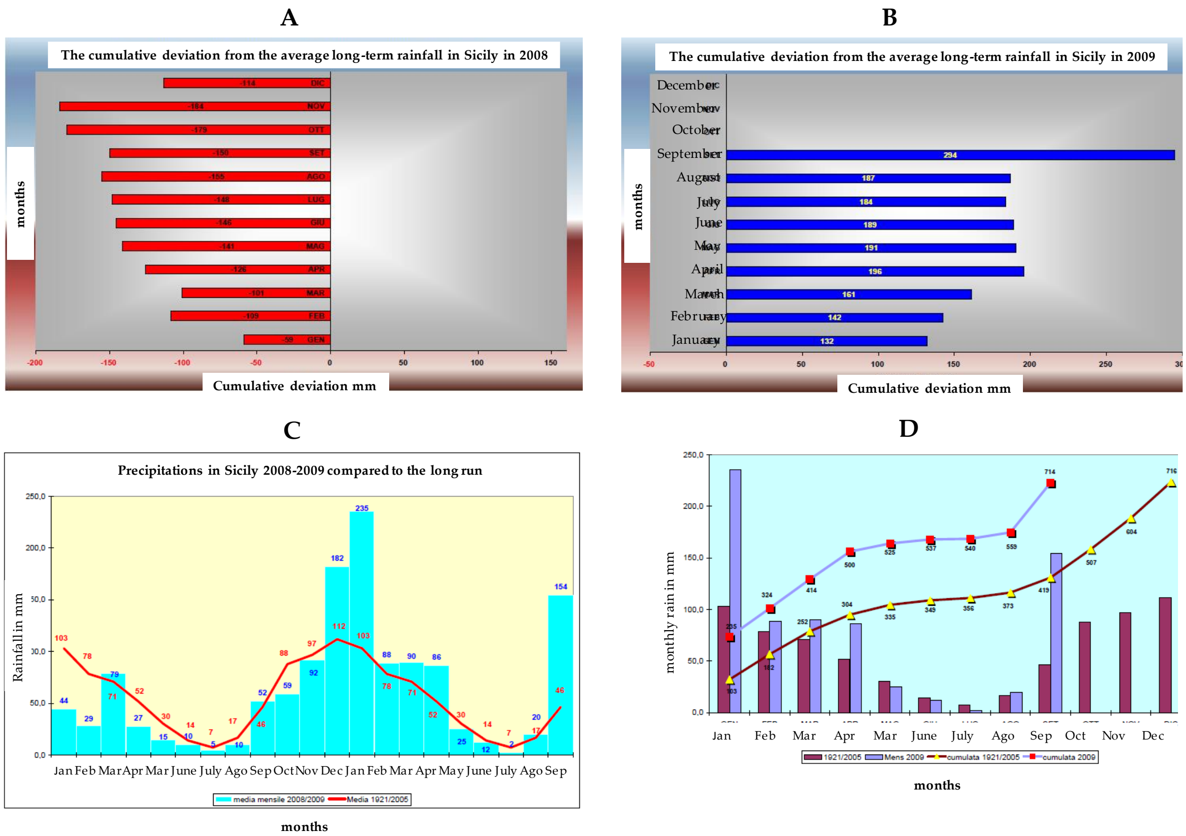


**Figure 2.** The cumulative deviation from the average long-term rainfall in Sicily in 2008/2009; precipitations in Sicily 2008-2009 compared to the long run; monthly rain in mm compared to the long run (http://osservatorioacque.it/).

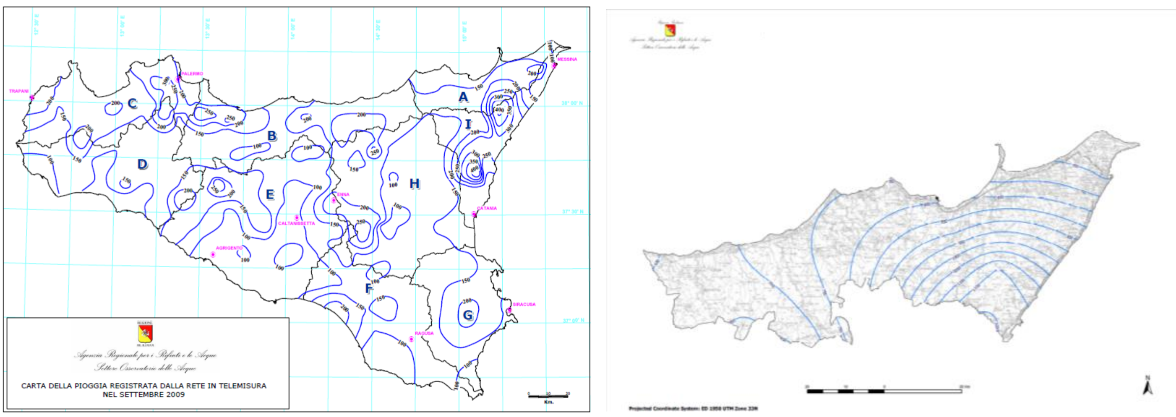


**Figure 3.** The isohyets for the September 2009 and for the year 2009 (http://osservatorioacque.it/)

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*2.3 Identification and Analysis of Risky Areas*

The situation of the disasters is described by the Detailed Basin for the Hydrogeological Arrangement Plan [18], which maps the perimeter of the areas based on the hazards and the risk to which they are exposed, particularly where vulnerability is associated with serious dangers to people, structures and infrastructures and environmental heritage, and safeguard standards are also defined.

As a consequence of further landslides, in February 2010, the entire context has been declared a hydrogeological high-risk area. As a result of the analysis of the phenomenon of landslides, five degrees of hazard have been distinguished:

- Very high hazard areas (P4) with 69 instabilities for a total area of 157.91 ha;
- High hazard areas (P3) with 230 instabilities for a total area of 196.67 ha;
- Medium hazard areas (P2) with 151 instabilities for a total area of 304.27 ha;
- Moderate hazard areas (P1) with 108 instabilities for a total area of 56.49 ha;
- Low hazard areas (P0) with 7 instabilities for a total area of 11.20 ha.

About risk, four degrees have been defined as follows:

- R1 – moderate risk: social, economic and environmental damages are low;
- R2 – medium risk: probability of minor damages to buildings infrastructures and environment, not compromising human safety, use and economic activities;
- R3 – high risk: envisaged problems to human safety; damages to buildings and
- infrastructures compromising their use and provoking hold-up of socio-economic activities and severe damages to the environment;
- R4 – very high risk: envisaged losses of human lives and severe lesions to persons; severe damages to buildings, infrastructures and the environment and socioeconomic activities destruction.

Figure 4 synthesizes the number and extension of the instabilities, the hazard and the risk for each of the five municipalities affected.

| Municipality | Instabilities n. | Surface (He) | landslide index (%) |
|---|---|---|---|
| Alì | 39 | 38.37 | 3.63% |
| Alì Terme | 28 | 19.96 | 3.88% |
| Itala | 45 | 63.03 | 5.84% |
| Messina | 406 | 467.49 | 3.27% |
| Scaletta Zanclea | 47 | 76.34 | 15.30% |
| **tot.** | **565** | **665.19** | **31.9%** |

| Municipality | Geomorphological hazard | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P4 | | P3 | | P2 | | P1 | | P0 | | Total | |
| | n. | Surface (He) | n. | Surface (He) | n. | Surface (He) | n. | Surface (He) | n. | Surface (He) | n. | Surface (He) |
| Alì | 3 | 3.07 | 7 | 5.37 | 13 | 26.39 | 16 | 5.47 | | | 39 | 40.30 |
| Alì Terme | 5 | 17.91 | 17 | 13.13 | 4 | 1.16 | 2 | 1.27 | | | 28 | 33.47 |
| Itala | 11 | 29.70 | 14 | 20.28 | 11 | 16.05 | 9 | 4.04 | | | 45 | 70.07 |
| Messina | 34 | 75.57 | 178 | 132.14 | 114 | 237.3 | 74 | 41.74 | 6 | 10.14 | 406 | 496.89 |
| Scaletta Zanclea | 16 | 31.66 | 14 | 25.75 | 9 | 23.37 | 7 | 3.97 | 1 | 1.06 | 47 | 85.81 |
| **tot.** | **69** | **157.91** | **230** | **196.67** | **151** | **304.27** | **108** | **56.49** | **7** | **11.2** | **565** | **726.54** |

| Municipality | Risk | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | R4 | | R3 | | R2 | | R1 | | Total | |
| | n. | Surface (Ha) | n. | Surface (Ha) | n. | Surface (Ha) | n. | Surface (Ha) | n. | Surface (Ha) |
| Alì | 9 | 1.23 | 2 | 0.17 | 20 | 1.55 | 11 | 0.33 | 42 | 3.28 |
| Alì Terme | 7 | 2.34 | 12 | 0.5 | 5 | 0.21 | | | 24 | 3.05 |
| Itala | 16 | 1.85 | 19 | 2.4 | 9 | 0.57 | | | 44 | 4.82 |
| Messina | 138 | 17 | 89 | 5.23 | 100 | 6.63 | 35 | 2.35 | 362 | 31.21 |
| Scaletta Zanclea | 25 | 4.05 | 26 | 1.66 | 16 | 0.7 | 7 | 0.69 | 74 | 7.1 |
| **tot.** | **195** | **26.47** | **148** | **9.96** | **150** | **9.66** | **53** | **3.37** | **546** | **49.46** |

**Figure 4.** Synthesis of the entity and extension of instabilities, hazard and risk in each of the municipalities of the affected area.

*2.3 Funding*

As effect of the state of emergency, declared the day after, several national and regional regulatory measures ruled the funding of: reimbursement of expenses for first aid interventions and assistance to the population and identification of damages; restoration and reconstruction of destroyed and damaged properties; autonomous housing of the families that are left unattended; contributions to business owners located in buildings or areas cleared; social security, welfare and suspension of tax obligations and payments by residents in the province of Messina.

The Italian Government requests the intervention of the European Union Solidarity Fund (FSUE), which puts at disposal 139 mln € of which:

- € 60 million available to the Delegate Commissioner (Article 4 OPCM No 3815/2009), divided into: € 20 million of the resources allocated to the Sicilian Region under the FAS 2000/2006 and PAR-FAS 2007-2013 funds; € 20 million from the funds of the Ministry of the Environment and the Protection of the Territory and the Sea; € 20 million to the resources of the Civil Protection Fund specifically supplemented by the Ministry of Economy and Finance;
- € 45 million art. 9 OPCM n. 3865/2010 from the PAR-FAS fund 2007-2013, approved by the Resolution of the Sicilian Regional Council No 315 12-08-2009, intended for the continuation of urgent initiatives;
- € 10 million for the Delegated Commissioner, President of the Sicilian Region;
- € 24 million for assistance to the population.

Additional € 181 million (Article 1, paragraph 1 OPCM 3886/2010) come from the financial resources allocated to the Municipalities of the Province of Messina

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and broken down by the Program Agreement signed on 30/04/2010 by the Sicilian Region and the Ministry of 'Environment and the Protection of the Territory and Sea' (which includes interventions on the entire Sicilian territory for € 304.3 million) are transferred to the special accounts of the President of the Sicilian Region Delegated Commissioner, excluding € 24 million for the interventions to be carried out in Giampilieri, and € 18 million allocated for interventions in the town of San Fratello, which are managed by the Delegated Commissioner, President of the Sicilian Region.

The Program of Action of € 320 million includes:

- € 20 million for reimbursements to the population and production activities;
- € 25 million for repayment to damaged buildings;
- € 10 million for housing construction;
- € 15 million for urbanization works and network facilities;
- € 22,4 for assistance to the population and management of the Commissioner structure;
- € 15,4 million for the expenses incurred by the various institutions during the first emergency phase;
- € 212,2 million for security measures "(Civil Protection Department, 2011).

## 3. Methods

### *3.1 General framing introduction*

As above mentioned according to [16] territory can be considered as the result of a unity-difference of social system and environment. The former arises from an external communication process by which social system perform general communication means at the highest symbolic level allowing it to differentiate from environment. The latter results as everything (natural, artificial and human) which she social system doesn't communicate with; in fact, social system communicates within itself *on* environment. Furthermore, an internal communication process gives rise to the progressive break down of the system into several sub-systems, each of which performs an its own code (value or program), by which it selects and includes everything what allows it to increase its self-referential closure enforcing its ability to prevailing over the other subsystems, which reduce to environment.

Environmental fluctuations, like a flood, can be considered the result of the defeat of communication between social system and natural eco-system, occurring when the former (in this case) doesn't share its own resources with hydrogeological system, impoverishing it to the extent of compromising the equilibrium between social and natural systems. The subsequent irritation of the social system generates a new arrangement of the internal power relations between sub-systems.

In the proposed case, the prevailing of the part of the economic sub-system dominating the political one to the extent of hindering the proactive policies hindering the land protection works.

Figure 5 synthetically displays the scheme of the relationship between social system and environment, and between subsystems in event of natural disaster: a)

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the unity-difference between social system and environmental is characterized by a balanced communication pattern between the sub-systems, for example: political (local government), economic (sampled by the productive one), cultural (as expression of the relation to landscape) and anthropic (daily life); b) productive sub-system prevails, so that the others become environment; c) vice versa; d) the political sub-system cannot guarantee the public interest like protection and safety and the social system becomes more vulnerable; the social system is affected by a natural disaster; all the sub-systems become environment; a higher administrative body, in such cases a Commissioner, rehabilitate as far as possible the physical status quo ante, but an ecological and social print remains as a defeat of communication and democracy.

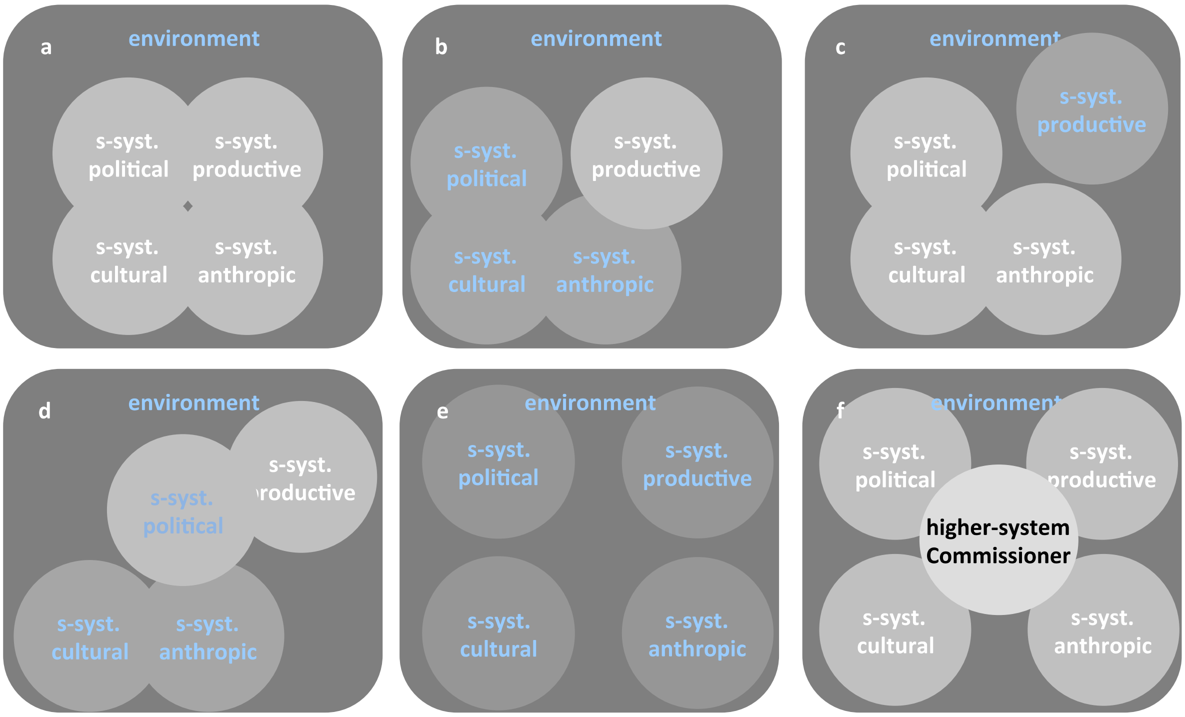


**Figure 5.** Synthetic representation of the relationship between social system and environment, and sub-systems in event of natural disaster.

*3.2 The imputed preferences*

Luhmann [19] distinguishes risk as probable damage due to decisions, from hazard, i.e. probable damage due to forces coming from outside, from environment. As, in everyday practice, the contributions coming from the two sources are hardly distinguishable, the perspective and the fate of territory needs to be trusted to politics, and precisely to the responsibility of the central (national) institutions, whose mission overcome the interests of the local communities and involve the land wealth distribution pattern. Risk and opportunities are asymmetrically distributed over the territory of a state; proactive policies typically involve the individual location pattern and the arrangement of private property, trying to reduce the natural disaster risk and, as a consequence, to internalize the

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externalities coming from environment. Such an approach can be considered a sort of environmental equalization pattern involving the ability of the social system to include the natural environment in the social communication process as much as possible, in order to prevent the weaker sub-systems from becoming environment themselves as well. In such case, the external communication defect causes a drastic reduction in internal (intra-systemic) communication.

Such equalization policy is to share the costs of mitigating vulnerability – according to Luhmann [19], the part of risk due to decisions – by means of subsidies for prevention, then entrusting the whole national community.

The methodological consequences of such premises concern the choice of the procedure for the monetary comparison of the cost of the proactive policy and the ones incurred by the public for the rehabilitation of the areas affected.

In particular, the approach considering the imputed preferences, then the *defensive expenses* and the *rehabilitation cost* can be considered the most objective monetary measurements for this comparison, although the rehabilitation cannot be considered able to turn the clock back on the natural disaster. Died people cannot be restored as well as the deeply damaged areas and towns, so that the rehabilitation cost can be considered just a partial estimate of the value of the patrimonies affected.

The unbridgeable gap between cost and value highlights the importance of the proactive policies and suggests to overcome the methods based on the individual preferences, like the hedonic price approach, and on the trade-off, based on an overestimated concept of utility, unable to compare the loss and any possible gain in return. Furthermore, the approach based on the hedonic prices, does not comprises by definition the awareness about the complexity of the natural system, so that individual preferences cannot lead to collective decisions in absence of "collective rationality arising in argumentative and conversational contexts" [20, 21] based on relations, interdependence, sharing information and reasoning, that are the premises for the social systems arise. Arrow *et al*. [22] and Bresso [23] criticized the contingent valuation approach about the real capability of the stated preferences to capture the complex articulation of the relevant value contents involved within the decision processes.

The last, but not the least, even if we agree with the Coase approach, considering safety and environmental a prerogative of rich individuals and groups more willing to pay for them, shouldn't be forgotten that the environmental risk is asymmetrically distributed amongst territories, and it often affects the most significant and frail ones.

The method for comparing the economic value of a protection program to the expenses for rehabilitation, is the Discounted Cash Flow Analysis (DCFA) referred to the flow of the annual public expenses whose present value is calculated by means of an appropriate discount rate. The imputed expenses approach highlights the value of territory from the perspective of public, that is at least greater than, or equal to the public expenses. On the other hand, the cost for rehabilitation is less than the real social cost, as it does not comprise the value of life of the victims and of

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the damage to the injured people, the irreversible landscape changes, the economic losses due to the suspension of business and commerce.

According to the DCFA approach, the economic value of the "harmony between territory and environment" – that is the capability to internalize the risk coming from decisions – depends on the social discount rate also known as Social Rate of Temporal Preference (SRTP), that measures the inter-temporal solidarity of a community: the higher the SRTP the lower the economic value, and vice versa.

### *3.3 The inter-temporal solidarity and the approaches to the social discount rate*

A disaster can be considered the occurrence of a sudden and large-scale adversity disrupting the basic fabric and the normal functioning of a community, or an event, or a series of events, giving rise to victims and/or damages and losses of properties, infrastructures, services, livelihoods. An exceptional climatic weather event, such as the one that can cause a flood, can break down and destroy the basic components of a territory by deeply altering its layout.

In this case, the evaluation process supports the ex post evaluation helpful to quantify the damage caused by the event, namely the loss of value of the components of the areas affected, restoration and mitigation actions, but it can also support the ex-ante evaluation of actions for the disaster prevention and management, instrumental to outline proactive policies based on the information infrastructures [24, 25].

In both cases, since the evaluation process involves actions developing in different time spans, a discount process needs to be performed on the basis of an appropriate social discount rate.

The choice of the social discount rate (SRTP) can be made on the basis of various approaches that indicate a different sensitivity to the inter-temporal preferences, intergenerational ethics, and level of sustainability. Accordingly, the choice of the social discount rate is a crucial stage of the evaluation path, both in cases of reconstruction and prevention.

In the last few years, as a consequence of the increasing importance of the environmental issue – specifically, the global warming – and in the perspective of sustainability, scientific community has proposed new approaches and specific econometric algorithms to support the determination of the social discount rate, so as to ensure it can be able to capture and characterize the intergenerational dialectics in the field of the of public goods and services value, basing on a range of sustainability approaches according to different visions.

The approaches in literature can be grouped into the following:

- Descriptive or positive approach, where SRTP is determined on the basis of the markets interest rates analysis, and assumes values greater than zero [26-30];
- Prescriptive or regulatory approach, sometimes referred to as "ethical approach", where SRTP is determined basing on ethical motivations, and can be set to zero or less than zero [31-36];

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- Empirical approach that introduces uncertainty and risk, where SRTP is determined on the basis of studies of the behaviour of individuals who point out the need to adopt declining rates when the temporal horizon is farthest in time, following a more flexible, hyperbolic or quasi-hyperbolic –not exponential – trend of the discount factor over time [37-56].

It is possible to find that, despite the considerable scientific efforts, at the moment the values of the social discount rate are different also within the Euro area; this choice is discretionary to the countries, depending on the different levels of wealth and a different environmental sensitivity and intergenerational ethic [57].

The European Commission currently recommends to assume as social discount rate: the one obtained as a benchmark for financial analyses in the member states, 5.5% in Cohesion countries, and 3.5% in the more advanced ones [58, 59], however admitting different rates, whose use can be justified by specific socio-economic conditions.

The values of the social discount rate proposed by the European Commission are greater than zero and therefore they refer to a descriptive or positive approach, albeit in countries such as the United Kingdom the use of the digressive approach of declining has been introduced, like, i.e. the social discount rates declining by "steps" [58, 59], which refers to an empirical approach, which includes uncertainty and risk.

In the same Euro Area, it is possible to find different approaches with different types of assessments of the effects of floods and of the interventions both for reconstruction and for prevention; such variety suggests multiple interpretations of the relationship between values and time.

Some of these issues have been utilized in order to provide different scenarios and a range of values estimated as support of the proactive land policy in case of flood.

## 4. Applications and results

*4.1 Regional Government Departments balance sheets*

The imputed preferences approach is based on the effective costs incurred by the public entities responsible for land protection and improvement. In this application the public expense is that incurred by the Sicilian Regional Government through the different Department directly and indirectly involved in territory and environment protection, conservation and enhancement, whose balance sheets have been analyzed. The following balance sheet items have been taken into account: "Commitments" of annual expenditure in terms of "Current expenditure" (Title I); "Capital Expenditure" (Title II); "Loans repayments" (Title III), for operation and investment in "fixed social capital". These expenditures have been differently charged: since the expenditure for the protection of the territory and the environment is disbursed through the action of the same Department, whose expenditure has been accounted for the entire amount. Part of the same balance sheet items have been accounted from the Agriculture Department and precisely

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from the competent Forestry Department; to these expenses have been added lower quotas of the budget of the Presidency of the Regional Government, and of the Economic and Financial Affairs Department, which carries out higher-level activities aimed at the functioning of the aforesaid Department; those quotas are the ratio between the amount of expenditure charged to the two Departments and the total regional expenditure, and of course varies from year to year. Figure 6 shows the total and charged flow of these expenses.

| | Total Regional Expences | **29,635,376** | **24,875,250** | **29,635,736** | **27,390,211** | **27,701,186** |
|---|---|---|---|---|---|---|
| | *years* | *2007* | *2008* | *2009* | *2010* | *2011* |
| 1 - REGION PRESIDENCY | Current expenditures | 878,443 | 895,431 | 953,038 | 51,854 | 21,760 |
| | Capital expenditures | 40,937 | 10,730 | 124,623 | 68,173 | 41,315 |
| | total | **919,380** | **906,161** | **1,077,661** | **120,027** | **63,075** |
| | coefficient | 0.44% | 1.33% | 2.98% | 3.19% | 3.12% |
| | ***total imputed*** | ***4,057*** | ***12,061*** | ***32,131*** | ***3,828*** | ***1,966*** |
| 2 - DEPARTMENT OF AGRICULTURE AND FORESTRY | Current expenditures | 471 | 441,509 | 542,323 | 143,124 | 118,454 |
| | Capital expenditures | 134,327 | 91,027 | 570,251 | 705,840 | 728,381 |
| | total | **134,798** | **532,536** | **1,112,574** | **848,964** | **846,835** |
| | coefficient | 50% | 50% | 50% | 50% | 50% |
| | ***total imputed*** | ***67,399*** | ***266,268*** | ***556,287*** | ***424,482*** | ***423,418*** |
| 4 - DEPARTMENT OF ECONOMIC AND FINANCIAL AFFAIRS | Current expenditures | 4,469,269 | 3,865,806 | 3,579,685 | 3,186,839 | 3,119,154 |
| | Capital expenditures | 7,518,280 | 8,274,255 | 9,040,985 | 7,210,592 | 9,175,041 |
| | Loan rembursement di prestiti | 338,578 | 236,766 | 207,726 | 838,283 | 250,530 |
| | total | **12,326,127** | **12,376,827** | **12,828,396** | **11,235,714** | **12,544,725** |
| | coefficient | 0.44% | 1.33% | 2.98% | 3.19% | 3.12% |
| | ***total imputed*** | ***54,388*** | ***164,736*** | ***382,491*** | ***358,343*** | ***390,989*** |
| 11 - DEPARTMENT OF TERRITORY AND ENVIONMENT | Current expenditures | 62,644 | 64,582 | 86,445 | 224661 | 210,966 |
| | Capital expenditures | 721 | 241 | 240,885 | 224418 | 228,997 |
| | total | **63,365** | **64,823** | **327,330** | **449,079** | **439,963** |
| | coefficient | 100% | 100% | 100% | 100% | 100% |
| | ***total imputed*** | ***63,365*** | ***64,823*** | ***327,330*** | ***449,079*** | ***439,963*** |
| | Total expense | **13,443,670** | **13,880,347** | **15,345,961** | **12,653,784** | **13,894,598** |
| | *Imputed expenditure* | ***189,209*** | ***507,888*** | ***1,298,239*** | ***1,235,732*** | ***1,256,336*** |
| | Imputation basin coefficient | 0.95% | 0.95% | 0.95% | 0.95% | 0.95% |
| | annual expediture imputed to the basin | **1,797** | **4,825** | **12,333** | **11,739** | **11,935** |

| | Total Regional Expences | **26,266,860** | **25,905,185** | **22,290,621** | **15,179,646** | **14,961,125** | **17,477,131** |
|---|---|---|---|---|---|---|---|
| | *years* | *2012* | *2013* | *2014* | *2015* | *2016* | *2017* |
| 1 - REGION PRESIDENCY | Current expenditures | 13,170 | 14,087 | 9884 | 5644 | 5578 | |
| | Capital expenditures | 11,925 | 4,659 | 3702 | 1313 | 1313 | |
| | total | **25,095** | **18,746** | **13,586** | **6,957** | **6,891** | **9,145** |
| | coefficient | 2.55% | 2.73% | 1.09% | 0.91% | 0.92% | |
| | ***total imputed*** | ***639*** | ***513*** | ***148*** | ***64*** | ***63*** | ***92*** |
| 2 - DEPARTMENT OF AGRICULTURE AND FORESTRY | Current expenditures | 103,891 | 225,335 | 177614 | 16014 | 15939 | |
| | Capital expenditures | 616,425 | 415,142 | 16618 | 9930 | 8365 | |
| | total | **720,316** | **640,477** | **194,232** | **25,944** | **24,304** | **81,493** |
| | coefficient | 50% | 50% | 50% | 50% | 50% | |
| | ***total imputed*** | ***360,158*** | ***320,239*** | ***97,116*** | ***12,972*** | ***12,152*** | ***40,747*** |
| 4 - DEPARTMENT OF ECONOMIC AND FINANCIAL AFFAIRS | Current expenditures | 3,258,683 | 4,139,313 | 2634533 | 2047248 | 2651547 | |
| | Capital expenditures | 9,783,419 | 8,605,564 | 7138119 | 809706 | 275111 | |
| | Loan rembursement di prestiti | 225,298 | 259,432 | 286493 | 273331 | 254,882 | |
| | total | **13,267,400** | **13,004,309** | **10,059,145** | **3,130,285** | **3,181,540** | **5,456,990** |
| | coefficient | 2.55% | 2.73% | 1.09% | 0.91% | 0.92% | |
| | ***total imputed*** | ***337,893*** | ***355,591*** | ***109,428*** | ***28,608*** | ***29,315*** | ***55,784*** |
| 11 - DEPARTMENT OF TERRITORY AND ENVIONMENT | Current expenditures | 193,234 | 193,991 | 145242 | 125712 | 125656 | |
| | Capital expenditures | 115,570 | 194,124 | 129 | 45 | 45 | |
| | total | **308,804** | **388,115** | **145,371** | **125,757** | **125,701** | **218,750** |
| | coefficient | 100% | 100% | 100% | 100% | 100% | |
| | ***total imputed*** | ***308,804*** | ***388,115*** | ***145,371*** | ***125,757*** | ***125,701*** | |
| | Total expense | **14,321,615** | **14,051,647** | **10,412,334** | **3,288,943** | **3,338,436** | **9,082,595** |
| | *Imputed expenditure* | ***1,007,494*** | ***1,064,457*** | ***352,063*** | ***167,401*** | ***167,231*** | ***551,729*** |
| | Imputation basin coefficient | 0.95% | 0.95% | 0.95% | 0.95% | 0.95% | 0.95% |
| | annual expediture imputed to the basin | **9,571** | **10,112** | **3,345** | **1,590** | **1,589** | **5,241** |

**Figure 6.** Sicilian Region Government Balance Sheets 2007-2016 and imputation coefficient. Year 2017 reports the average amounts of the previous ten years (000EUR).

*4.2 Imputed expenditures*

The last line of Figure 3 reports the coefficients for the imputation of the total expense to the relative value of the affected Hydrographic Basin, no. 102, on the total of 102 basins, that form the entire regional territory, as identified and delimited by Hydrogeological Arrangement Plan. Each basin has been

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characterized by quantitative and qualitative criteria based on the data contained within the Regional Landscape Territorial Plan (RLTP) Guidelines. The expenditures imputed to the basin are calculated with regard to 1. to the ratio between the surface of the basin and total surface of Sicily, and 2. to the ratio between the length of the hydrographic network of the basin and the overall length of all the Sicilian basins; finally, a qualitative correction factor that takes into account the territorial value of the landscape context [60].

The qualitative factors are related to the degree and type of man-made environment defined by combining land uses, ecological and natural value. To this end:

- the different uses of the soil have been classified into a dimensionless numerical scale depending on the rarity, degree of naturalness, cultural value, landscaping and environmental value;
- the naturalistic value has been determined on the basis of the area of the basin occupied by the CIS (Community Interest Sites) and/or SPZ (Special Protection Zones).

The qualitative criteria are defined based on the spatial analysis functions of the Geographical Information System (GIS).

1. Territorial extension (surface area); Basin 102 covers about 4,136 ha, corresponding to 0,69% of the regional territory.

2. Hydraulic basin dimension; the total length of the entire hydrographic system of the Basin 102 is approximately 71.2 km, which corresponds to 0.55% of the entire regional hydraulic network (Figure 7).

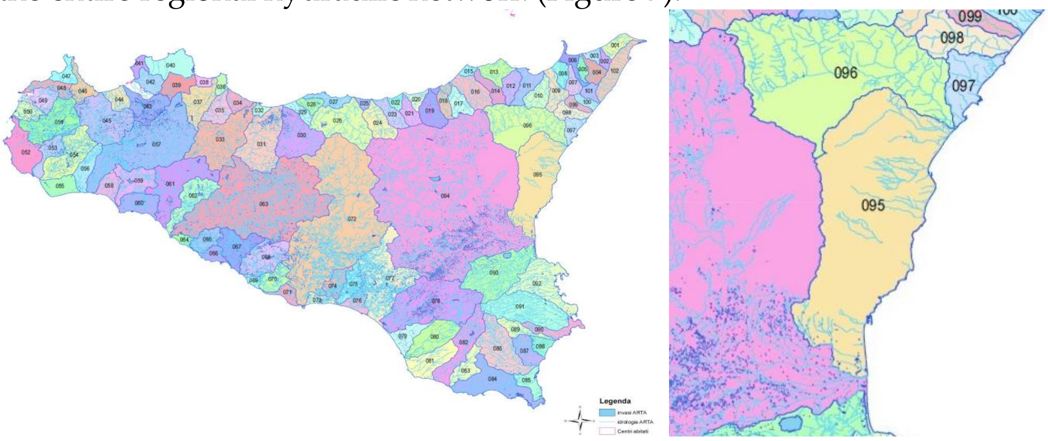


**Figure 7.** Hydraulic Regional framework (left) and detail of the Province of Messina displaying the Fiumedinisi basin n. 102 (right).

The average imputation ratio basing on the basin dimension is 0.65%.

3. Anthropological importance. It refers to land uses; the valuation is the average score of those attributed within the RLTP Guidelines, weighed according to the surface of each mapped area. The scores measure the importance of each land use in terms of economic, functional, vegetation and agricultural performance; the value of Basin 102 (0.91%), is lower than the median of the entire Sicilian territory (0.98%) (Figures 8 and 9).

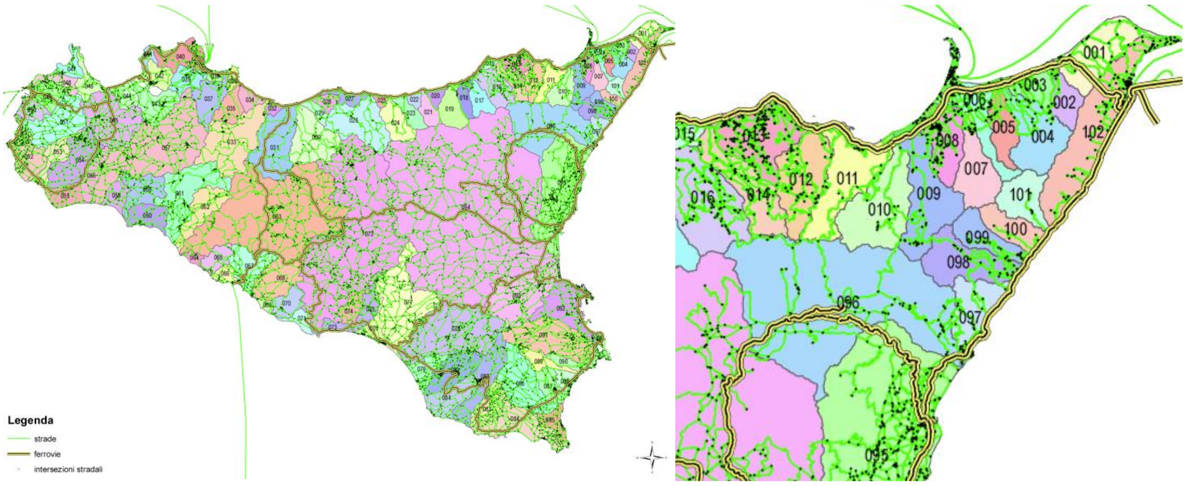


**Figure 8.** Anthropological arrangement in Sicily (left) and in the Fiumedinisi basin area (right).

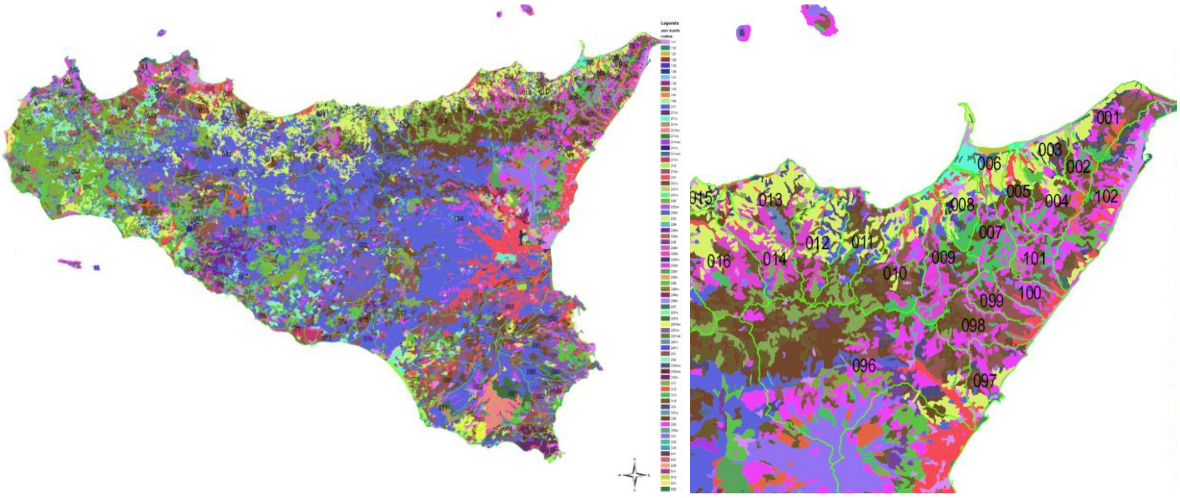


**Figure 9.** Land uses in Sicily (left) and in the Fiumedinisi basin area (right).

4. Ecological, eco-systemic and naturalistic importance. It refers to the surface of the basin occupied by protected areas (Sites of Community Importance – SCI – and Zones of Special Protection - ZSP); the basin comprises the protected areas ITA030008, ITA030010 and ITA030011, for a total surface 3,768 ha area, corresponding to 21.6% of the total area, above the median of the basins of the entire regional territory (Figure 10); this feature compensates the lower anthropic value and increases the imputation ratio up to 0.95% (Figure 11).

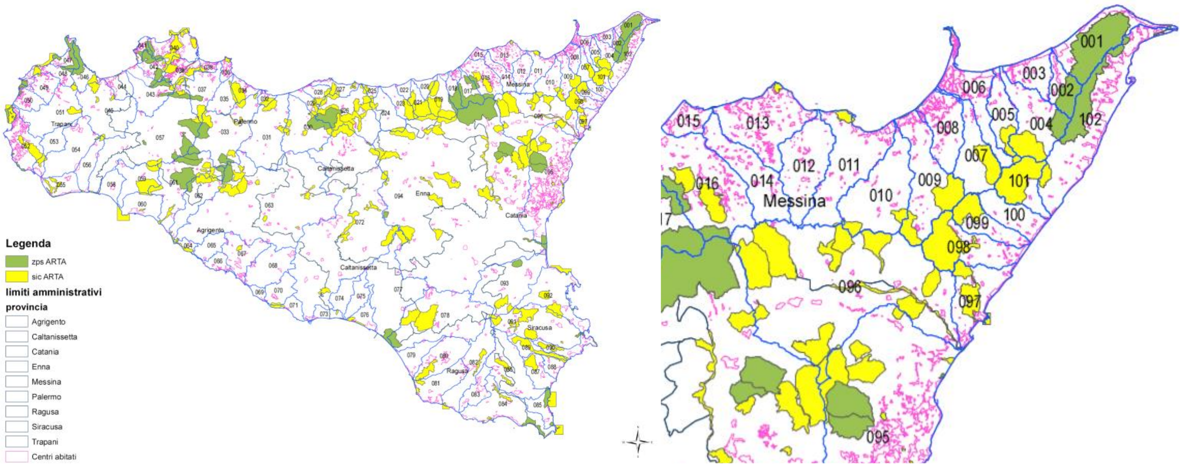


**Figure 10.** Sites of Community Importance and Zones of Special Protection in Sicily (left) and in the Fiumedinisi basin area (right).

| id | Basin | Surface (sq.m) | Watercourses lenght | % Surface over total | % Lenght over total | Land use merit | SCI merit | ZSP merit | Imputation coeff. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Capo Peloro e T.te Saponara | 85,264,758 | 108,990 | 0.34% | 0.38% | 0.49 | 0.65 | 0.65 | 1.20% |
| 2 | T.te Saponara | 31,299,203 | 40,967 | 0.12% | 0.14% | 0.49 | 0.54 | 0.54 | 0.39% |
| 3 | T.te Saponara eF.ra Niceto | 34,783,244 | 27,995 | 0.14% | 0.10% | 0.45 | - | - | 0.09% |
| 4 | F.ra Niceto | 81,725,113 | 87,520 | 0.32% | 0.31% | 0.50 | 0.36 | 0.13 | 0.42% |
| 5 | T.te Muto (Gualtieri) | 40,202,768 | 44,044 | 0.16% | 0.16% | 0.49 | 0.17 | - | 0.13% |
| 6 | T.te Corriolo(Floripotema), T.te Corriolo e T.te Muto e | 65,379,636 | 42,093 | 0.26% | 0.15% | 0.43 | 0.03 | - | 0.16% |
| 7 | T.te Mela | 64,967,961 | 75,705 | 0.26% | 0.27% | 0.50 | 0.23 | - | 0.22% |
| 8 | T.te Longano, T.te Longano e T.te Mela e T.te Longan | 63,207,913 | 81,833 | 0.25% | 0.29% | 0.47 | 0.00 | - | 0.22% |
| 9 | T.te Termini (Rodi) ed T.te Termini e T.te Mazzarrà | 114,150,442 | 103,968 | 0.45% | 0.37% | 0.50 | 0.26 | - | 0.35% |
| 10 | T.te Mazzarrà | 119,233,622 | 87,647 | 0.47% | 0.31% | 0.50 | 0.08 | - | 0.33% |
| 11 | T.te Elicona, T.te Elicona e T.te Mazzarrà e T.te Elicor | 120,235,480 | 76,862 | 0.47% | 0.27% | 0.49 | 0.03 | - | 0.32% |
| 12 | T.te Timeto | 95,894,238 | 70,667 | 0.38% | 0.25% | 0.50 | - | - | 0.27% |
| 13 | T.te Timeto eF.ra di Naso | 115,325,924 | 103,810 | 0.45% | 0.37% | 0.48 | 0.01 | - | 0.35% |
| 14 | F.ra di Naso | 88,837,472 | 70,280 | 0.35% | 0.25% | 0.50 | 0.00 | - | 0.26% |
| 15 | F.ra di Naso eF. di Zappulla | 28,260,454 | 17,353 | 0.11% | 0.06% | 0.46 | - | - | 0.07% |
| 16 | F. di Zappulla edF. di Zappulla eF. Rosmarino | 182,637,402 | 152,408 | 0.72% | 0.54% | 0.49 | 0.23 | 0.10 | 0.77% |
| 17 | F. Rosmarino | 101,134,763 | 88,105 | 0.40% | 0.31% | 0.50 | 0.55 | 0.55 | 1.06% |
| 18 | T.te Inganno eF. Rosmarino e T.te Inganno | 81,194,246 | 102,976 | 0.32% | 0.36% | 0.49 | 0.42 | 0.39 | 0.80% |
| 19 | T.teFuriano e T.te Inganno e T.teFuriano | 154,821,262 | 145,177 | 0.61% | 0.51% | 0.50 | 0.60 | 0.05 | 0.59% |
| 20 | T.teFuriano e T.te Caronia | 49,833,707 | 64,531 | 0.20% | 0.23% | 0.50 | 0.15 | - | 0.18% |
| 21 | T.te Caronia | 82,467,141 | 77,410 | 0.33% | 0.27% | 0.50 | 0.69 | - | 0.26% |
| 22 | T.te Caronia e T.te di S. Stefano | 34,595,238 | 48,973 | 0.14% | 0.17% | 0.49 | 0.00 | - | 0.13% |
| 23 | T.te di S. Stefano ed T.te di S. Stefano e T.te di Tusa | 99,267,427 | 94,505 | 0.39% | 0.33% | 0.49 | 0.33 | - | 0.31% |
| 24 | T.te di Tusa | 161,647,301 | 132,710 | 0.64% | 0.47% | 0.50 | 0.10 | - | 0.47% |
| 25 | T.te di Tusa eF. Pollina | 25,523,997 | 21,646 | 0.10% | 0.08% | 0.49 | 0.22 | - | 0.08% |
| 95 | F. Simeto eF. Alcantara | 718,284,752 | 292,713 | 2.83% | 1.03% | 0.44 | 0.16 | 0.08 | 2.16% |
| 96 | F. Alcantara | 549,948,563 | 368,243 | 2.17% | 1.30% | 0.50 | 0.28 | 0.00 | 1.49% |
| 97 | F. Alcantara eFiumara Agrò | 71,417,084 | 55,530 | 0.28% | 0.20% | 0.47 | 0.26 | - | 0.20% |
| 98 | F.ra d'Agrò edF.ra d'Agrò e T.te Savoca | 85,354,136 | 60,900 | 0.34% | 0.21% | 0.50 | 0.50 | - | 0.24% |
| 99 | T.te Savoca | 44,568,718 | 35,335 | 0.18% | 0.12% | 0.50 | 0.36 | - | 0.13% |
| 100 | T.te Pagliara ed T.te Pagliara e T.teFiumedinisi | 42,209,977 | 43,402 | 0.17% | 0.15% | 0.49 | 0.01 | - | 0.14% |
| 101 | T.teFiumedinisi | 49,989,278 | 61,237 | 0.20% | 0.22% | 0.50 | 0.71 | - | 0.18% |
| **102** | **T.te Fiumedinisi e Capo Peloro** | **174,508,907** | **157,020** | **0.69%** | **0.55%** | **0.45** | **0.03** | **0.19** | **0.95%** |
| | | | | | | | | total in Sicily | 100% |

**Figure 11.** Synthesis of the coefficient of imputation calculated for the basins comprised in the Messina Province according to the four criteria (basins 2-25 omitted).

*4.3 Overall economic valuation*

The partial results listed so far can be finally used to calculate the economic value of the protection policy to be compared to the overall cost for the rehabilitation. A Discounted Cash Flow Analysis was performed by using the imputed expenses coming from the Regional Government balance sheets, over a period of 20 years, conventionally assumed, from 2007 until 2026. The cash flow includes the real expenditures until 2016 and the average supposed amounts from 2017. Furthermore, some scenarios were outlined assuming different hypotheses about the Social Discount Rate, so assuming different approaches to intergenerational solidarity.

As first, the comparison of the different areas involved has been carried out by charging different quotas of the overall imputed amount to the five municipalities, in proportion to the instabilities occurred within the related affected areas: Messina 61.9%%, Scaletta Zanclea 14.8%, Itala 11.6%, Alì Terme 6,5%, Alì 5.3%.

As second, within a range from 3% to 6% (as recommended by the European Cost-Benefit Analysis Guidelines) a different Social Discount Rate has been attributed to each of the five Municipalities in inverse proportion to the instabilities caused by the flood: Messina 3.0%, Scaletta Zanclea 4.8%, Itala 5.5%, Alì Terme 5.7%, Alì 6.0%. The overall SDR, 4.0% has been calculated as average SDR weighted according to the number of instabilities, as well.

As third, the value of the land protection in each Municipality has been calculated by discounting the related cash flows.

Figure 12 displays the comparison of the imputed 0-discount and discounted cash flows for the five Municipalities, and for the overall area, each of them according to the related SDR.

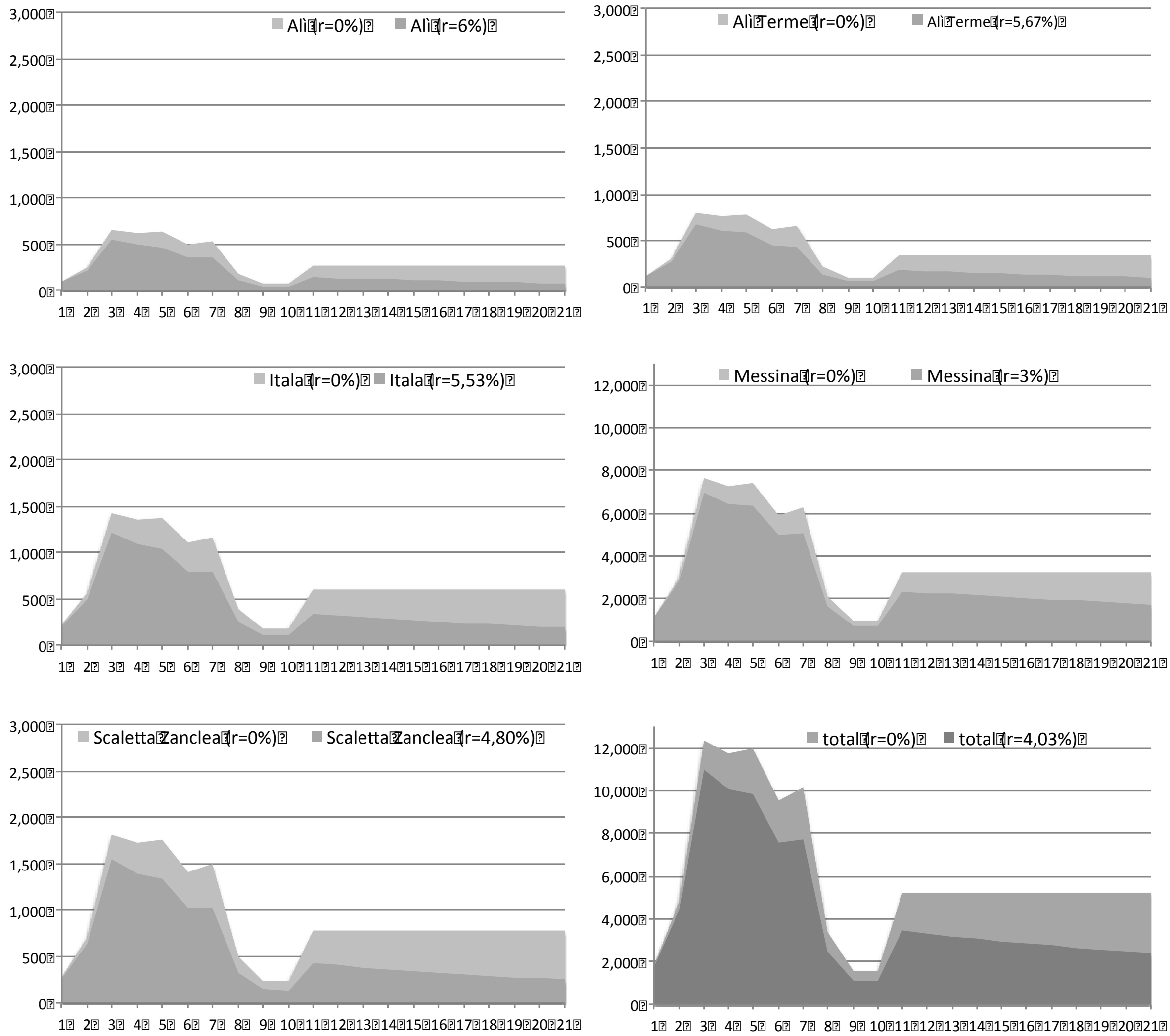


**Figure 12.** Comparison of the imputed 0-discount and discounted cash flows for the five Municipalities and the overall area, each of them according to the related SDR ($r$) (y-axis: 1000€).

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As fourth, the different scenarios about the type of discounting has been carried out, comparing four of the many possibilities outlined in subsection 3.3, and in particular, "0 discount", "decreasing by step discount", "decreasing discount", "constant discount" (Figure 13).

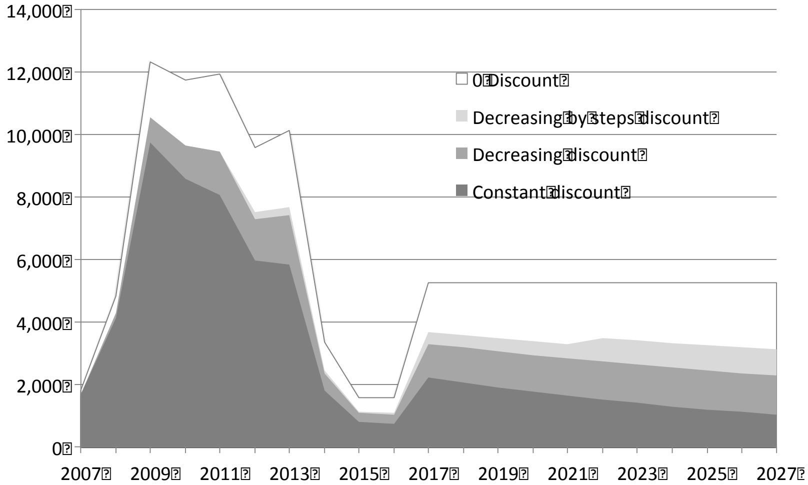


**Figure 13.** Scenarios of the Net Present Values (the white and grey surfaces) of the imputed expenditures cash flow according to different hypotheses of inter-generational solidarity (y-axis: 1000€).

## 5. Discussion and conclusions

The economic valuation of the damage involves the determination of the discount rate also based on its temporal articulation, which should be assumed basing on the expected greater awareness and responsibility about the hazard and the exposure of the territories, and especially about the speed at which climate change modifies the rainfall regimes. The comparison between the various inter-temporal solidarity hypotheses shows that: the value of the current discounted expenditures is equal to € 63.3 million; if the SDR has a hyperbolic decrease, the Net Present Value (NPV) is € 84.0 million; if the SDR has a hyperbolic decrease by steps (every five years) NPV is € 91.5 million, whereas the 0-discounted value is € 126 million.

The outlined range of values cannot be considered adequate to the cost for rehabilitation, € 320 million, if we recognize that some important components of land value, as mentioned, cannot be rehabilitated or replaced, and especially if we consider that a large part of the imputed expenditure are devoted to cover the operating costs of the responsible entities.

Some critical considerations concern the issue of the social discount rate. The discount factor $1/(1+r)^n$, where $r$ is SDR and $n$ the time span, expresses how much the future is worth for us *today*. To foresee that the discount rate varies over time, it means to predict that in the future we'll evaluate future benefits and costs differently from we do now. To hypothesize a declining discount rate means to predict solidarity with future generations in the future, not that the future benefits and costs will have a greater value for us today, as it does seem to make eminent literature on the subject.

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But progress in the value of future benefits and costs, should be more simply accounted by admitting to the latter an "*increase in value* rate" compensating for the loss in value is revenues are discounted with positive a normally positive SDR. Or, more simply, as has always been done, with variations of the present SDR.

The mathematical explanation according to which the essay is deduced from the variation of value does not depend on the categorical difference between values and rates: the rate is, in fact, the lens through which we look at future values now. And now we look at values, not at the lens through which in the future we will look at those values (which will then be the present) and transfer them to the present (which will then be the past).

The nature and culture of the discount rate and its effects return one of the main characteristics of sociality, the relation to future. In wealthy and structured socio-territorial communities, capital invested in stable assets [61, 62] encourages expectations, so that individual choices are influenced by business-friendly territorial policies; here, infrastructure and real estate assets are at the same time sources of utility, sources of income, stocks of capital value, sources for tax revenue. For such communities, the cost of prevention is not a valid alibi to lower the disaster guard.

**Supplementary Materials:** The following are available online at

http://osservatorioacque.it/: Figures 2, 3; http://pti.regione.sicilia.it/portal/page/portal/PIR_PORTALE: Figure 6.

**Author Contributions:** Maria Rosa Trovato and Salvatore Giuffrida equally conceived this study, analyzed the data, performed the calculations and wrote the paper.

**Conflicts of Interest:** The authors declare no conflict of interest.

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