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Edited by *Francesco Adamo*, Emeritus Professor,
Università del Piemonte Orientale

GEOPROGRESS EDITIONS
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GeoProgress Journal

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EDITORIAL NOTE

The Covid-2019 pandemic related health crisis that has persisted for a year, has slowed down, if not blocked, some initiatives of this Journal for the year 2020. These initiatives were relying on receiving a sufficient number of valuable articles to be published in two special issues, focused on specific topics, and that it is hoped they will be published in 2021.
This first 2020 ordinary issue, therefore collects articles of various contents. However, these articles have in common the fact of being consistent with the objectives of the Journal, of promoting and publishing analyses and proposals on problems of substantial relevance for the sustainable development (i.e. progress) of territorial systems, of various geographical scales and decisional levels.

The first three articles relate to some central issues of the eco-sustainability of development: the first one investigates the issue of soil erosion and deals specifically with its measurement; the second article, in the context of the enormous problem of conservation and use of water, focuses on the case of river contracts; the third contribution highlights the importance of new technologies to adapt agriculture to climate change, in particular how the Internet of Things (IoT) allows "optimizing the wine production and quality and, at the same time, preserving the environment by lowering the carbon footprint, reducing water and electricity use and recycle vine and wine waste, thus promoting an effective agroecological transition".

The last two papers deal with other themes which are also essential for the sustainable development of territorial communities, respectively: the conservation and improvement of the health of human resources, that is the foundation to achieve any progress; the earnings management practices by capital firms, whose investments are an essential factor sustaining the economic progress of almost all the current territorial communities. In particular, the fourth article deals with the issue of "nervous system injuries and disorder; which every year affect millions of people worldwide, causing a significant and, unfortunately, rising incidence of social and health costs among all the countries". The fifth contribution, on the other hand, offers empirical evidence showing that Italian private firms manipulate their financial reporting process in order to benefit from capital subsidies, and how their earnings management practices distract European development funds.

Francesco Adamo

ARTICLES

SOIL EROSION MEASUREMENT USING FALLOUT CESIUM 137 TECHNIQUE IN SIDI SALAH BASIN (EASTERN CENTRAL TUNISIA)

Azaiez Naima*

Abstract

According to FAO, Tunisia is classified among the countries worst hit by different processes of soil degradation, particularly the semi-arid domain, making the example of an ecosystem with increased steppization. Climatic deterioration and inadequate reckless human intervention have led to a deterioration of edaphic factors accompanied by a progressive invasion by steppe facies at the expense of a previously dense and stable forest. This change in landscape has exposed the domain to a severe erosive manifestation and has attracted the attention of many researchers on the problem of water erosion which has been weighing heavily on rural communities for decades. Efforts aimed at estimating soil losses have been made worldwide to choose adequate ways of intervention and deal with this significant degradation. Different empirical models have been established, tested and compared to have a quantitative estimation of this degradation (Tamura, 1964; Rogowski and Tamura, 1970 a and b; Kachanoski et al., 1984, 1987 and 1993; Mabit et al., 1999, 2002, 2008 and 2013; Moukhchane, 2008; Felah 2010; Azaiez, 2016 and 2020 and Akwasi et al., 2020). In this context, it was proposed to quantify soil losses in a test watershed through the Cesium 137 method known for its preferential absorption by the soil's fine particles and its high sensitivity to mechanical erosion. To do this, a representative transect has been selected in a small basin of 2.3 km^2 in area, that of wadi Sidi Salah located on the semi-arid margins of the Eastern tell. Seven samples have been taken along the transect oriented by the soil loss map issued from the application of the USLE equation, allowing to integrate as many compartments subject to various erosive factors and processes as possible. The results of the modeling of soil loss through the Cesium 137 technique have shown a significant specific loss of 32.5 t / ha / year but one which is variable between the different compartments of the basin.

Keywords: Cesium 137, Modelling, Sheet Erosion, Soil loss, Transect Sampling

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1. Introduction

Because of its predisposition and adaptation to long-term erosion studies, Cesium 137 was used in the quantitative inventory of water erosion to establish a spatial mapping of soil losses at world scale. The Cesium 137 is an artificial radioactive isotope resulting from the fission of Uranium 235 and Uranium 238 with a half-life of 30.4 years. This by-product has been released into the stratosphere since the 1950s, then redistributed by clouds and carried to the earth's surface by precipitation.

This method has been in application since 1960s. It was used not only to obtain the net value of soil loss but also to evaluate the sediment balance (erosion and deposition) at various scales ranging from plots to catchment scales. Between suspicion and acceptance of the Cesium 137 assumption by the research community, this technique has been carried out on experimental plots and small watersheds to ensure the accuracy and the consistency in the application of the isotopic techniques on various scales. The first attempts to use Cesium 137 in erosion study were started in the mid-1960s, with Yamagata, Rogowski and Tamura among those who found a close relationship between soil loss and Cesium 137 activity decrease, but on a few months scale, because of the most recent deposition date of the Cesium 137 elements (Yamagata et al., 1963 Tamura, 1964, Tamura and Rogowski, 1965 and 1970).

The Radio-Cesium 137 displacement by runoff and mechanical process of erosion, was later confirmed and compared to the empiric modelling by other researchers, specifically relating to research results presented by Ritchie and McHenry, 1974 and 1977, Walling and Quine, 1990, Navas and Willing, 1992, Wicherek, 1993 and Felah, 2010. The same applies to specifying the emitting sectors of sediments in order to evaluate the silting up of dams and for dating deposited sediments and check dams against fast sedimentation (Sogon, 1999; Zhang et al., 2015). With regard to the Cesium 137 behavior with soil element, several studies were devoted to specifying the cation exchange capacity of clay element in soils such as illite, smectite and vermiculite which have higher affinity to Cesium 137 (Yigzaw, 2009; Grzegorz, 2006; Mabit et al., 2013 and Staunton and Roubaud, 1997).

The Cesium 137 fallout has been significantly more important in the northern hemisphere - precisely around latitude 45° north - than in the southern hemisphere due to the greatest flux of Cesium 137 since 1954 (Walling and Quine, 1990 and 1993; Moukhchane et al., 1998; Moukhchane, 2008; Zapata, 2002; Zhang et al., 2015 and Ni et al., 2017).

Its effects are still being perceived even today in central-east Tunisia. Considering research on Cesium 137, on a world scale, it can be noted that several models were developed for quantitative erosion at medium and long-term measures. The isotopic method of Cesium 137 has been applied to regions suffering mainly from severe degradation under extreme climatic conditions and which are limited and inadequate for empirical modeling. These Cesium 137 isotope tracers are a very interesting alternative capable of overcoming some of the difficulties that have accompanied previous empirical and experimental methods that required a huge amount of work and continuous monitoring on the ground.

These radioactive isotopes are of paramount importance as their introduction into the soil coincides with the major changes in the rural landscape and natural vegetation cover over the last five decades in Tunisia steppe, which have been marked by the emergence of new agricultural structures increasingly based on mechanization, mono-cropping and unsuitable tillage methods (Attia, 1977; Hamza, 1988 and Azaiez, 2016).

In particular, the use of the polydisc tractor caused the radioactive elements to be dragged deep, thus allowing their leaching with the clay fraction (Zhang, 1999 and Zhang et al., 2015). However, emphasis must be laid on the circumstances where it is appropriate to apply the isotopic method, that is not prescribed to be routinely used in such cases by rote (Rogowski et Tamura, 1970; Zhang, 1999; Grzegorz, 2006 and Fulajtar et al, 2017).

Once the requirements set out above, referring to the isotopic method, were fulfilled in central eastern Tunisia, it was possible to use this method to develop new insights on the ongoing erosion and sediment displacement in semi-arid steppe in Tunisia, in particular in the watershed of Sidi Salah, a catchment area with a pastoral function. Considering the outcomes on the studies with Cesium 137, it appears that most of the optimum adsorption of Cesium 137 occurs on the surface of the soil and its diffusion in depth becomes increasingly difficult. Its vertical displacement in soil horizons by infiltration is limited. But the samples analysed in the Eastern Central part of Tunisia have shown that fields which are deeply plowed contain a higher concentration of Cesium 137 to a depth of 20 and 25 cm. But this radioactive element was completely expunged between 25 and 35 cm of depth.

The aim of this work is to propose a quantitative estimate of soil losses and to highlight the different factors that are at the origin of the erosive effect not only by their statistical weight but also by their causality relationship (Walling and Quine, 1990 and 1993; Moukhchane et al., 1998 Zapata, 2002; Mabit et al., 2002; Felah 2010; Ben Mansour et al., 2000 and 2012; Toumi, 2013; Zhang et al., 2015 and Azaiez, 2016).

Based on this isotope technique, a preferential transect from upstream to downstream was chosen for sampling. This work does not attempt to provide a comprehensive and exhaustive quantitative study, but rather a consistent interpretation of the erosion event itself as well as its trends, depending on land use and the physical environmental characteristics responsible for sediment transport along the slopes.

2. Study Area

The watershed of wadi Sidi Salah, a tributary of wadi Saadine, extends over the semi-arid margins of the eastern Tell which has a Mediterranean climate with contrasting seasons. It drains an area of 2.3 km^2 of the eastern slopes of the Ejhaf, Diour and Fartout mountains (Figure 1).

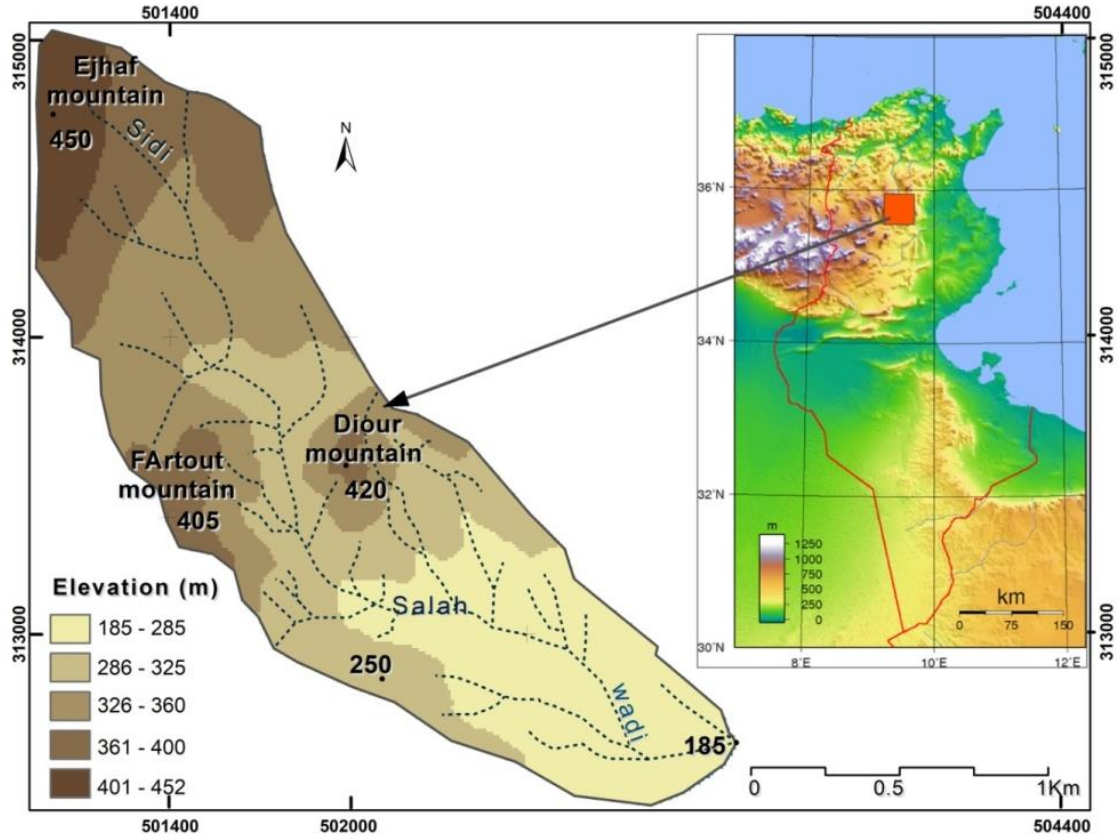

Figure 1: Location map of the study area.

With altitudes ranging from 185 m to 452 m, this watershed has an average slope of 18° and can reach 43° on the middle slopes and, to a lesser extent, on the north-western slopes.

The steepness of the slope in the middle part of the watershed, precisely on the edges of the glacis, is explained by the vicissitude of the glacis, which are partially covered by consolidated debris (Dresch, 1957). Generally speaking, it consists of an aerated and spaced landscape of low morphostructural diversity (Figure 2). Added to this is the instability of the glacis edge caused by the effects of breaking up the crust that is followed by farmers to exploit the underlying fine-textured soil layer.

Currently, these glacis on the middle stream are in the form of intensely dismantled and dissected strips overlying a clay layer that is unstable due to the predominance of clay elements of the smectite, vermiculite and illite type, susceptible to erosion process (Figure 3) (Jamoussi, 2001). Full of gypsum elements, these clays have high swelling and shrinking properties. The gypsum dissolution creates an internal cavity of different size, which disturb the slope stability, especially on the middle reaches of the water course of Sidi Salah.

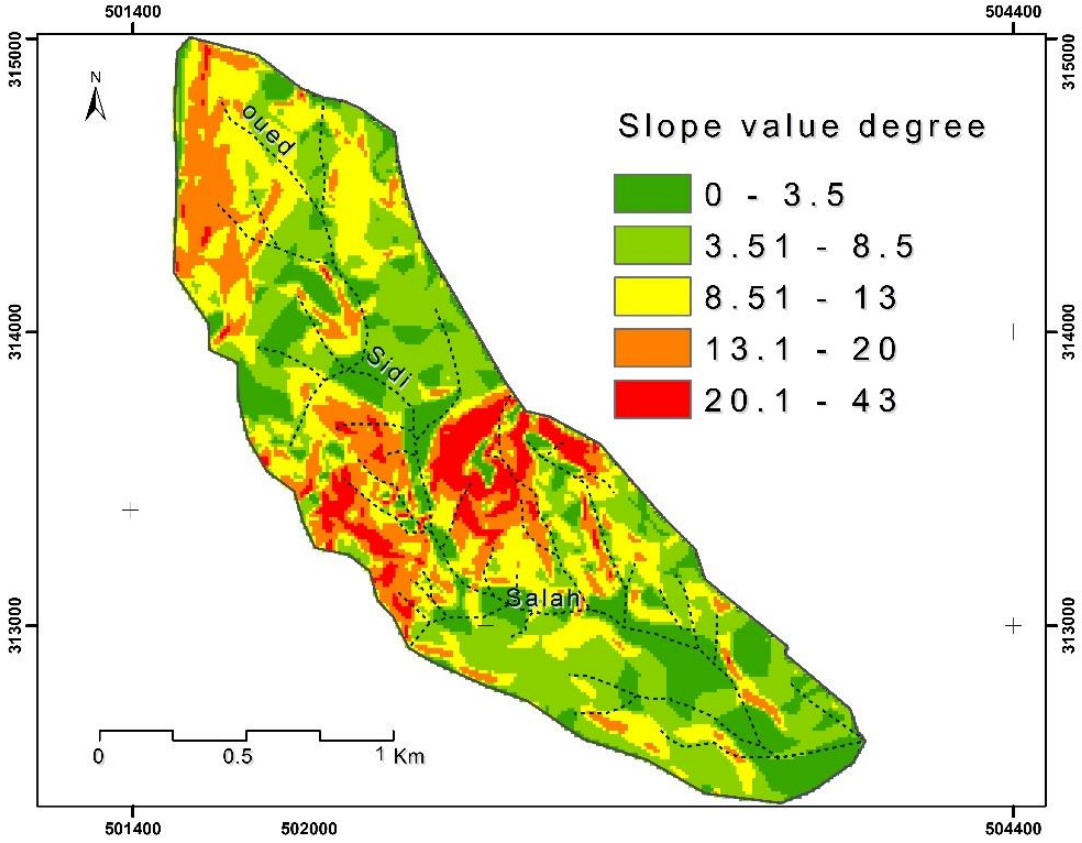

Figure 2: Slope map of wadi Sidi Salah basin. Source: Obtained from the DEM developed on the basis of the topographic map of Zaghouan at 1/25000.

All these conditions favored a rapid return of water erosion, which accelerated with the proliferation of intense and variable rainfall combined with a contrasting lithology marked by alternating marl-clayey-limestone upstream and clayey-sandstone downstream. (Hamza, 1988; Avenard, 1995; Roose, 2004; Toumi, 2013, Azaiez, 2016 and 2020 and Azaiez et al, 2020)

The surface formations are seriously affected by various forms of water erosion and prove that this watershed is widely disposed to the agents of morphogenesis, given the predominance of silty-clay and sandy-silt textured soils that are sensitive to the processes of mechanical erosion and the effects of hypodermic flow. These types of soils represent 40% of its total surface area (Figure 3). These results related to the soil texture were obtained by particle size analysis and the sand equivalent test based on the French standards already established by AFNOR (AFNOR, 1993 and 1998) and the observations of the digital Soil Map of the governorate of Zaghouan, 2003.

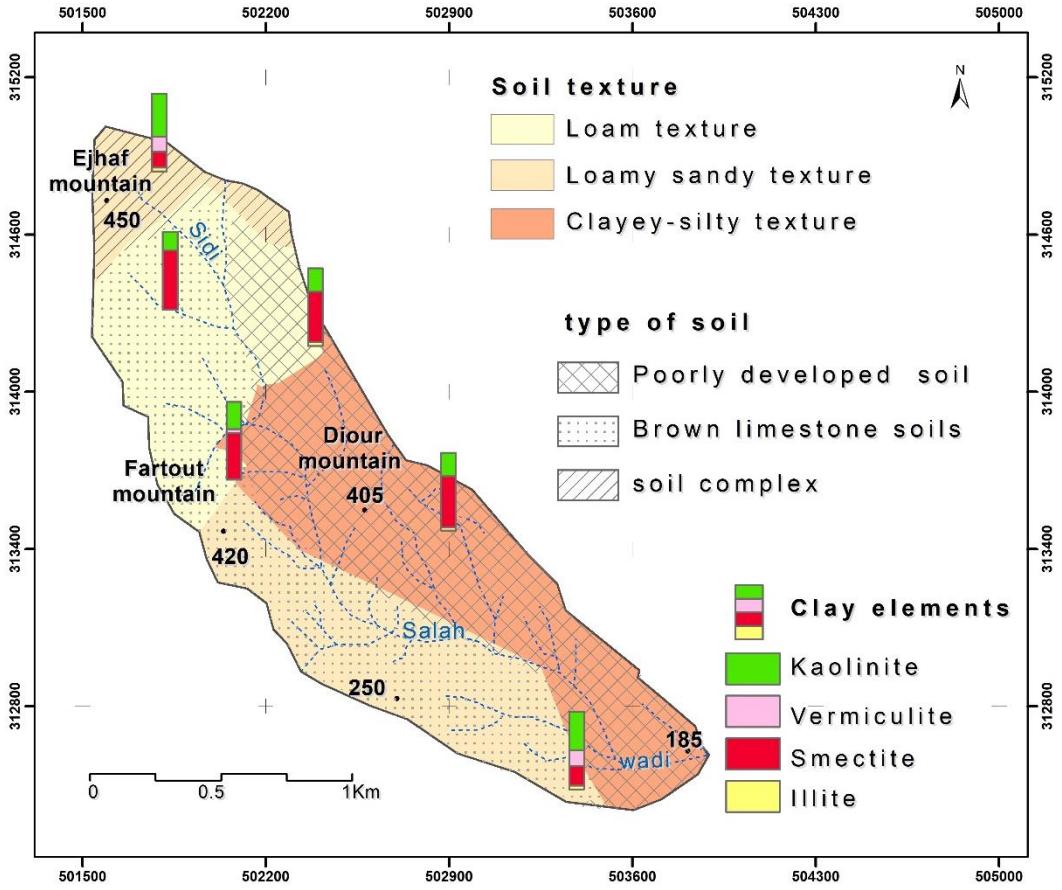

Figure 3: Type of soil, soil texture and clay elements map of the study area.
Source: This map was produced on the basis of the results of particle size analysis, mineralogical analyses and the digital agricultural map of Zaghouan, 2003.

X-ray diffractograms specific to the samples taken from soils with silty-clay and silty-sandy textures as well as geotechnical tests show an enrichment in clay minerals of the illite and smectite type that are very favorable not only for swelling and shrinking but also for mechanical shear due to their low plasticity and low consistency (Yigzaw, 2009) (Figure 3).

However, these processes are subject to the unpredictability of the climate, especially the highly variable and aggressive autumn rains and the associated environmental problems (Abdelkhalek, 2009 and Azaiez, 2016**)**.

The effects of water erosion seriously affect the quantity and quality of soil and plant resources and call into question the problem of the longevity of equipment and hydraulic developments located downstream related to the enrichment of sensitive clay minerals (Figure 3). It is worth highlighting that the majority of these erodible soils are located on very steep slopes that generally correspond to the Erosion talus of the intensely dismantled glacis. Thus, the soils enriched in smectite and illite are located in the middle course of the wadi Sidi Salah, beyond two banks of the main watercourse.

Anthropic pressure and climatic deterioration have given rise to a phenomenon of dematorralisation of the steppe forests marked by an inevitable expansion of the chamephyte and therophyte species on some slopes at the expense of an open garrigue because of the discontinuity of the soils on the one hand and the selective migration of

the fine fraction by selective erosion on the other hand (Attia, 1977; Le Houérou, 1995 and Tassin, 2012). There has been a progressive degradation of the old plant associations that were able to fight against climatic aggressions.
Thus, an erosive manifestation began in response to the different agro-sylvo-pastoral uses that have taken over for several decades (Attia, 1977). Currently, the plant cover is essentially made up of a young secondary resinous forest, also known as anthropic, which has replaced the primitive forest (Attia, 1977; Le Houérou, 1995 and Azaiez, 2016). On the exposed slopes, a scrubland of mastic grass, Aleppo pine and rosemary, which have a great colonizing power on marly-limestone substrata, has gained ground (Le Houérou, 1995) (Photo1 and Figure 4).

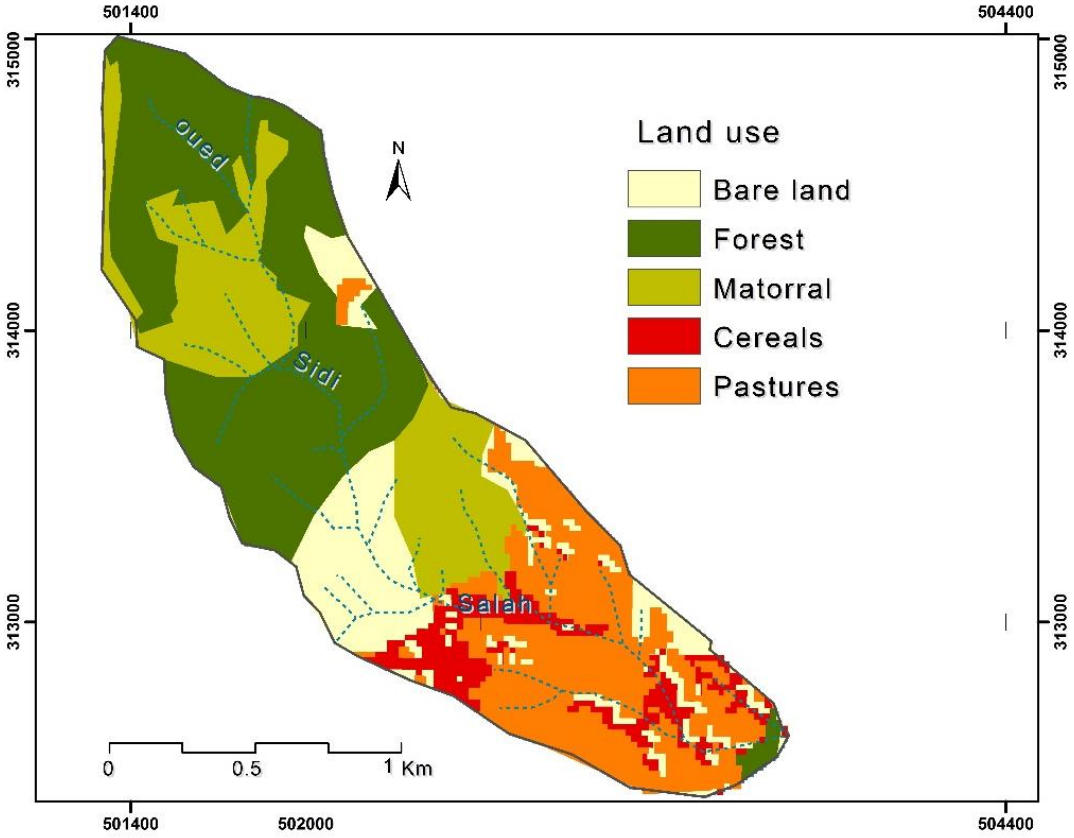

Figure 4: Land use map of Sidi Salah basin. Source: This map was produced on the basis of the digital agricultural map of Zaghouan, 2003 and Google Earth Pro Image 2019.

Photo 1: Matorral of Aleppo pine and rosemary in the upper stream of wadi Sidi Salah basin (Photograph taken in 2015).

The clearings that were established during the colonial period following land clearing for cultivation are now occupied by open bushy plant formations. These plant forms evolve rapidly into scrubland in the northern combe clearings in this watershed. On the middle slopes, however, these plant forms find it difficult to develop not only because of erosion facilitated by low density and overgrazing, but also because of their proximity to the large village community.

However, it is necessary to emphasize the interactions between the climate and the plant cover, which are exerted on a largely undeveloped soil complex. A comparison between different parts of Sidi Salah basin, shows a strong sensitivity of the western slopes of the middle and of the downstream (Photo 2 and Figure 5). This indicates that erosion is very active and severe on soils with fragile texture subjected to strong human pressure and rainfall amount whilst the low sensibility areas are dominated by forest and plant cover on a gentle slope in the upper stream (Figure 5).

Photo 2: Soil erosion in the middle course of wadi sidi Salah (Picture taken in 2015).

The water erosion sensitivity map is the product of the superposition of four layers involving several factors. They are: the permeability index obtained from the soil texture triangle, the slope map produced by the DEM on Arc GIS, the vegetation cover index obtained from the USLE equation, and the map of the hydrographic density calculated by each type of soil texture. From this combination, it seems clear that the sectors most prone to water erosion are the least permeable (clayey silty soil), the steepest, those that have the highest hydrographic density and the least dense vegetation cover. This is a very favorable situation for the formation of runoff due to infiltration relatively low (Figure 5).

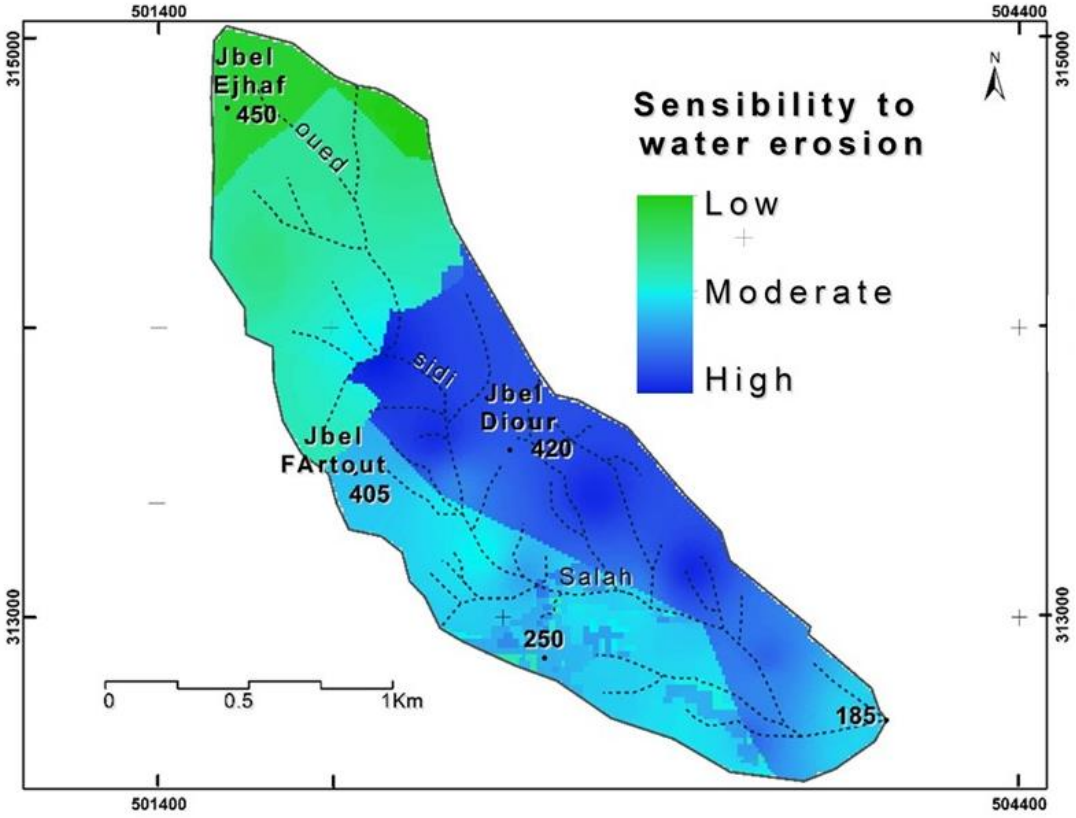

Figure 5: Erosion sensibility in the wadi Sidi Salah Basin. Source: This map was produced on the basis of the digital agricultural map of Zaghouan, 2003 and Google Earth Pro Image, 2019.

3. Method and Tools of Transect Sampling

Sampling was carried out using a 6 cm diameter PVC tube to a depth of 25 cm, which represents the average thickness of the tillage layer in this area. The quantities collected were largely sufficient for isotopic, mineralogical and granulometric analyses. These last two analyses will be of greater use in explaining the erosive manifestation from the point of view of rhythm and distribution.

The Cesium 137 technique is a universal method, applicable in different climatic, lithologic and topographic contexts (Mc Henry, 1985; Walling and Quine, 1990; Felah, 2010 and Ben Mansour et al., 2000 and 2012). Its widespread use around the world is explained by the absence of factors that would limit its application especially in the northern hemisphere. Its widespread use around the world is explained by the absence of factors that would limit its application, especially in the northern hemisphere because of the Cesium 137 abundance due to fallout from atmospheric nuclear tests conducted since 1950 in the region.

Although this approach is widely validated in the Mediterranean environment, its success, however, remains dependent on the way it is applied because some watersheds are suited to sampling by metric grid because of the high heterogeneity of the landscape, controversial topography, dissected orography and aggressive rainfall, while others are suited to division into homogeneous units, when similar landscape units are scattered over several sectors. Whereas for other elongated watersheds where the units are arranged one after the other, a representative transect had to be followed.

In the case of the watershed of the Sidi Salah wadi, the sampling was guided by two major facts.
Firstly, the results of the soil loss map resulting from the application of the USLE equation, which served as a reference, and also by the elongated shape of the watershed. The units are more homogeneous transversally and less and less homogeneous longitudinally.
The selected transect, oriented north west south east, delicately follows the arrangement of the morphostructural units and the different plant associations accompanying each surface formation. This transect passes through as many compartments as possible that have almost similar lithologic, topographic and human conditions.
Seven samples were taken from upstream to downstream on either side of the mainstream. Using a 6 cm diameter PVC tube, soil samples were taken from a depth of 25 cm because the soils are not very evolved and the regosols are not very deep. (Figure 6). This feature affected the choice of the suitable depth to carry out the sampling process as, at greater depths, steeper slopes may inhibit Cesium 137 fixation because of the clay-humic compound of the soil.
Only in the hillside reservoir the sampling was carried out over a depth of 35 cm as it constitutes the reception area for almost all the sediments coming from different compartments of the watershed, except for sediments that are trapped against obstacles within the watershed.
Sample 1 was taken in a stable reference section of a state-owned forest that is very little subject to human activity. Sample 7 was taken from the hill reservoir located downstream of the watercourse before reaching Wadi Saadine. The rest of the samples were taken in areas subject to the effects of surface water erosion to varying degrees.

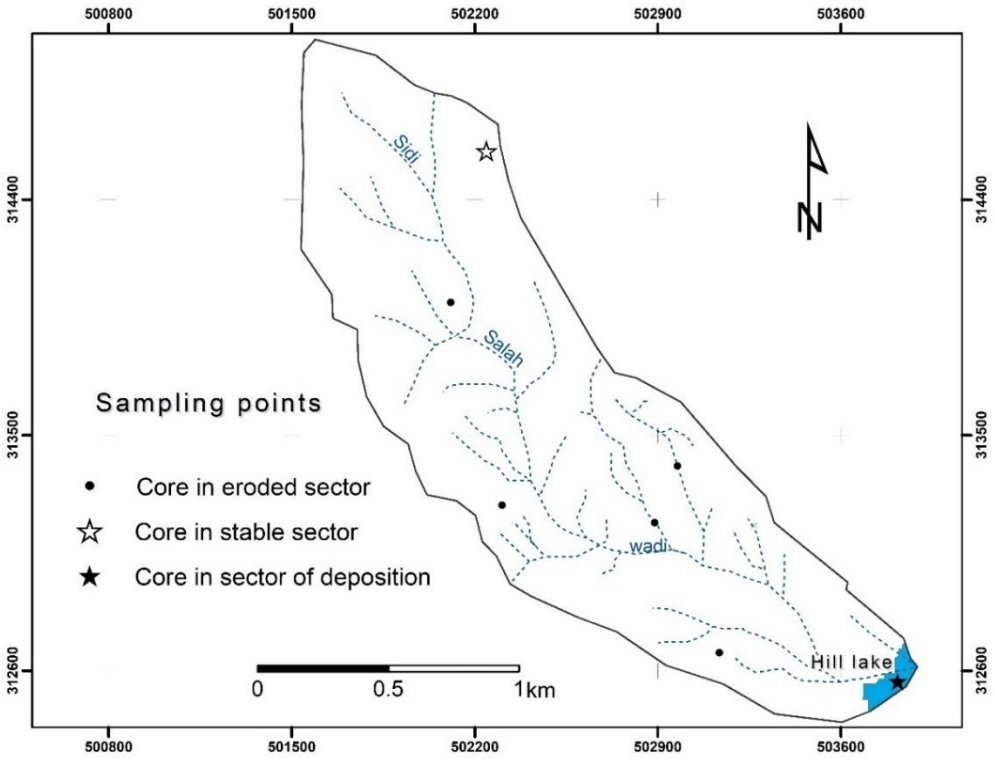

Figure 6: Map of the soil sampling locations in Sidi Salah basin.

The map of homogeneous units was then used in the generalization of the results of Cesium 137 activity in the non-sampled compartments. After applying the sediment drying protocol in the open air and then in the oven and after cleaning and removal of volatile organic matter, the fine fraction (less than 0.2 mm) was separated using a sieve.
Measurements of Cesium 137 were carried out on the whole core after its homogenisation. A sequential division of each core was not carried out due to the very high cost of isotope analysis, as this research was not undertaken as part of a funded project. The principle consists in studying the redistribution of Cesium 137 which is closely related to the movement of soil particles by physical and mechanical processes compared to a reference site whose fallout has remained stable since its adsorption by fine soil particles (Felah, 2010; Ben Mansour et al., 2012; Toumi, 2013). By contrast, at the accumulation sites the Cesium 137 content was significantly higher than the baseline value at the reference site (Ritchie et al., 1990; Zapata, 2002 and Felah, 2010).

4. Distribution of Cesium 137 activity: analysis and interpretation

The variation in Cesium 137 activity in different parts of the watershed can be interpreted either in terms of reduction or enrichment compared to a reference site. An erosive phase occurs if Cesium 137 activity is reduced in some slopes compared to the reference site. Sedimentation occurs if other areas are enriched in Cesium 137 radioactive elements, particularly in the deposition areas such as the convex banks of meanders, slope breaks, the embankments of contour benches and the hillside reservoirs (Walling and Quine 1990 and 1993; Zapata, 2002; Felah, 2010 and Azaiez, 2016).
To get the correct spatial distribution of cesium activity in the Sidi Salah basin, it was necessary to apply the Kriging method as an interpolation model from the toolbar spatial analyst tools under Arc Gis program. The Kriging interpolation was well advised to be the optimal method, in statistical terms, of interpolation and extrapolation of the Cesium 137 activity (Figure 7). It allows to make an unlimited interpolation between different values by taking into account data, their spatial position and their relative distance from the target. It also allows the definition of the spatial correlation while smoothing the real variability and making it possible to calculate the estimation error (Gratton, 2002**)**.

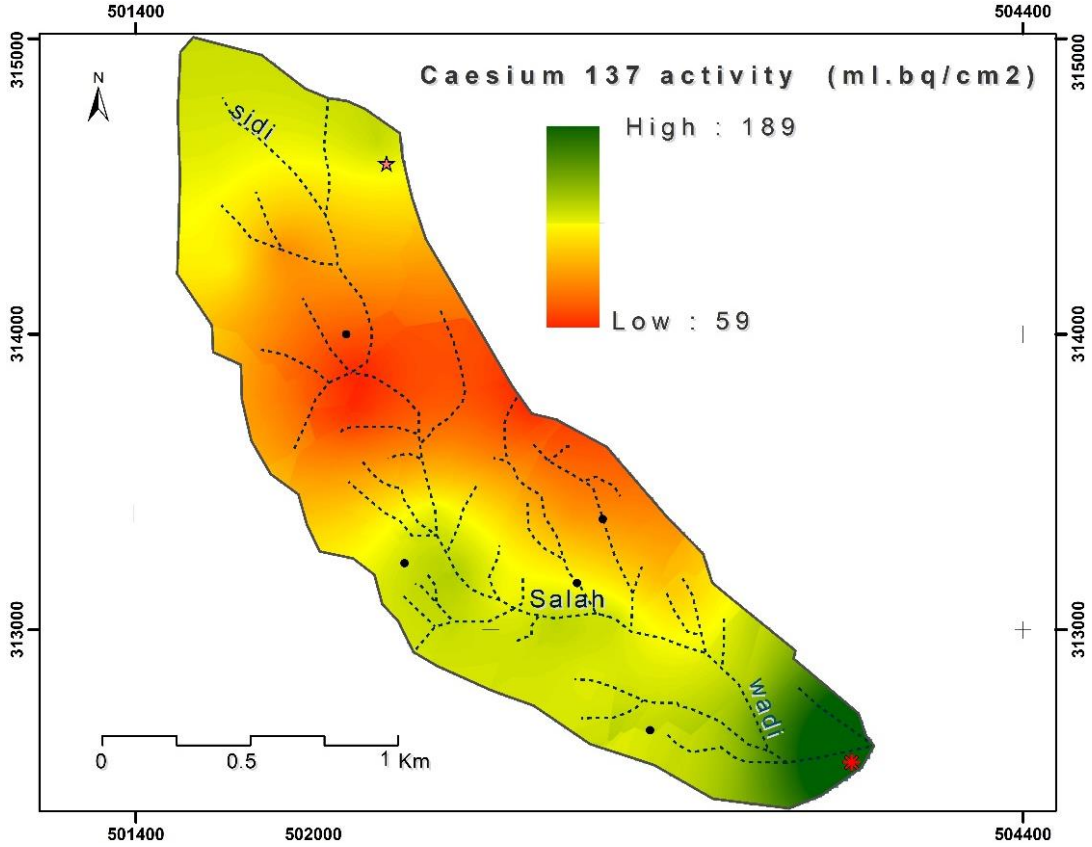

Figure 7: The Cesium 137 activity in the Sidi Salah basin. Source: This map was produced on the basis of the results of isotopic analysis, 2015, National Center for Nuclear sciences and Technologies, Tunisia.

In the Sidi Salah wadi watershed, Cesium 137 activity decreases considerably from upstream to downstream, except in the hillside reservoir in the basin outlet, where sedimentation prevails over any erosion process. This activity reaches its lowest values on the mid-slope, especially on the long and steep slopes (Figure 7). This significant reduction in radioactive elements is explained by mechanical processes related to diffuse runoff and the opening of the gullies, which caused a selective migration of the fine fraction of the soil in which the isotopes of Cesium 137 are adsorbed.

All the elements stripped and carried along the slopes are trapped in the form of deposition pockets at the convex meanders and slope breaks. Most of these isotopes that are detached by mechanical processes are decanted in the hillside reservoir of the wadi of Sidi Salah. However, it should be pointed out that the reduction of Cesium 137 activity is also linked to the specific characteristics of the Cesium 137 isotope.

This latter systematically loses almost half of its activity over thirty years. Another finding proved by the team of researchers at INRA Montpellier confirms that the reduction of Cesium 137 through its circulation via plants is weakened in soils with a very low organic matter content in clay minerals. In fact, a compensation can be generated by the current additional inputs from nuclear reactor emissions (Colle et al., 2005).

Another finding proved by the same research team from INRA in Montpellier confirms that only plants with a superficial root system are capable of absorbing these radioactive elements, since 90% of the Cesium 137 is concentrated in the first 10

centimeters of the tillage layer (Colle et al., 2005; Sonia Mohamed et al., 2018 and Akwasi Dwira Mensah et al., 2020**)**. Contrary to this situation, chamephytic and therophytic plants generally have a deeper root system and therefore Cesium 137 remains accessible only to the surface layer, in other words the roots close to the surface (Tassin, 2012).
All these arguments and explanations must be taken into consideration when interpreting the variation in Cesium 137 activity between the different areas of the watershed and to subsequently qualify the land losses obtained from the modeling. However, Cesium 137 activity is quite considerable in improved rangelands, dense scrub and garrigue consisting of young pine, juniper, lentisk and rosemary.
This finding is confirmed by other researchers who have emphasized the role of matorral-type vegetation cover in significantly reducing water erosion (Rogowski and Tamura, 1970 a and b; Ben Mansour et al., 2000 and 2012; Zapata, 2002; Felah, 2010 and Azaiez, 2016). In the case of this watershed, the diffuse flow presents a harmful action, solicited by a matrix texture separated by two-dimensional interfoliar spaces that favour the reopening of micro-shear planes, especially during the heavy and continuous autumn rains that occur after a long dry, hot season (Yigzaw, 2009).

5. Modeling of soil loss

To convert the Cesium 137 activity into soil losses, two models were applied to perform the calculations. The proportional model and the Mass Balance 2 model. The proportional model was applied for cultivated watersheds. (Kachanoski, 1993; Zapata, 2002 and Felah, 2010). It is expressed as follows:

$$Y = 10 \times \left(\frac{BdX}{100T}\right) \qquad [1]$$

With
Y: the soil loss (t / ha / year),
B: the soil density of the fine fraction <0.2mm (kg/m^3),
d: the depth of the plowing layer (m),
X: the percentage enrichment or reduction of the activity of Cesium 137 and relatively expressed to the reference:

$$= \frac{[Aref - A]}{Aref} \times 100$$

With
T: the number of years since 1963 (reference date for the start of massive Cesium 137 emissions),
Aref: specific activity in Cesium 137 (Bq / m^2) of the reference site,
A: specific activity in Cesium 137 of the sample from a degraded site.

While the Mass balance 2 model has been applied to uncultivated sectors, strongly subjected to the action of peasant society through cultivation, grazing, transformation of agricultural techniques and land use change. It is expressed as follows:

$$Y = \left(\frac{10dB}{P}\right) \times \left[1 - \frac{\left(\frac{1-X}{100}\right)1}{(t - 1.963)}\right] \qquad [2]$$

With
P: a corrective index linked to the selective start of the fine fraction (of the order of 0.93),
t: number of years between the departure date and the date of the sample (Zapata, 2002; Felah, 2010 and Azaiez, 2016).
A first comparison between the map of Cesium 137 activity and that of soil losses resulting from the interpolation by Kriging model in spatial analyst tools, shows a relation of proportionality between soil loss and quantity of Cesium 137 removed from the soil.
The amount of eroded soil is directly proportional to the redistribution of Cesium 137 activity. The sectors enriched in cesium are the sectors of accumulation while those which have recorded a decrease in Cesium 137 are the degraded sectors (Figure 8).

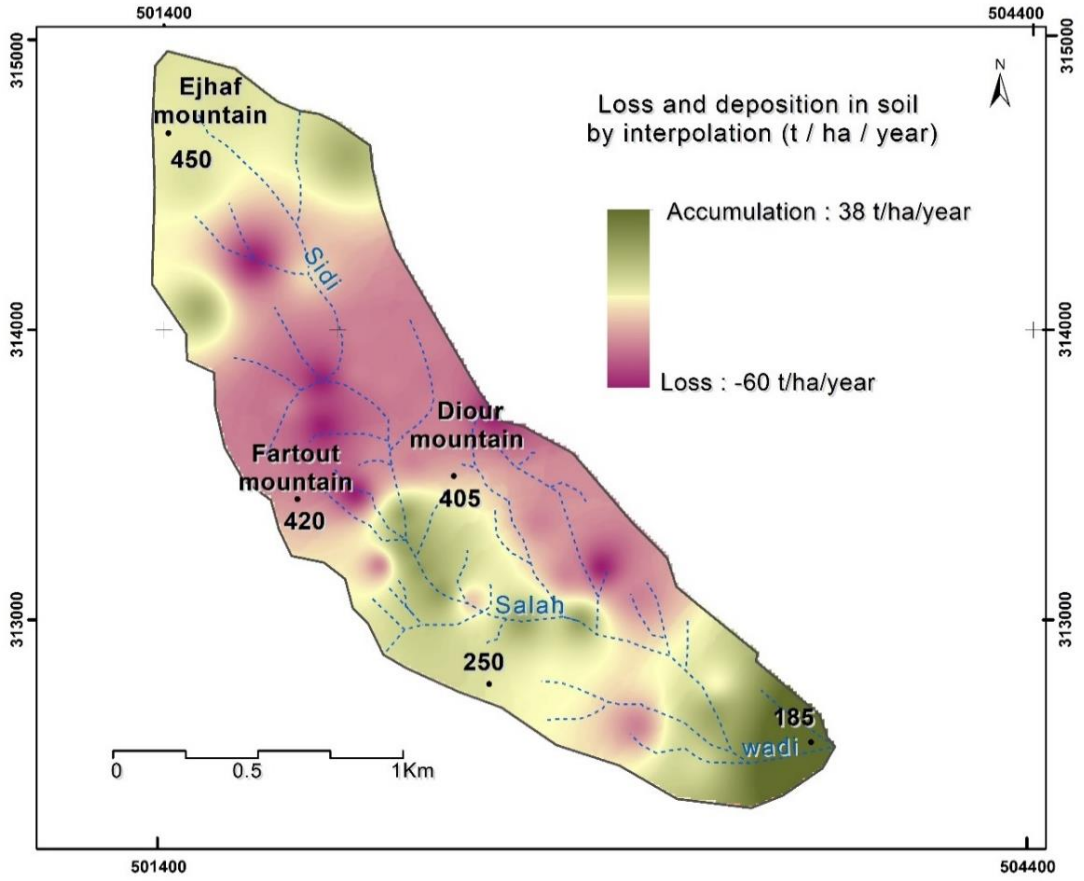

Figure 8: Soil loss in the Sidi Salah basin based on kriging interpolation method.
Source: Results of isotopic analysis, 2015, National Center for Nuclear sciences and Technologies, Tunisia.

6. Discussion and recommendations

The spatialized modeling of soil losses resulting from the isotope method shows a concentration of degraded land in the center of the watershed, in other words, the areas where the greatest anthropogenic pressure has been exerted. This proves that the erosive manifestation clearly takes on both human and natural dimensions. The human dimension appears in the confirmation of the steppe character of the study area as a

result of the combined effect of climate deterioration and the behaviour of the various successive farming communities. During the colonial period and in the decades that followed, they resorted to land clearing, mono-cropping and extensive grazing. These local conditions have made the watershed a very sensitive area to water erosion, as farmers do not even respect mulching in fallow land as a way of soil management because of the high pastoral load. The natural dimension is reflected in the matrix structure of the clay fraction of the soils, which is not very consistent, and the micro-aerated texture, which frequently creates a vacuum in the arable layer. This problem concerns the soils that are above the clayey-marly outcrops of the middle course of the wadi Sidi Salah and are in fact the most degraded areas. The specific loss in soils with a silty-clay texture exceeds 45.5 t/ha/year on the left bank of the wadi Sidi Salah. (Figures 8 and 9). The Ministry of Agriculture described it as an alarming situation. Based on the results of the pilot basins, the Ministry has set the value of 40 t / ha / year as a tolerance value for soil erosion in Tunisia. The rate of soil loss in sidi Salah basin is considered as one of the strongest compared with other basin localized not far from our study area (Table 1). The modelling results in the next table can be used as a guideline to identify soil erosion tolerance according to empirical and experimental models.

Watershed names	**Specific soil loss (t/ha/year)**	**Model**
El Mssine	34	USLE
Jannet	26	KINEROS model and USLE
Chaddad	39	USLE (adjusted)
El Ogla	30	USLE, RUSLE, MUSLE and FAO
Sidi Salah	32.5	Cesium 137
	39.8	USLE

Table 1: The average rates of soil loss in a few basins in order to define tolerable soil erosion values in central eastern Tunisia.

The erosion speeded up considerably under increasing pressure from deforestation in the upper stream and the compaction of the soil resulting from inappropriate agricultural practices going against the equitable use of soil and water in semi-arid region. These facts are at the origin of the appearance of suffosion holes in agricultural plots, degraded pastures and grazed fallow land. On the calcareous back slopes and the open combe in marly-limestone outcrops, the soil loss nevertheless remains much lower than the specific loss of the watershed (32.5 t/ha/year). The establishment of a sediment budget must be taken with caution. Because only a part of the detached elements is carried downstream while a good part of these sediments remains trapped within the watershed in the form of small benches in the convex meanders or in the form of pockets fixed by riparian vegetation that develops in tufts.

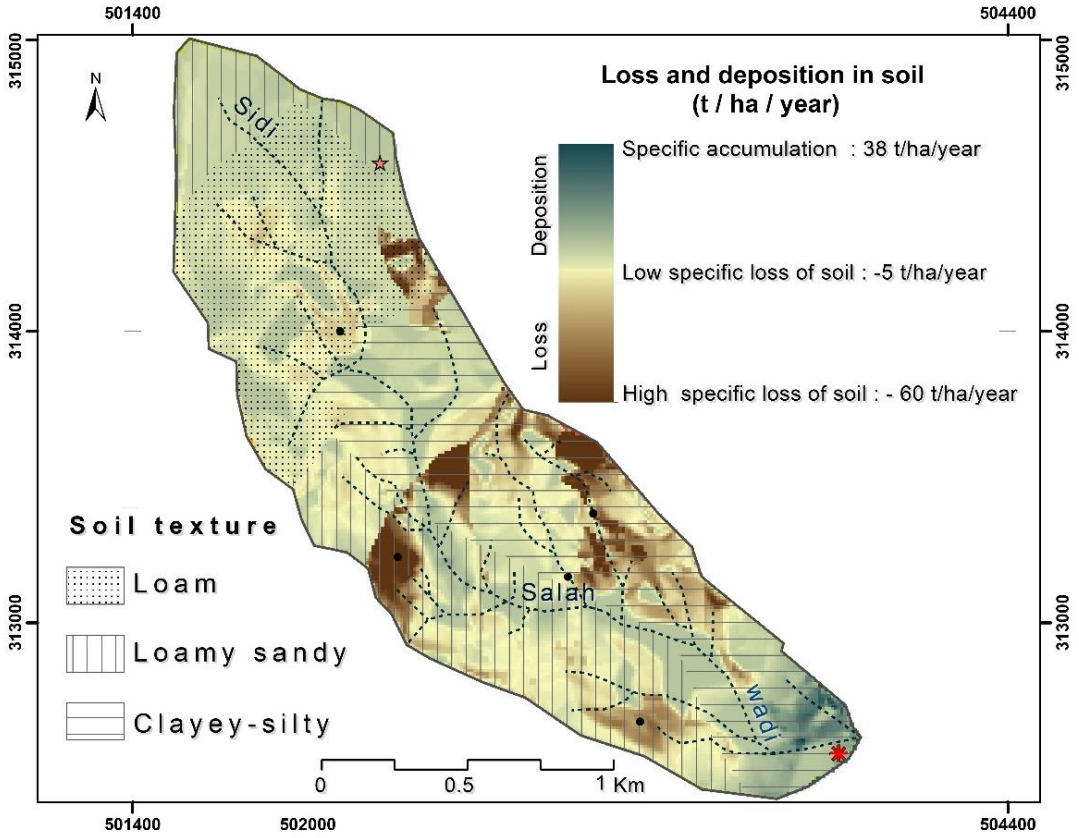

Figure 9: Map of relationship between soil loss and soil texture in the Sidi Salah basin. Source: Results of isotopic analysis, 2015, National Center for Nuclear sciences and Technologies, Tunisia, particle size analysis and the agricultural map of Zaghouan, 2003.

The advantage of this technique compared to those previously developed is that it has helped to obtain an overall budget for the movement of soil particles. Several reproaches can be made about the modeling via the isotope method of Cesium 137 applied in the watershed of the Sidi Salah wadi.

Firstly, it only provides an estimate of long-term (40 years) soil losses, but on a seasonal scale, it does have a number of deficiencies. The erosive manifestation differs from one season to another and even from one rainfall to another. Also, the limited number of samples taken (Felah, 2010 and Azaiez, 2016, Ni et al., 2017). Indeed, with exhaustive sampling the results could have been better and more accurate, but not radically different from the results obtained. These results would probably have shown caution if a sequential analysis of each sample had been chosen instead of simply calculating a simple average of the Cesium 137 activity over the entire core. The highest accuracy of erosion rate was obtained at scale of different cores collected on representative sites selected between the upper and the outlet basin. However, the results remain the lowest at the catchment scale because of its spatial variability and heterogeneity between all basin units. The Cesium 137 method requires a careful modelling because it cannot be used automatically everywhere under all forms of erosion. It is not the appropriate method for sectors prone to gully erosion with varying degrees of rigor.

Only sheet and rill erosions are involved because of the runoff removing the soil in sparse sheets of topsoil and can be extending to 25 cm of depth. All other types of water erosion are not taken into consideration in the modelling process. It seems advisable consider various forms of erosion in Sidi Salah basin, particularly gully erosion and badlands constitute the main type of soil erosion that occurs in the clayey-silty soil sector. Thanks to this revolutionary technique of cesium 137, it was possible to quantify soil loss in the inter-gully sector.

However, this was not the case for the badlands sectors strongly affected by ravines and gullies in the middle courses of wadi Sidi Salah. That is why it is important to take a few simple steps to ensure a good result before choosing the isotopic technique at the catchment scale (Ni et al., 2017). Despite these limitations, the Cesium 137 is still an appropriate method for erosion study.

Due to its wide use in the analysis of environmental changes, Cesium 137 is regarded as being the most promising application to measure quantitative erosion of soil, providing new, continuously updated, information about the erosion process. A detailed study into soil loss needs more than one illustrative and standard approach. The phenomenon is a far more complex issue than commonly believed.

There is no single method that has been proven to be, alone, effective for quantifying soil erosion. In fact, various complementary methods and techniques should be used to do real field research and to achieve the objectives of the study. In fact, it was possible to compare the modelling results with the empirical ones through the USLE equation, that involves, among others, 6 factors: LS factor describing the slope, R factor which measures the rainstorm, K factor taking into consideration the soil erodibility index, C factor related to land use index and finally the P factor which includes all anti-erosion works in the basin (Figure 10).

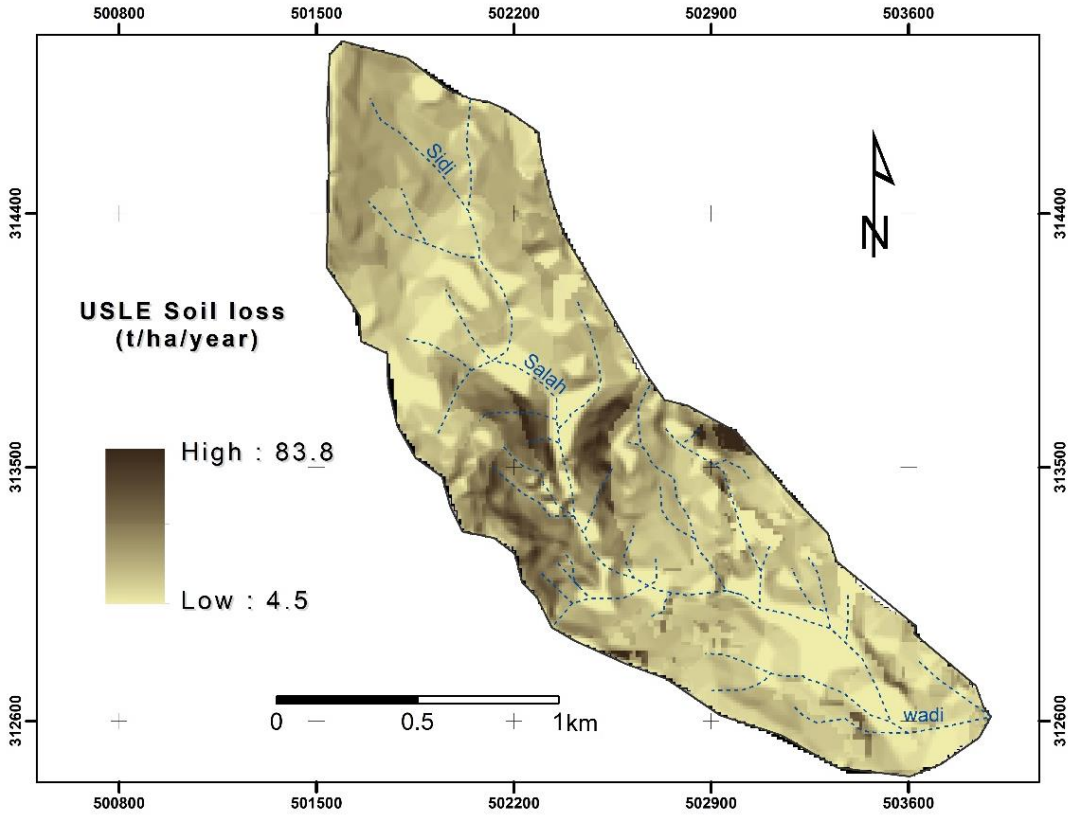

Figure 10: Soil loss in the Sidi Salah basin obtained by application to the USLE equation. Source: Results of modelling process under Arc Gis program.

This present research opens the way for the monitoring of the various actions taken against erosion, able to provide a sufficient environmental protection in Sidi Salah basin.

Until 2019, this watershed remained without any development, in particular, the absence of soft slope techniques and especially mechanical benches as the most widespread method of erosion control in the semi-arid area. It is the technique that is booming in the Maghreb countries, to the point that it has become the unique solution to tackle all forms of water erosion (Avenard, 1995; Nasri, 2002 and Roose, 2004).

However, this is not the case for this watershed in the central east of Tunisia. No total or partial retention benches were installed, only stream treatments with stepped gabions and gully head treatments with sills or dry-stone piles. This absence of benches on the mid-slope in the middle course wadi is reasonably justified by the predominance of clay and marl and the concentration of gypsum element in the soil. Under these conditions, the benches and heavy developments only worsen erosion rather than counteract it. Moreover, the most degraded slopes are south-facing, in other words, the hottest and driest. They are therefore the most suitable areas for the formation of crust which hinders infiltration and favours the concentration of runoff water and its overflow over benches.

Very quickly the latter will be subject to the opening of rills, breaches, gullies and then ravines if this process is combined with the opening of suffosion tunnels. All these areas will be transformed into Badlands territory as a phase of deterioration that cannot be reversed. Indeed, the strategy of the fight against erosion is not only the simple

technical operation of setting up certain soil conservation structures, but first of all it is necessary to build a good knowledge of the laws of nature before embarking on the application and falling into the choice of a badly designed and badly conceived development (Hamza, 1988; Nasri, 2002 and Azaiez, 2016 and 2020). The effort of local stakeholders must act directly on the factors responsible for the erosion dynamics. Benches are very expensive, in terms of both installation and maintenance, and yet they are not the miracle solution for all types of soil (Avenard, 1995). Sometimes simple structures, lighter and cheaper than benches, can ensure the stabilization of ravines either by biological treatment or treatment of watercourses by sills or dry stone piles.

Sometimes all three techniques can be used together, depending on the physical entity being studied. It is these last structures that have been adopted in the watershed of wadi Sidi Salah from the year 2013 (Figure 11), some of which have shown promising results in 2019 as shown in the Google Earth Pro images. A retention of sediment and water occurred behind the sills implanted on the course of some gullies, which favored the appearance of a dense riparian vegetation cover. Depending on the objectives of the anti-erosion strategy undertaken, local stakeholders can choose the plant species suitable for protecting the slopes. If the objective is to stop the concentration of runoff water and to minimize silting of downstream dams, it is recommended to choose repellent plant species that are less grazed by livestock to avoid the problem of overgrazing. In contrast, if the main objective is to stabilize slopes and improve degraded rangelands, in this case it would be necessary to plant species that are suitable for livestock grazing.

Figure 11: Treatment of watercourses by stepped gabion sills. Source: Google Earth Pro Image 2012 and 2015.

However, the success of the erosion control strategy remains dependent on the participation of the key partner, the farming community (Mabit et al., 1999, 2002 and 2008; Roose, 2004 and Fulajtar et al., 2017). However, it is also important to select

the suitable methods of tillage under semi-arid climate in order to preserve water and soil. The appropriate tillage practices and the making stubble decomposition in situ may increase the soil resistivity. Inversely, treating the soil to the minimum necessary should reduce water loss by evaporation, increase soil organic matter and its water retention power.

7. Conclusions

As a conclusion on the subject of water erosion, it turned out that the problem of soil degradation remains a topical issue that is difficult to study through a single method or a universal model that could be effective at different spatio-temporal levels. A first observation on the problem of erosion has been established through the present study, which has allowed the application of a modeling of sheet and rill erosion, also the sector appear to be slightly less affected by gully erosion over the last four decades through the Cesium 137 technique. It was found that land use, soil texture characteristics, rainfall intensity and topographic slope, especially the clear break in slope in the middle course, are the main indicators of erosion dynamics. The rate of loss varies considerably according to these factors, particularly the rate of vegetation cover. The results obtained constitute a first step in understanding the manifestation of erosion. Several comparative studies between isotopic and empiric methods (especially USLE and RUSLE models) have already been developed in Morocco to ensure the accuracy of the Cesium 137 outcome, especially those by Moukhchane, Bouhlassa and Bouaddi 1998, Sadiki 2005, Moukhchane 2008, Felah 2010 and Ben Mansour et al. 2012. Subsequently, some attempts and tentatives in the same direction have been made in Tunisia and Algeria by Toumi in 2013 and Azaiez in 2016. These efforts lead towards an easier future collaboration to adopt a regional approach to identify common quantitative and qualitative aspects of water erosion in Maghreb countries in the Mediterranean context. A second step is to make all experiences and results available to allow a promising collaboration with most Mediterranean countries in order to develop and implement an integrated regional strategy for addressing the erosion problem at Mediterranean scale. So, we have structures in place, but they require expansion and consolidation. In terms of validation of the modelling process in the present research, it was possible to compare the specific soil loss with that obtained by the empirical model of the universal equation USLE applied in the neighboring watershed of the Chaddad wadi, not far from Sidi Salah basin, where a maximum loss of 63 t/ha/year was recorded, calculated using the adjusted Universal Equation USLE (Azaiez, 2020). This comparison proves once again that regional erosion was controlled by the same factors (slope, soil texture, land use and a climate affected by extreme heat and dry periods).

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A SUSTAINABLE MANAGEMENT OF WATER AND SOIL: THE CASE OF RIVER CONTRACTS

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Abstract

Water and soil preservation represents a challenge for humanity, being part of the 17 Sustainable Development Goals envisaged in the UN 2030 Agenda. In particular, with regard to the theme of water, such Objectives emphasize the need to intervene to improve water quality by reducing pollution; protect and restore water-related ecosystems, including rivers and lakes; support and strengthen the participation of local communities in improving water management. In this perspective, the River Contract represents a voluntary bottom-up programming instrument aimed at the protection and management of water resources and the enhancement of river systems by integrating in a balanced manner the three dimensions of sustainable development: - economic, social and environmental. In fact, national and UE rules underline the relevance of the adoption of River Contracts as innovative governance instruments, since they are capable of building integrated strategies aimed at the redevelopment and management of the environmental and landscape quality of a river area through the involvement of the local whole community represented by public institutions, private subjects and citizens. In view of these brief considerations, this paper will address the analysis of different governance cases applied to the River Contracts as adopted in central and southern Italy to deal with the challenges of protecting and safeguarding river basins and their ecosystems.

1. Introduction

The preservation of water and soil represents a challenge for humanity that is part of the 17 Goals for Sustainable Development envisaged in the UN 2030 Agenda[1]. This one has revolutionized the approach to the theme of sustainable development by emphasizing the non-postponement of a mental and behavioral change in activating actions, both on a global and a local scale, through governances capable of activating

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[1] 2030 Agenda is the final document of the United Nations Summit on Sustainable Development, which took place in New York, USA, in September 2015. Underwritten by the Governments of the 193 UN member countries, it incorporates 17 Sustainable Development Goals into a broaden action program including a total of 169 "targets" or goals to be achieved by 2030.
For further information see: https://www.un.org/sustainabledevelopment/.

organizational and decision-making processes based on the principle of participation and co-responsibility in terms of *Community Led Local Development* (CLLD)[2].
Agenda 2030, in fact, addresses global issues that must necessarily be implemented through a local-global ("glocal") strategic vision. A "globalization bottom up" (Magnaghi, 2010): local networks in solidarity with each other that, as responsible for the whole planet earth, take the path of local (self) sustainable development. In this vision of sustainable development, the community (i.e. all the energies from civil society made up of public institutions, private entities and citizens) becomes an active part in public policies and in the conception and implementation of local-global development projects.
As we will see later, the River Contract (RC), introduced in Europe following the second World Water Forum (WWF)[3], represents a suitable voluntary instrument of strategic and negotiated planning as it is implemented by local communities that pursue the purpose of a correct management of water resources and the safeguarding from hydrogeological risk on a local scale, but which contributes to produce effects on a global one. It also represents a space for discussion capable of encouraging the dissemination of best practices and in which the involvement of local communities is not limited to the consultative and/or informative sphere alone, but rises to a process of reading of the territory and the environmental levels composing it, declining it according to its variegated *genius loci* (Norberg-Schulz, 1979).

2. Agenda 2030 and the Sustainable Development Goals

2030 Agenda addresses 17 Sustainable Development Goals (SDGs), including those relating to water resources and water-related eco-systems.
In particular, Goal 6 (*Ensure availability and sustainable management of water and sanitation for all*), provides for various Targets[4] aimed at reducing water pollution and at protecting and rehabilitating ecosystems linked to water (mountains, forests, wetlands, rivers and lakes), also through the support to forms of integrated participation of local communities.
Goal 15 (*Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss*), through Target 15.1 plans to ensure the preservation, restoration and the sustainable use of terrestrial and inland freshwater ecosystems and their services, especially of forests, swamps and mountains.

[2] The expression "*Community Led Local Development*" is used by the European Commission to describe a bottom-up approach in which, through a local partnership made up of public and private institutions, an integrated and innovative development strategy is developed and implemented.
For further information see: https://enrd.ec.europa.eu/leader-clld_it.
[3] The second WWF was held in The Hague in 2000. It was founded and is co-organized by the World Water Council (WWC), an international multi-stakeholder platform organization. The WWC, based in Marseille, France, was created in 1996. It has over 300 organizations from more than 50 different countries. Its mission is to raise awareness among public opinion and policy makers on crucial issues relating to water.
For further information see: http://www.worldwatercouncil.org/en.
[4] Target 6.5 "By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate"; Target 6.6 "By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes"; Target 6b "Support and strengthen the participation of local communities in improving water management".

Furthermore, through Target 15.9, it aims at integrating the principles of ecosystem and biodiversity into projects and strategies implemented at national and local level.
Directly linked to the potential actions to implement through the RC, Goal 14 (*Conserve and sustainably use the oceans, seas and marine resources for sustainable development*), through its Targets aims at reducing the pollution of marine and coastal ecosystems significantly, also intervening in activities carried out on land such as industrial discharges and plastic waste.
Other issues affecting RCs and addressed by Agenda 2030 concern urbanization and models of consumption and production of goods: on the issue of urbanization, Goal 11 addresses the problem of "*making cities and human settlements inclusive, safe, resilient and sustainable*" by supporting the economic, social and environmental links between urban, peri-urban and rural areas, and by strengthening local integrated policies for soil protection and territorial regeneration[5]; with regard to the issue of production and consumption models, Goal 12 aims to disseminate the adoption of an environmentally friendly approach by increasing people's awareness on issues related to sustainable development[6].
As we will see, the RC represents the appropriate instrument to respond to the objectives of sustainable development: it guarantees that local planning is consistent with the purposes dealt with by Agenda 2030 as it assimilates the principles of democratic participation in decisions and the themes of sustainable development.
On the other hand, for the RC Agenda 2030 represents the essential document since the latter aims also at "encouraging and promoting effective partnerships in the public sector, between public and private sectors and in civil society, based on the experience of partnerships and their ability to find resources"[7].
The importance of a territorial governance capable of raising awareness and involving local communities in environmental issues, and in particular in those related to water environments, is also emphasized in the works of the WWF. It is therefore recognized that not only an institutional but also a cultural effort is needed to (1) raise awareness and promote agreements between public institutions and public and private partnerships, as well as (2) clearly define and formalize all players' roles through the contract: an agreement with clear objectives, mutual commitments and a clear differentiation of the respective roles, tasks and responsibilities between the Authorities and each of its public and private operators.
For the resolution of the problems addressed by 2030 Agenda's Goals, and in particular for those relating to local water services, water infrastructures and the ecosystem, therefore, it is necessary to implement political strategies capable of spreading information, transparency and trust, in order to feed the responsibility of stakeholders, at all levels, towards the issues of sustainable development and in an overall global vision.

[5] Target 11a "Support positive economic, social and environmental links between urban, per-urban and rural areas by strengthening national and regional development planning"; Target 11b "By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels".
[6] Target 12.8 "By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature".
[7] 2030 Agenda, Goal 17 - Target 17.17.

Such approach, which stimulates the implementation of effective policies at all levels, is also referred to in the document "*Revitalizing IWRM for the 2030 Agenda*" (Smith M. et al., 2018), according to which strategies for disseminating culture of participation and empowerment are necessary, in order to manage the change locally and globally[8].

3. River Contracts in Italy: experiences of governance

In Italy the instrument of the RC began its institutional path in 2007 with the establishment, between Regions of northern Italy, of the "National Table of the River Contracts" and with the subsequent adoption, in 2010, of the "National Chart of the River Contracts" as a response to the need to "provide" the single territories with governance capable of promoting the environmental and landscape requalification of river territories through actions of prevention, mitigation and monitoring of hydrogeological, pollution and landscape/naturalistic emergencies, in line with the "Water Framework Directive" (2000/60/EC) and the "Flood Directive" (2007/60/EC)[9].

In 2015, the RC obtained legal recognition by the "Codice dell'Ambiente" (Environmental Code)[10] as, also on the basis of European experiences, it is considered the suitable instrument for the integrated management of river basins, when it is managed by an inclusive and collaborative governance (multi-stakeholder) able to face and combine objectives and processes at different decision-making scales (multi-level). In fact, while not providing information on the legal nature of RCs, the above-mentioned Environmental Code introduces the characterizing elements: it is a voluntary agreement of strategic and negotiated planning that contributes to the implementation of planning instruments for the purposes of protection, proper water management and territorial enhancement, thus contributing to local development.

In 2017, the Ministry of the Environment (MATTM) established the "National Observatory of the River Contracts", aimed both at monitoring RCs on the Italian territory and at disseminating best practices by promoting collaborations and experiences.

The subsequent growing diffusion of RCs in Italy has highlighted the need to harmonize their operating methods while leaving the needs and peculiarities of the individual territories unchanged. For this purpose, within the "National Table of the River Contracts", the document "*Definizione e requisiti qualitativi di base dei contratti di fiume*" (Definition and basic qualitative requirements of river contracts) was prepared, according to which RCs are "*voluntary instruments of strategic and negotiated planning that pursue protection, proper management of water resources*

[8] https://www.worldwatercouncil.org/en/publications/revitalizing-iwrm-2030-agenda.

[9] Directive 2000/60/EC of the European Parliament and of the Council, of 23 October 2000, establishing a "framework for Community action in the field of water policy";
(https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32000L0060);
Directive 2007/60/EC of the European Parliament and of the Council, of 23 October 2007, "on the assessment and management of flood risks"
(https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32007L0060).

[10] Legislative Decree n.152/2006, article 68bis: "*River contracts contribute to the definition and implementation of district planning instruments at the river basin and sub-basin level, as voluntary strategic and negotiated planning instruments that pursue the protection, the correct management of water resources and the enhancement of river territories, together with safeguarding from hydraulic risk, thus contributing to the local development of that areas*".

and enhancement of river territories together with safeguarding from hydraulic risk, contributing to local development"[11].
The document identifies the operating methods of RCs as different and consequential phases: a) activation of open and inclusive participatory processes that allow the sharing of intentions, commitments and responsibilities to be formalized with the signing of the "Document of Intent" from the various stakeholders; b) drafting of the Preliminary and Integrated Cognitive Analysis on the environmental, social and economic features of the territory with the definition of operational objectives; c) elaboration of the "Strategic Document", which defines the scenario, referring to a medium-long term time future, which integrates the objectives of district planning and more generally of a wide area, with the local development policies of the territory; d) definition and adoption of the "Action Plan", which indicates the players involved, their respective obligations and commitments, times and methods of implementation, the human and economic resources needed, as well as the related financial availability for the signing of the RC and the related formal and binding assumption of obligations and commitments by all contracting parties.

3.1. The River Contract of the Ofanto River: an experience of interregional integration

The 134 km long Ofanto River originates in the Campania Region, in the Province of Avellino, from the Irpino plateau at 715 meters above sea level. It affects a vast territory, made up of 51 Municipalities, and crosses the Basilicata Region and the Puglia Region too, flowing into the Adriatic Sea[12]. It represents an interesting example of integration between two different RCs: Alto Ofanto and Medio e Basso Ofanto.
In the Campania Region, the RC was born on the initiative of the Local Action Group (LAG) "CILSI" which included in its "Local Development Plan" the instrument of the RC "Alto Ofanto", thus starting the partnership construction process that led, in 2015, to the signing of the "Document of Intent" by 19 Municipalities in the Province of Avellino[13].

[11] The document was drawn up in 2015 by the "Working Group 1": *Recognition of RCs at a national and regional scale, definition of quality criteria*, of the National Table of River Contracts. Ministero dell'ambiente e della tutela del territorio e del Mare (MATTM) - Ministry of the Environment and Land and Sea Protection -, Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA) - Higher Institute for Environmental Protection and Research - and National Table of River Contracts.
[12] In 2013 the Campania Region subscribed to the National Charter of RCs through the Regional Board Resolution no. 452/2013. In 2019 it disciplined the River and Lake Contracts by the Regional Law no. 5 of 06 May 2019. In the Campania Region three RCs have been activated: RC Alto Ofanto; RC Alto Calore; RC Sarno.
The Puglia Region subscribed to the National Charter of the RCs in 2017 also establishing the "Permanent Regional Technical Coordination Table" through the Regional Board Resolution no. 1788/2019.
The Basilicata Region adopted the National Charter of RCs in 2012. With Regional Board Resolution no.702/2016, it allocated financial resources to support the preparation of the RCs, and recognized RCs as negotiated programming instruments. Subsequently, with Regional Board Resolution n.213/2017, the Basilicata Region assigned a support function to the Basin Authority in order to make its know-how available to RCs in the fields of flood prevention and water resource planning.
[13] Local Action Groups (LAGs) are public-private, local partnerships that implement the strategies of rural areas through the development of a Local Development Plan. They operate as managers of the UE "LEADER"(*Liason Entre Actions de Development de l'Economie Rurale*) Funds of the European

In the Puglia Region, the RC "Bassa e Media Valle dell'Ofanto", consisting of a large public-private partnership, developed a Document of Intent which clearly states both the will for cooperation with the already operating RC "Alto Ofanto", and the need to overcome "old logics" and territorial schemes based on provincial and/or regional borders, in the full epistemological application of sustainable and integrated bottom-up development: "*the specific circumstance that considers the presence of an initiative of the River Contract of the Alto Ofanto river already consolidated, imposes cooperative approaches that guarantee procedural autonomy by the two Contracts, in compliance with the requests from the "bottom" (prerogative of RCs) while sharing the need to identify bioregional actions or actions competing with higher-ranking objectives in its Plans, in compliance with the prerogatives of coordination entrusted to the same District Basin Authority. The territorial system of the RC (...) therefore has the clear purpose of overcoming the vision of the Ofanto river as an administrative border between two Regions, (Puglia and Basilicata), but rather to integrate the structural, environmental, ecological and hydrographic characteristics, but also historical-cultural of the territories affected and influenced by the river system*" [14].

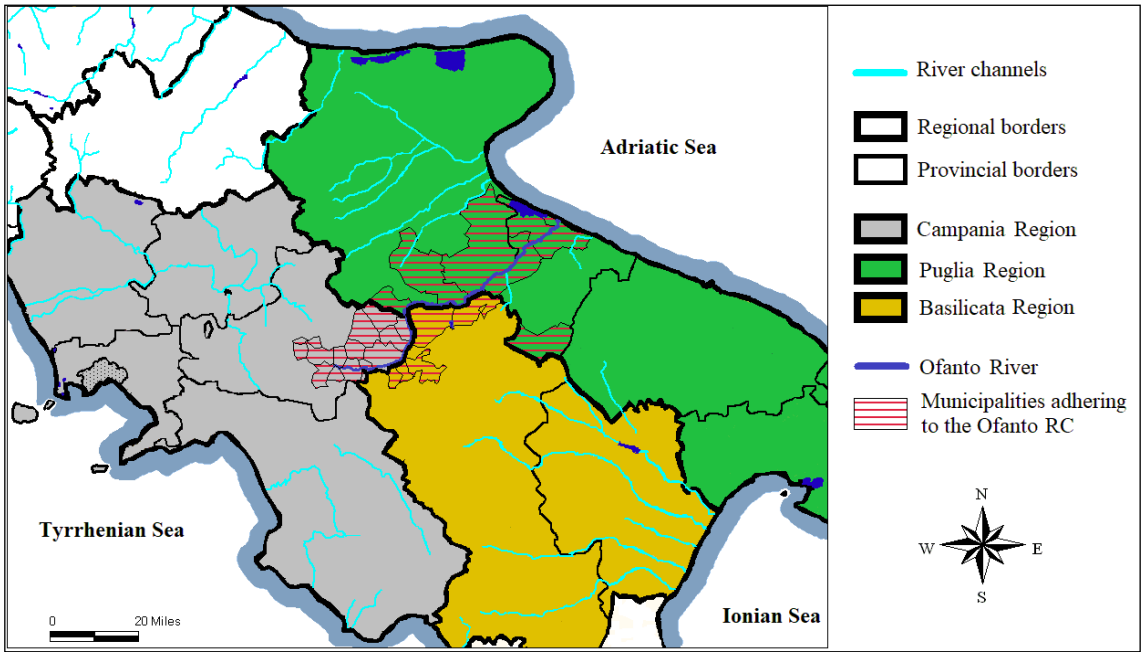

Figure 1: River Contract of the Ofanto River. Source: Our elaboration.

As for the governance profile of the RC, this is composed of (1) the Assembly, made up of 64 public and private subjects, including the Puglia Region, the Polytechnic University of Bari, the University of Basilicata, 16 Municipalities and other stakeholders; (2) the Technical-Scientific Coordination Committee with functions of executive body, composed, among others, by the Basin Authority, the Puglia Region,

Agricultural Fund for Rural Development (EAFRD), through the *Community-Led Local Development* (CLLD) methodology.
For further information see: https://enrd.ec.europa.eu/leader-clld_en.
[14] Document of Intent of the RC "Bassa e Media Valle dell'Ofanto": https://www.cdfbassamediavalleofanto.it/documenti/.

ISPRA, University; (3) the Technical Secretariat managed by the Agency of the Territorial Pact for Employment Nord Barese Ofantino.
For both RCs, the main impulse came in 2014 following the agreement called "Val d'Ofanto Pact: a Manifesto for interregional sustainable development of Valle d'Ofanto in the European 2014-2020 programming"[15], aimed at implementing a sustainable development on a bioregional scale by building "synergies between the Ecological Network and the Economic Network of the production chains". The agreement was signed by many public entities and stakeholders from the three regions concerned, including three LAGs[16].

3.2. Marche Region: the Esino River Contract

In 2014 the Marche Region recognized RCs as "forms of negotiated and participatory strategic planning for the purpose of environmental redevelopment and the reduction of the hydraulic risk of regional river basins", adhering to the National Charter of RCs. In 2016, it also established the "Regional Permanent Technical Table for the Coordination of River Contracts"[17].
With the establishment of the Regional Technical Table, first actions for the dissemination of the practice of CLLD in local communities were launched through the preparation of "*guidance and guideline documents for the homogeneous development of governance and implementation paths of RCs*". Furthermore, the objectives of the Regional Technical Table include those to organize awareness-raising seminars on environmental issues and sustainable development, as well as to launch project-ideas for other communication initiatives addressed civil society and public institutions.
In addition to the representatives of the Marche Region, the Regional Technical Table is composed of environmental protection associations, the LAGs operating in the Region, the National Association of Italian Municipalities (ANCI), the Regional Reclamation Consortium and other stakeholders.
The activities of the Regional Technical Table and the impetus of local communities have allowed the launch of 12 RCs in the regional territory[18].

[15] http://www.galvulturealtobradano.it/maggio14/manifesto.pdf.
[16] The following have subscribed to the "Val d'Ofanto Pact": the Province of Barletta-Andria-Trani; the Municipalities of Aquilonia, Andretta, Bisaccia, Cairano, Calitri, Conza della Campania, Lacedonia, Lioni, Monteverde, Morra De Sanctis, Rocca San Felice, Sant'Angelo dei Lombardi, Teora, Torella dei Lombardi, Villamaina in the Province of Avellino; the Municipalities of Ascoli Satriano, Cerignola, Rocchetta Sant'Antonio in the Province of Foggia; the Municipalities of Atella, Lavello, Melfi, Rapone, Ruvo del Monte in the Province of Potenza; the Municipalities of Barletta, Canosa di Puglia, Margherita di Savoia, Spinazzola, Trinitapoli in the Province of Barletta; the intermunicipal Consortium CO.-RIT. of Avellino; the Territorial Agency for the Environment of Barletta; the Puglia Regional Union of Reclamations; the Regional Union of Campania Reclamations; the Regional Natural Park of the Ofanto River; the University of Bari; the LAG "CILSI"; the LAG "Piana del Tavoliere"; the LAG "Vulture-Alto Bradano" and other stakeholders.
[17] Regional Board Resolutions no.1470/2014 and no.217/2016.
[18] Foglia RC; Metauro e Torrente Arzilla RC; Biscubio, Bosso, Burano e Candigliano RC; Cesano RC; Misa-Nevola RC; Esino RC; Musone RC; Potenza RC; Fiastrone e Lago di Fiastra RC; Aso RC; Tesino RC; Zona Umida della Sentina RC.

3.2.1. The Esino River Contract

The Esino River originates from Monte Cafaggio, in the Province of Macerata, and flows south north for a length of about 90 km, flowing into the Adriatic Sea near the Municipality of Falconara Marittima.
In addition to the Marche Region, the Province of Ancona, 24 Municipalities, managing bodies of protected natural areas and other public and private stakeholders[19] subscribed the Esino RC by signing the "Document of Intent". The “Document of Intent” emphasizes the role of the local community both as a “guarantor” of continuous control and monitoring on the territory, and as an active subject in planning actions to be undertaken.
The governance is composed of (1) the Assembly, in which all the subscribers of the “Document of Intent” (public institutions, companies, associations, citizens) participate; (2) the Institutionl Technical Committee, composed of 3 Municipalities, the Marche Region, the Province of Ancona, the Consortium of Reclamation, the LAG “Colli Esini San Vicino”, the Ripa Bianca Natural Reserve. The technical feature of the RC is handled by (3) the Secretariat Committee managed by the Municipality of Jesi and the Ripa Bianca Natural Reserve.
In line with the guidelines of the quoted document "*Definition and basic qualitative requirements of river contracts*" for the Esino RC, in addition to (a) the signing of the "Document of Intent", the phases relating (b) to the Preliminary and Integrated Cognitive Analysis and (c) the preparation of the Strategic Document functional to (d) the drafting of the Action Plan, were activated.
As regards the dissemination of information and the co-responsibility of the local community, information brochures and cognitive questionnaires were distributed. In addition, "thematic workshops of SWOT analysis" were organized on the subject of both the quality of water, the river ecosystem and the hydraulic risk, as well as the landscape, the urban development planning and the use and economic development of the river area[20].
Finally, the role of the LAG “Colli Esini San Vicino” assumes considerable importance in the implementation of plans and programs of the RC, since, together with the participating Municipalities and the Consortium of Reclamation, it also plays the role of “potential moneylender”. However, as for most of the Regions, even in the Marche Region the 2014-2020 programming of the European Funds did not provide for “reward” mechanisms for RCs. In particular, the incisiveness of LAGs in the role of “potential” provider of funding for the interventions provided for in the Action Plans of RCs has been lost due to the lack of harmonization between the EAFRD European program and the national and regional regulations on RCs. However, the role of LAGs remains relevant within RCs both for the “technical structure” they have, and for the ability to activate bottom-up processes in a CLLD key.

[19] The following have subscribed: (1) the Marche Region; (2) the Province of Ancona; (3) the Municipalities of Agugliano, Camerata Picena, Castelbellino, Castelpiano, Cerreto d’Esi, Chiaravalle, Cupramontana, Esanatoglia, Fabriano, Falconara Marittima, Genga, Maiolati Spontini, Matelica, Mergo, Monsano, Montecarotto, Monte Roberto, Rosora, Santa Maria Nuova, San Paolo di Jesi, Sassoferrato, Serra San Quirico, Staffolo, Jesi; (4) the Gola Rossa and Frasassi Regional Park; (5) the Ripa Bianca Natural Reserve; (6) the Consortium of Reclamation; (7) the LAG “Colli Esini-San Vicino”; (8) private entities and associations.
[20] For further information see: Bastiani M. et al. (2018);
https://www.comune.jesi.an.it/articoli/Analisi-conoscitiva-preliminare-integrata/.

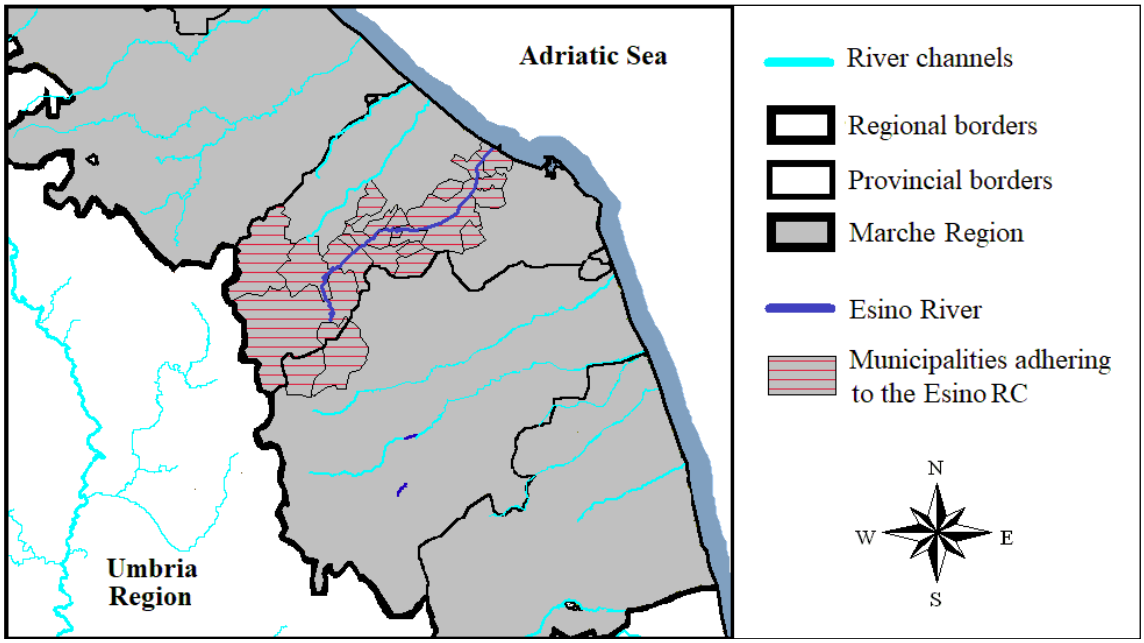

Figure 2: Esino River Contract. Source: Our elaboration.

3.3. River Contracts in Lazio Region: some experiences

In Lazio Region, the instrument of the RC starts in 2014 with the subscription of the National Charter of RCs[21]. In 2016, through the Regional Law no. 17, the Lazio Region recognized the "River, Lake, Coast and Mouth Contract" as a "*voluntary instrument for strategic and participated planning, aimed at the integrated management of the river basin and sub-basin policies, together with the protection, enhancement and redevelopment of water resources and connected environments, the protection from hydraulic risk, the sustainable management of naturalness and the river landscape and hydrogeological risk, capable to contribute to local development*"[22].
In 2018, in order to arrange the governance of RCs, the Lazio Region established a specific office dealing with small Municipalities and river contracts ("*Ufficio di Scopo Piccoli Comuni e Contratti di Fiume*") having the task of the operational management of regional RCs while, in 2019, the "Regional Forum of River, Lake, Mouth and Coast Contracts", consisting of representatives of different RCs, and the "Technical Committee" – composed of, among others, the representatives of the Regional Civil Protection Agency, the Regional Agency for Environmental Protection of Lazio, the District Basin Authority of Central Apennines and the District Basin Authority of Southern Apennines[23] – were activated. The Technical Committee has the task of coordinating the different RCs and, in particular, of harmonizing and making regional policies consistent with the European ones on the subject of sustainable development. In order to support the establishment of RCs and to spread interest in the local community on sustainable development issues, in 2019 the Region launched a call to finance the various phases of RCs subscription process and make them fully

[21] Regional Board Resolution no.787/2014 "Adhesion to the National Charter of River Contracts".
[22] Regional Law no.17 of 31 December 2016, article 3 paragraphs 95-96-97.
[23] Regional Board Resolution no.335/2019.

enforceable[24]. In particular, 19 RCs[25] were funded for the phases following the subscription of the "Document of Intent": - for the drafting of the Preliminary and Integrated Cognitive Analysis on environmental, social and economic aspects; - for the development of the Strategic Document; - for the definition and adoption of the Action Plan.

3.3.1. The Melfa River Contract

The Melfa River is located in the Lazio Region, in the southeast of the Province of Frosinone. It originates from Monte Petroso in the Canneto Valley in the Municipality of Settefrati, on the Lazio side of the Abruzzo, Lazio and Molise National Park. In its 40 km course it crosses the mainly rural area of the Municipalities of Picinisco, San Biagio Saracinisco, Villa Latina, Atina, Casalvieri, Casalattico, Colle San Magno, Arpino, Santopadre, Roccasecca, flowing into the Liri River.
The catchment area is an element of interest in the regional territory due to its environmental and biodiversity characteristics, with a significant presence of Park Areas, Sites of Community Importance (SCIs), Special Protection Areas (SPAs) and Wilderness Areas[26].
In 2017, implementation phases of Melfa RC were launched through territorial animation activities that saw the participation of numerous stakeholders: 11 Municipalities of the river basin, the University of Cassino and various local associations. The Lazio Region and the Liri-Garigliano and Volturno River Basin Authority were also involved in the preparatory activities for the subscription of the "Document of Intent".
The governance is composed of (1) the Assembly, which includes all the participating stakeholders, and (2) the "Control Room", whose coordination has been entrusted to the association "Agen.Pa", as promoter of the initiative[27].
The "Control Room" started the animation path in the inclusive and accountability of the local community logic and the definition of the main Catalyst Topics: safeguard of the territory; enhancement of the environmental and cultural heritage; sustainable development.
Currently the Catalyst Topics are the subject of meetings, Focus Groups and thematic tables aimed at sensitizing the local community in the logic of (self)sustainable development through the conception of bottom-up projects capable of protecting all environmental and cultural resources of the rural area, including some aimed at

[24] Regional Board Resolution no.337/2019.
[25] Almone RC; Amaseno RC; Aniene RC; Arrone RC; Cosa RC; Farfa RC; Fibreno RC; Garigliano-basso Liri RC; Media Valle del Tevere RC; Melfa RC; Paglia RC; Sacco RC; Santa Croce Capo d'Acqua RC; Tevere da Castel Giubileo alla Foce RC; Ufente RC; Agro Pontino Coast Contract; Riviera di Ulisse Foce del Garigliano Coast Contract; Lago Bracciano Martignano Lake Contract; Bolsena Marta Tarquinia Lake, River and Coast Contract.
[26] SCI "Gole del Fiume Melfa" IT6050027; SCI "Val Canneto" IT6050020; SCI "Abruzzo, Lazio and Molise National Park" IT 7120132. For further information see, among others, Grossi G., Polsinelli V. (2019).
[27] The following have subscribed the Melfa RC: the Municipalities of Settefrati, Arpino, Casalvieri, Casalattico, Colle San Magno, Roccasecca, Santopadre, San Biagio Saracinisco San Donato Val di Comino, Villa Latina, Atina; the Association of Architects, Planners, Landscapers and Conservators of the Province of Frosinone; Acqua Filette srl; the associations Agen.PA, Italian Alpine Club (CAI), CICAS Frosinone, Vivinatura; the Civil Protection Unit of Atina, the Comino Valley Tourist Association, the Melfa River Protection and Safeguard Committee.

intervening on: the restoration of the minimum vital flow of the river; the sustainable management of the hydroelectric plans; the enhancement of the river through the creation of a green road system for "slow tourism" and naturalistic sports; the conservation of biodiversity and territorial identity; the protection of typical local products. The thematic tables are multidisciplinary and include university researchers, designers, landscapers, engineers and representatives of citizens' associations.
At present, in addition to the subscription of the "Document of Intent" and territorial animation activities, first phases of analysis, study and development of the Strategic Document by the technical-scientific group are underway.

3.3.2. The Garigliano-basso Liri River Contract

The Garigliano River originates at the point of confluence with the Liri River, in the Municipality of Sant'Ambrogio sul Garigliano, in the Province of Frosinone, and extends for 38 km to its mouth in the Tyrrhenian Sea, in the territory of the Municipality of Minturno, in the Province of Latina, marking the border between the Lazio and the Campania Regions. Three rivers contribute to its basin, the Sacco, the Liri and the Gari rivers. The territorial area in which it flows is mainly rural and with a high presence of Park Areas, Special Protection Areas (SPAs) and the final section is identified as Sites of Community Importance (SCI) [28].
The development process of the "Garigliano - Basso Liri" RC began in 2016 through the coordination and territorial animation activities carried out by the local association Agen.PA and supported by the LAG "Aurunci and Valle dei Santi". Following the first Forum "The waterways and the mills", the first Organizing Committee was set up, consisting of 4 local associations, the LAG and 14 Municipalities belonging to the catchment area[29].
Its governance is composed of (1) the Assembly of the members and (2) a "Control Room" whose coordination is entrusted to the association Agen.PA as promoter of the initiative.
The instrument of the RC was included in the Local Development Plan of the LAG among the catalyst topics of local development and was subsequently adopted by all the Municipalities of the territory within the "Area Plan": a voluntary development document which provides for shared planning of interventions and actions among all Municipalities, in the medium term and from the wide area perspective[30].
The approach to the integrated planning of actions, as is evident with the adoption of the Area Plan, represents an indicator of the maturity of the territory in question not only because of the sharing of actions and interventions having the capacity to have an economic and social impact on large territories compared to municipal ones, in a vision of "wide area", but also due to the adoption of an intervention practice based on participatory planning capable of elaborating multi-dimensional and interdisciplinary

[28] SCI "Fiume Garigliano (final section)" IT6040025.
[29] The following subscribed the "Garigliano - basso Liri" RC: the Municipalities of Pignataro Interamna, San Giorgio a Liri, Sant'Apollinare, Sant'Ambrogio sul Garigliano, Sant'Andrea del Garigliano, Vallemaio, Ausonia, Coreno Ausonio, Esperia, Castelnuovo Parano in the Province of Frosinone; the Municipalities of Spigno Saturnia, Castelforte, Santi Cosma and Damiano, Minturno in the Province of Latina; the LAG Aurunci and Valle dei Santi; the Association of Architects, Planners, Landscapers and Conservators of the Province of Frosinone; Acqua Filette srl; the associations Agen.PA, Italian Alpine Club, CICAS Latina, CICAS Frosinone, Vivinatura, Guardian and Care.
[30] For further information see: Grossi G. (2019).

projects and interventions with the possibility of intercepting different public funds. Also in this case, in fact, as in the "Ofanto" and "Esino" RCs, the role of the LAG is significant and shows its relevance above all in the dissemination of good practices of consultation and cooperation, both in the multi-stakeholder and multi level logic, and in the functional integration between plans, projects and European funds.
The sharing of the RC instrument in strategic area plans and projects activated by the Municipalities within the Local Development Plan of the LAG testifies that the territory at issue is made up of local players aware of having to "overcome the logic of the emergency" by activating integrated and widely shared policies that see the environment and the territorial sustainability at the center of local development choices, in the logic of the CLLD.

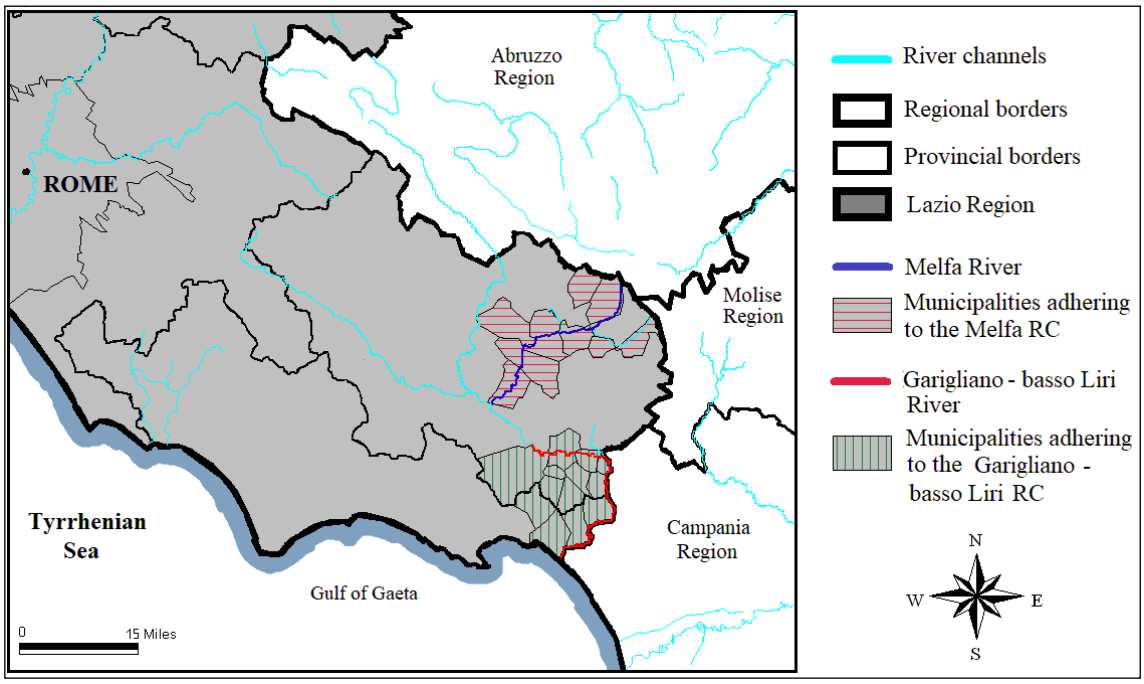

Figure 3: "Melfa" and "Garigliano - basso Liri" River Contracts. Source: Our elaboration.

3.3.3. The Tevere River

The Tevere is the main river in central Italy. It extends for 405 km from Monte Fumaiolo (in the Province of Forlì-Cesena in Emilia Romagna Region) and runs through a large stretch in the Lazio Territory until it reaches its mouth in the Tyrrhenian Sea, between the Municipalities of Rome and Fiumicino.
In Lazio Region there are two RCs that affect the Tevere River: (1) "Tevere da Castel Giubileo alla foce - tratto urbano" RC, which mainly affects the urban stretch in the city of Rome up to the mouth; (2) "Media Valle del Tevere da Orte alla Riserva Tevere-Farfa" RC which affects the Lazio (and partly Umbria) section of the route of Tevere up to the gates of Rome.
These are two RCs moving their activities on a main common objective linked to the revitalization of the ecological passageway of the Tevere River, not only in an environmental key but also in terms of value for local development, while operating in different territorial contexts: the "Media Valle del Tevere" RC, mainly rural and

with widespread presence of SCIs and SPAs[31], and the mainly urban-metropolitan "Tevere – tratto urbano" RC.

As regards the "Tevere da Castel Giubileo alla foce - tratto urbano" RC, in addition to the Municipalities of Rome and Fiumicino, in 2017 Agenda Tevere Onlus - which associates different other associations operating in the environmental and social field, Universities and Research Institutes - subscribed the "Document of Intent"[32]. This one debates the problems affecting the river channel as well as the objectives and the actions to be implemented both for environmental protection and for ecological-urban enhancement, considering that the Tevere River is the main ecological passageway of the City of Rome.

The governance is constituted by (1) the Assembly, currently consisting of 54 subscribers of the "Document of Intent", (2) the "Inter Institutional Committee" with the function of guidance and programming, (3) the Technical Secretariat with the job of study, research and insights for the development of analysis and document preparation. The phases relating to the preliminary and integrated cognitive analysis and the preparation of the Strategic Document, functional to the drafting of the subsequent Action Plan, are currently underway. As regards the dissemination of information and the co-responsibility of the local community, numerous stakeholders were involved, mainly consisting of associations operating in the field of environmental safeguard and river enhancement[33].

As regards the "Media Valle del Tevere da Orte alla Riserva Tevere-Farfa" RC, the process of establishment was born in 2013 by 11 Municipalities and the following subscription of the "Document of Intent" by the Regional Agency for Environmental Protection of Lazio, the Biodistrict of "Via Amerina e delle Forre", 15 environmentalist and representatives of citizens associations, and other stakeholders[34]. The RC is operating in the analysis and study activities, having organized three Focus Groups on land use and water and heritage, and having entered into agreements with some Research Institutions: the National Research Council; the Institute for Technologies Applied to Cultural Heritage of the National Research Council; the Department of Engineering, ICT and technologies for energy and transport.

The governance's structure is articulated in (1) the Assembly of River Basin, made up of all members, (2) the Institutional Technical Committee, with coordination functions, (3) the Technical Secretariat.

Both RCs discussed in this contribution address the challenge of activating a process of re-appropriation by the local community of the important ecological passageway

[31] The territory of the "Media Valle del Tevere" RC is affected by the Natura 2000 Area "Riserva naturale Tevere-Farfa" - IT6030012.

[32] Among the underwriters of the "Tevere – tratto urbano" RC, there are Municipalities I, II, III, VII of the City of Rome, the Municipality of Fiumicino, Rome Capital City, Rome Metropolitan City, the Special Archaeological Superintendence of Fine Arts and Landscape of Rome, the Central Apennines District Authority, the Port Authority of Rome, the Regional Agency for Environmental Protection of Lazio, the National Research Council, the University of Rome La Sapienza, the University of Rome Tre, the National Urban Planning Institute, 37 private stakeholders.

[33] For further information see: http://www.agendatevere.org/contratto-di-fiume/; Galassi A. et al. (2020).

[34] The following subscribed the "Media Valle del Tevere" RC: the Municipalities of Orte, Gallese and Civita Castellana (in the Province of Viterbo), Torrita Tiberina (in the Province of Rome), Magliano Sabina, Collevecchio, Stimigliano, Forano, Poggio Mirteto, Montopoli in Sabina (in the Province of Rieti), the Municipality of Otricoli (in the Province of Terni in the Umbria Region).

represented by the Tevere River through the restoration of the relationship between the river and the city. To this end, the role of RCs is also fundamental in generating a patrimony of knowledge, awareness and responsibility in the communities and, in particular, with regard to aspects related to the "anthropized" environment. Such challenge (especially in the "Tevere – tratto urbano" RC) is addressed through Forums and Focus Groups, in order to catalyze the attention of a wide audience of players and stakeholders to environmental and sustainable development issues in urban-metropolitan contexts, within a system that integrates sustainable development policies and urban planning instruments.

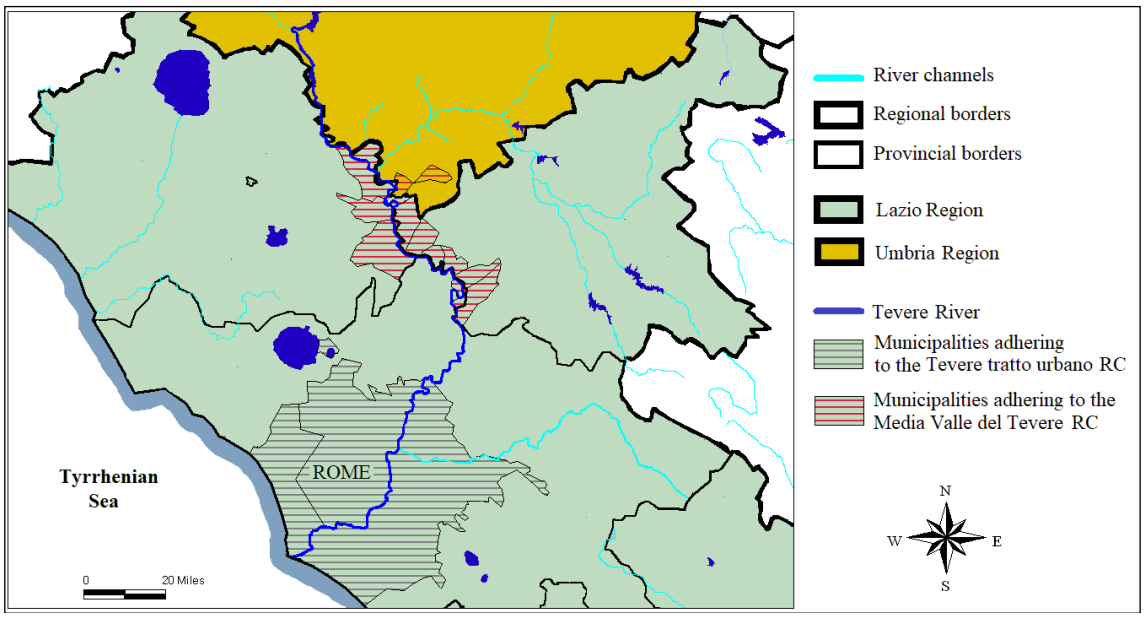

Figure 4: "Tevere tratto urbano" and "Media Valle del Tevere" River Contracts. Our elaboration.

4. Conclusions

This contribution stems from the awareness that it is no longer possible to consider water only as a commodity to protect but that, on the contrary, it must be conceived as an attractor of new economic, environmental and social opportunities, on a local and global scale. Water conservation, the protection, safeguarding and conservation of river basins and their ecosystems and the reduction of pollution represent, in fact, a global challenge whose themes are included among the main Sustainable Development Goals of the UN Agenda 2030. In Italy, as in other countries, the challenges of Agenda 2030 are faced through integrated local development policies whose prevailing operating model, represented by the RCs, is operating above all in territories where there is the "awareness of places" meant as awareness of the importance of the protection of common goods: environment, landscape, culture, knowledge, etc.
In this paper we represented some experiences related to the RCs activated in central-southern Italy that, in general, show local communities with a strong sense of collective responsibility with respect to sustainable development issues and which, in many cases, recognize in the hydrographic basin the matrix of one's own cultural identity. The collective responsibility demonstrated in the territories in question facilitates (and feeds) the behaviors of participation and co-responsibility in the

conception and implementation of local-global sustainable development projects to be activated through the RCs. Even with their peculiarities and differences, the RCs discussed show adherence to the principles of democratic participation in decisions as not only is the role of local communities within the process of establishing governance well defined, but also highlight the commitment made in the actions of territorial awareness, in the transparency of decisions, in the dissemination of information among the stakeholders, thus feeding the climate of trust. The RCs also show a good degree of participation and inclusion in governance and implementation processes, measurable, as seen, both through the variety of adhering subjects - such as Local Institutions, Universities, Economic Public Bodies, Citizens' Associations, representatives of private interests, Local Action Groups, etc. -, both through the technical-scientific quality of the Technical Committees, mainly composed of professionals, university researchers, etc.

We should also underline that the RC represents a strategic and negotiated programming instrument in which the voluntary nature of the development process, compared to the "induced" one, is emphasized. In other words, the RCs show the peculiarity of the spontaneous mobilization of local players, also as this is aimed at providing a contribution in achieving the global goals of sustainable development.

This aspect introduces the long-debated problem of financial support to the RCs, both with regard to the process of constitution and territorial cognitive analysis, and with regard to territorial animation actions and dissemination of information, and with respect to the implementation/realization of the interventions included in their Action Plans.

Among the intrinsic purposes of the RC (as well as for any local development strategy), in fact, it is important to intercept the necessary funding to be allocated to the implementation of the interventions, especially given the known scarcity of the allocation of the Local Institutions that (remember) represent the basis of the governance of bottom-up policies. Financial resources, therefore, constitute a variable necessary to achieve the governance objectives and on which the stability of the agreement process and the active role of the local community depend.

Therefore, legislative intervention on a national and/or community scale for the definition of funding instruments in favour of RCs is no longer postponed, also in order not to frustrate the efforts of local cooperation in contributing to the global challenges of sustainable development.

In this sense, an initial response has come, among those examined, by Basilicata and Lazio Regions, which, with a special public Call, granted the Local Institutions financial support for the preparatory phases for the establishing of RCs, from the drafting of the Document of Intent until the definition of the Action Plan. However, with regard to the implementation of the interventions envisaged in the Action Plans, there is a significant lack of information in the resolution of a specific allocation of national funding and a fragmented regulatory nature on the part of the Regions.

The European "Multifund CLLD" Programs, activated with the 2014-2020 programming, could have represented the natural financing instrument for the RCs interventions as: (1) their functioning moves within the logic of CLLD; (2) provide for the activation of projects related to interventions capable of operating on different themes (environment, culture, tourism, etc.); (3) contribute to implementing the local

development strategy through access to funds from the ERDF, the ESF, the EAFRD, the EMFF[35].

However, in Italy, in the 2014-2020 programming, the ERDF-ESF Multi-Fund Programs were activated only by three Regions: Puglia, Calabria and Molise. The EAFRD- ERDF Multifund CLLD was considered only by the Sicily Region, while the EAFRD-EMFF Multifund CLLD was envisaged only by the Puglia Region[36].

With regard to the EAFRD-ERDF-EMFF CLLD Multifund, therefore, the LAGs adhering to the RCs partnerships did not have the opportunity to "impact" in the interception of various public funds for the interventions' financing, but had to "limit themselves" to actions of dissemination of good concertation and planning practices on a local scale.

Another instrument to support the effectiveness of the RCs, always in the full logic of CLLD, is most likely represented by the Integrated Territorial Investment (ITI) established by the European Regulation no.1303/2013, although not currently effectively active in Italy[37]. Actions and interventions implemented in the form of ITI can be financed by the ERDF, ESF or CF Structural Funds and be complemented by financial support from the EAFRD and the EMFF[38]. In addition, for the management and implementation of an ITI, the Member State or a Managing Authority may designate one or more intermediate organizations, including Local Institutions, regional development institutions or non-governmental organizations. ITIs, in fact, are innovative instruments that allow to: a) adopt a "transversal strategy", linked to a plurality of issues that together contribute to local development through the activation of a plurality of structural funds; b) facilitate the integration between homogeneous territories, in a vision that looks at the territory as a *unicum* beyond administrative borders; c) realize the integration of the various European Funds (ERDF, ESF, EAFRD, EMFF) in order to support multi-dimensional and interdisciplinary interventions. Furthermore, the instrument of the ITI can also be activated through Memoranda of Understanding or Framework Agreements, which in fact represent the forms of activation of the RCs. Finally, the ITI, being a flexible instrument, allows it to be adopted with a top-down, or bottom-up, or mixed approach, facilitating the establishment of distinct forms of governance of the RCs, in line with the different planning requirements.

Underlying the aspects related to the financing of the interventions, moreover, we note the problem related to community empowerment, that is to say the endurance of the RCs and more widely to the practice of collective action. In fact, as seen, collective action for a "common good" requires a sense of responsibility of the local community and a sense of trust not only among the stakeholders who cooperate in the process of

[35] In the European 2014-2020 programming, the EU has provided for the possibility of activating Multi-Fund CLLD projects, i.e. financed by different Funds: EAFRD - ESF - EAFRD - EMFF.

[36] Sources:
http://capacitaistituzionale.formez.it/sites/all/files/1.3.5_lo_po_plurifondo_monofondo.pdf;
https://www.reterurale.it/

[37] Regulation (EU) no.1303/2013 of the European Parliament and Council of 17 December 2013, laying down common provisions on the European Regional Development Fund, the European Social Fund, the Cohesion Fund, the European Agricultural Fund for Rural Development and the European Maritime and Fisheries Fund.

[38] European Regional Development Fund (ERDF); European Social Fund (ESF); Cohesion Fund (CF); European Agricultural Fund for Rural Development (EAFRD); European Maritime and Fisheries Fund (EMFF).

defining local development Action Plans, but also (and above all) towards higher-scale Institutions. In particular, the collective and voluntary effort put in play for a local development project, albeit fed by a "global cause" (global sustainable development goals), where it does not achieve the implementation (or even only a partial implementation) of planned objectives, not only risks questioning the entire process, but also having a negative impact on the sense of responsibility and trust of the local community: "a high sense of responsibility cannot last long in a condition in which one thinks of not being able to do anything to change the situation" (Martini, Sequi, 1995).
The risk, therefore, is to destabilize the autopoiesis of a territory by triggering a cognitive process based on the representation by the local community of having processed an abstract development plan.

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IoT TECHNOLOGIES IN VITICULTURE: INNOVATION AND SUSTAINABILITY. THE IOF PROJECT CASE STUDY

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Abstract

The actual scenario, characterized at global level by cogent environmental challenges, urges the adoption of effective policies to fight climate change and variability. This is particularly true whit regard to agriculture, strongly affected by the mentioned phenomena. Traditional production areas have experienced, especially in recent years, substantial climatic changes with a general and constant warming trend observed in most production regions. As far as viticulture is concerned, specifically, as global temperatures continue to rise, several areas originally unsuitable for grape production because of insufficient warm climates are becoming adapted to support it. The climates of production regions merge with cultural factors at local level to create a unique combination reflected in the concept of terroir, the peculiar and complex interactions between each regions' physical and cultural factors, resulting in the quality and style of wine from a specific region. In this context, the application of IoT technologies through precision viticulture and remote vineyard monitoring represents a vital opportunity to innovate cultivation methods. The implementation of these technologies aims at optimising the wine production and quality and, at the same time, preserving the environment by lowering the carbon footprint, reducing water and electricity use and recycle vine and wine waste, thus promoting an effective agroecological transition. The present contribution will analyse the mentioned issues within the IoF project (www.iof2020.eu).

1. Introduction

The analysis at the core of the present discourse makes it necessary to consider the contribution of economic geography to the understanding of the "historical present", i.e. its institutional methodological structure and approach. As a science anchored to the investigation of the territory as a whole, economic geography does not, nor can it, deal exclusively with economic issues, but must constantly take into consideration also the physical, political, social, historical and cultural factors that those economic facts of that given territory are inextricably linked to. These same links give rise to so called spatial relationships, that take form both between economic subjects (individuals, families, communities, companies and entities of different nature and for various

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reasons operating in the economic field), as well as between economic subjects and the environment in which they operate and viceversa (Dematteis et al., 2010). The spatial relationships of the first typology, those between economic subjects, are called horizontal and basically concern the flows that affect these subjects (exchanges, movements of people, information, technologies, capitals) and the localization networks that derive from this interaction. The relationships of the second type, called vertical, or even ecological, identify the interactions that economic subjects have not only with the different natural contexts (climate, resources, altitude, position), but above all with the territory itself, embedded with all its human dimension, and organized in its different juridical, anthropological, historical aspects. The combination and intertwining of these two interpretative vertical and horizontal relationships provides both a framework useful to define the different hierarchies and territorial structures that characterize the present scenario, as well as a tool to analyse specific bundles of relationships, functional or critical, both on a local and global scale, which indicate the basic trend lines of the economy and contemporary society. This is particularly true with regard to agriculture, certainly the activity that, on one side, is most linked to natural conditions and to a whole heritage of traditions and, on the other side, creates continuous flows of economic exchanges at a global scale.

With specific regard to viticulture, at the core of the present analysis, research conducted in recent years shows that climate change will have an important economic impact on viticulture and will require changes aimed at the adoption of both mitigation and adaptation measures, as well as in business strategies and sector policies (Bethuel et al., 2017). Climate change is expected to have immediate and short-term effects, and medium/long-term ones; as to the first effects, they are mainly referred to yields, quality of wines and, as a consequence, prices and related incomes. As to the latter ones, it is vital to note how changes in the availability of production resources in most areas, combined with irreversible changes in the winemaking geographical distribution will cause a series of with economic and social impacts, related to changes in land values, in competitive relationships and employment distribution. It is fundamental to conduct an in depth analysis aimed at investigating the different aspects of the issue at stake. New climatic conditions make it necessary to adapt production techniques, with a predictable effect on costs; moreover climate change impacts on the unpredictability of phenological evolution, which makes it more difficult to plan production activities and poses a hazard to grapes with high oenological potential.

In this complex context, climate change is likely to represent one of the main drivers, if not the most relevant one, of the future (immediate and not) evolution of viticulture and winemaking techniques, with an inevitable process of selection phenomena among wine-growing territories and within them. Actors, both public and private, need to face the challenge of climate change both through mitigation and adaptation policies, in a perspective of environmental, social and economic future sustainability (Bethuel et al., 2017).

As a consequence of the mentioned scenario, the adoption of IoT technologies represents a fundamental tool to face the mentioned challenges and improve efficiency, all in the perspective of favouring the design and implementation of a sound agroecological transition (Soulignac et al., 2019).

2. Agriculture and ICTs

As to the possible definition of a framework for the analysis of ICTs in agriculture, the present contribution aims, as well, at questioning the central or peripheral positioning of ICTs tools as an essential step to measure the coherent place of the same digital tools in the support and development of agroecology, and the structure of a related new agricultural model. On one hand, digital agriculture is considered as a new model in itself, thus raising the question of its position in relation to other agricultural models, including that of agroecology. Digital tools can, for example, be added to the technological trilogy "certified seeds, fertilization and phytosanitary products" (Daniel et al., 2019); in such a scenario, farmers and agricultural producers might see their autonomy further reduced, and become more dependent on a market system capturing agricultural data and their associated decision models. Alternatively, on the other hand, digital tools are regarded as additional resources that can serve different agricultural models, certainly depending on the procedures adopted and how they are used, with farmers and agricultural producers remaining at the center of the final decision. As a consequence, it is possible to analyse how ICTs can support different types of agriculture and study the ways in which they can support agroecology, in particular, at the core of the present discourse. The mentioned support is fundamental to promote an effective agroecological transition within a territory, that needs to be planned and implemented. Following the approach adopted by Bergez et al. (2019), the method of designing a territorial agroecological transition is essentially based on numerous exchanges between actors within each territory kept into consideration.
In order to analyse the complex nature of the agroecological transition in agriculture, Duru et al. (2015a) propose a conceptual framework according to which the behaviour of the mentioned actors is determined by formal and informal norms and agreements that, through the use of technology, interact with material resources specific to farms, with supply chains and natural resources. The resources to manage are of two kinds: material resources, and cognitive resources. Three systems of material resources (MR) are identified, each one associated with a specific management process:

- The MR system of the farm (MR-F), used by farmers for their activities;
- The MR system used for collection, processing, and marketing activities all along the supply chain (MR-PC);
- The MR system used by actors for natural resources management at local level (MR-NT).

These three MR systems are interdependent and their management process is strongly influenced, better determined by technologies that are specific to it; the individual components of each system are also interconnected and interact, e.g. (to mention a few of them) fields, planned biodiversity (crops, domestic animals) for the MR-F system; transportation and processing equipment for the MR-PC system; water, soil, and landscape structures for the MR-NT system (Bergez et al., 2019).
It is vital to carry out an analysis and characterisation of current forms of agriculture (so called "Agricultural Systems in a Territory") and, afterwards, to proceed to design a future "Territorial AgroEcological System" (TAES), that entails the ecologisation of current Agricultural Systems in a Territory. The transition to a TAES (tTAES) requires a methodology that, as argued by Duru et al. (2015b), keeps into consideration the complementarities at local level, both biophysical (soil, climate characteristics and natural resources of the farms) and production-oriented.

The importance of the approach at stake is the potential to design, test and adapt a methodology to help local agricultural stakeholders in their desirable transition of local agricultural systems to TAESs. Five steps are encountered (Bergez et al., 2019):

- Analysis and characterisation of the current local agriculture;
- SWOT analysis and definition of the exogenous forces that will impact local agriculture in the future;
- Specific design of a Territorial Agroecological system (TAES) according to ecological principles (Biggs et al., 2012);
- Setting of steps to develop such a system, i.e. the transition to the TAES;
- Definition of a proposal of local governance and management to orient this transition.

It is fundamental, in each step and throughout the whole process, to keep into consideration the several interactions between farming systems, food chains and natural resources. The cited exchanges between actors require, in general, few tools and have a low technological intensity. At a minimum, the communication tools will disseminate the results from the design of the model, and even allow their enrichment and enhancement through social networks. Nevertheless, the concrete launching of a sound agroecological transition and, therefore, its routine operation, can be supported by different ICTs, as important tools to implement this same transition.

As a matter of fact, the agroecological transition of a territory does not concern only farmers, but the entire agricultural world up to researchers, actors in the food production circuits up to consumers, finally all those who interact with farmers production methods such as, among others, naturalist associations (Duru et al., 2015a; Bergez et al., 2019). As a consequence, such a transition requires a consistent amount of exchanges of data, information and knowledge, which can be facilitated by ICTs. Indeed, one of the strengths of these technologies is to break down the spatial and temporal barriers that usually prevent certain territorial actors from communicating effectively, thus slowing down or impeding the agroecological transition of a territory.

Proceeding to consider how ICTs support the agroecological transition, it is vital to investigate all information systems capable of valuing information, data and knowledge (Laborde, 2017). A differentiation of these digital devices tools according to their function is as follows: communication, functional use, knowledge management and decision support.

As to the first one, communication technologies facilitate the circulation of data, information and knowledge inside an organization or from an organization to its targeted public. They disseminate observation results, ideas or knowledge synchronously or asynchronously, and consist as well of applications that publicize events, products and so on (SCAR AKIS, 2016). These tools include videoconferencing systems, social networks or exchange of data systems.

As far as functional tools are concerned, these applications support repetitive processes that are easy to model. They include accounting management tools, online sales tools and similar devices. In addition to the facilitated organization of short circuits, these tools also promote positive and fruitful exchanges such as, for example, those between straw producers and manure producers, and therefore effective cohabitation between breeders and grain producers relevant from an agroecological point of view. In this field, crowdfunding potentially brings together holders of innovative projects and potential funders, all with the aim to enhance these web tools and versions that make

the territories more autonomous by relying on internal strengths and resources (CEMA, 2015).

Thirdly, as to knowledge management systems, they include all those tools useful for creating, storing, disseminating and updating knowledge. The agroecological transition requires a great deal of knowledge (Daniel et al., 2019) in order to reduce the risks taken by farmers. In order to reach this objective, the adoption of tools that include a knowledge creation component, regards two types of possible aspects: on one hand, that related to web tools, that break down geographical barriers between farmers. They make possible multiple sharing of experiences, both positive and negative, and this empirical knowledge can be capitalized and combined with scientific knowledge. On the other hand, as data are becoming more and more abundant, coming from drones, sensors, connected objects, satellite images, traceability, observations and agricultural management tools, and so on, it is important to adopt a systematic collection and organize specific ways to extract knowledge from these data. These advances may lead to new decision support tools (DSTs) (Rose et al., 2016; Bergez et al., 2019; Le Guen, 2008).

As to this aspect, agroecology requires a solid educational program and ad hoc trainings need to be organized at different levels.

Finally, decision support, or decision-making, tools are based on two resources: data and knowledge that infers these data to produce actions. They range from the reasoned fight against pests (e.g. date of intervention, quantities) to issues such as the design of systems rich in biodiversity. The acquisition of contextualized knowledge could open the door to multifactorial decision support tools that cross economic, agronomic, social and environmental components, as cited above (Duru et al., 2015b).

It is vital to analyse the challenges to face with regard to the connection between ICTs and agroecology, as these challenges concern research, education, farmers and the food industry, and stakeholders at multiple levels. As an example, in France, several actors gathered around the #DigitAg, Digital Agriculture Convergence Institute (https://www.hdigitag.fr/en/). To meet its different challenges, which include the development of information systems for the agroecological transition, #DigitAg has identified six axes: axes 1 to 2 highlight the social and economic dimensions, required to bring results from the laboratory to the field; axes 3 to 6 correspond to the classic themes of collecting-organizing, visualizing, understanding and modelling applied to specific chains of digital data. Moreover, two major societal issues related to agriculture are identified and addressed through ad hoc operational supports.

As a matter of fact, the adoption of digital devices and communication tools by farming communities depends on practical criteria such as their usefulness, their ease of use and their return on investment. In such a scenario, the participatory design process of the tools at stake becomes fundamental, as argued by Thareau et al. (2019). Several questions might arise as to the technical knowledge critical or missing concerning each practice, or as to how it is possible to diffuse and validate knowledge in each community. Collaborative design based on users behaviour or needs are consistent with the agroecological principles of participatory research and final-users inclusion in research, as already argued (Pillaud, 2015).

For the proper use of these tools, the importance of data accessibility is critical. Their double public and private origin does not easily guarantee it, and questions arise about the monetary value of each data, its intellectual property or its traceability (#DigitAg, 2018). It is fundamental to develop portals at all levels, to collect and store agricultural

data provided by actors involved in the value chain, as well as to have transparent data governance for the development of an agroecological system including ICTs as a necessary support (Agnès, 2019).

3. The IoF project

In the context of the European farming and food sector, the Internet of Food & Farm 2020 (IoF2020) project stems from the need to investigate and foster a large-scale implementation of Internet of Things (IoT) on order to contribute effectively to a paradigm shift in this field, by drastically improving productivity and sustainability. The project is composed by 5 trials, and 19 case studies (www.iof2020.eu) and, through the enhancement of the use of smart webs of connected objects, that are context-sensitive and can be identified, sensed and controlled remotely, in the agri-food sector, it is in line with recent initiatives towards the valorization of relevant opportunities offered by ICT, network and data–oriented technologies. The provision of solutions to facilitate the large-scale uptake of IoT, by addressing organizational and technological challenges faced by the European farming and food sector, is at the core of the initiative, that focuses on 19 use cases spread throughout Europe, and provides solutions to 5 agri-food areas: arable farming, dairy, meat, vegetables and fruits, taking into account their own needs and obstacles. Furthermore, the IoF2020 project involves all the stakeholders in the food chain: from farmers, cooperatives, equipment and logistic suppliers, food processing companies, to consumer organizations, including ICT developers, all with the aim of improving the technologies at stake, ensuring they meet the requirements and needs of the sector. In particular, the present contribution focuses on the Use Case (UC) dealing with Big Wine Optimization.

The Big Wine Optimization Use Case (UC)

European wine industry constitutes a sector of utmost importance for the continental economy; at global level and in terms of value, EU is the most important producer of wine, involving about 2.4 million vine growers. This "leadership" is rooted in historical savoir-faire, traditions, as well as in peculiar soil and climatic conditions of several areas. The wine industry in EU is composed by a constellation of small and medium enterprises and involves a broad range of other professionals such as consultants, service providers, marketing experts, and so on. As a consequence, in total, the European wine business has the highest share of EU agriculture revenues.

Nowadays, this sector encounters high pressure from emerging countries, such as China; in order to preserve the competitive advantage to third countries, European producers need to implement new cultivation methods, and precision viticulture and remote vineyard monitoring certainly constitute, in this context, two very promising technologies.

Alongside this, the organic wine sector is rapidly developing with excellent and promising, though challenging, market opportunities, and represents nowadays about 10% of EU vineyards (with higher rates in Italy, Spain and France). The deployment of IoT technologies both in conventional and, even more, in organic viticulture and wine-making processes enables the achievement of important goals; remote sensing and control actuators, information collection both in vineyards and cellars, big data analysis and management, and decision making are all important aspects to analyse, also with regard to the mentioned perspective of agroecology. Increased efficiency can

be achieved in inputs and labour resulting in higher quality, profit and environmental sustainability along with decrease in production costs.
The Use Case (UC) at the core of the present contribution, within the IoF project, addresses both conventional (for vineyard and cellar phase in France) and organic (for cellar phase in Italy) production systems.
The main challenges to analyse refer to what follows:

- Real time monitoring of weather conditions both at parcel and vineyard level.
- Optimization of the use of potable water resources during wine production.
- Manage a consistent amount of data (acquisition and handling) deriving from a high number of vineyards.
- Maximise the wine production and enhance and preserve its quality.
- Increase inputs efficiency thus reducing the costs related to the production and commercialization.
- Preserve the environment, through the reduction of carbon and water footprint, an improved control of electricity use and the recycle of vine and wine waste).
- Compliance with Quality standards and certifications (e.g. ISO 14001 and HVE 3 certifications).
- Manage storage, shipment and post-cellar phases with specific attention to reduce risks associated with un-controlled operations.

Furthermore, as to the socio-economic impact of the UC, this is particularly relevant due to the mentioned importance of this sector in the agriculture revenues in EU. As a matter of fact, wine production is a risky business due to the market volatility and the impact of weather conditions. Organic wines represent a precious opportunity for European producers as the market share is fastly and constantly developing (domestic and export), with increase rates of about 15% annually.
In the French UC, the end-user is Denis Dubourdieu Domaines (DDD), a winegrowing family since 1794 at the south of Bordeaux (Graves). They exploit 5 vineyards distributed over 300 parcels covering 135 hectares and producing around 600.000 bottles of wine per year. In addition, they exploit 200 hectares of forest to develop a neutral carbon balance in order to preserve the environment. DDD performs the complete activities related to the wine value chain from vine-growing to wine making and commercializing. DDD exports 60% of its production in more than 40 countries. French rules forbid the irrigation of the PDO French vines (PDO represents 99% of the wine production in Bordeaux). They are only irrigated by rain. This situation creates a strong dependency of the vine-growing on the weather conditions. In addition, the context is very difficult for producers in terms of pesticide use, especially in Bordeaux, because of a cool and temperate oceanic climate, vine growing is subject to the pressure of various diseases, rots and pests. Today, society and government push producers to reduce drastically use of pesticides and herbicides.
The Italian case study is based in Arcania vineyard and cellar in Friuli Venezia Giulia region, North-East of Italy. It is a society of 5 farmers, all certified organic since 1992, who manage 50ha of vineyard and directly process all the grapes in the society cellar, located in the Rive d'Arcano Castle. Produced wines are organic, PDO (several denominations) and a specific line offers also SO2-free wines. White wines (Collio, Colli Orientali and Grave Appellations) are particularly renowned in Friuli Venezia Giulia region, due to their qualitative aromatic profile gained thanks to the soils (specific clays) and the climate (cold and rainy). Nevertheless, this poses higher

challenges for the organic management of the vineyard and for the processing activities with zero or reduced aids. With regard to the production of organic white wines with no added SO2, this is particularly true due to the risks and complexity of the whole process, that requires a full knowledge of vineyard and cellar conditions and also of the procedures used in the following phases of the value chain, as final products are sold all-over the world and consumed years after their production.
The list of the project and business partners is the following:

- Denis Dubourdieu Domaines (DDD): a winegrowing family since 1794 at the south of Bordeaux (Graves). End-User.
- Process2Wine (part of ERTUS Consulting company): a software developer specialised in tools for wineries and vineyards. Technology provider
- Bordeaux INP - IMS Laboratory: Technical and scientific experts image analysis for vineyards and orchards. Research organization. Technology provider
- CEA-LETI: IoT Framework for Cloud and local data processing. Research organization. Technology provider
- STMicroelectronics - MMS Division (Grenoble/Rousset): Semiconductor Company and provider of Smart nodes and Gateways solutions including HW and SW.
- Vinidea- innovation broker specialized in the wine sector, with expertise in conventional and organic wine production and large experience in dissemination technical information at EU level. Technology provider and dissemination actor.
- ISVEA- development and validation of the analytical databases for remote acquisition. Research organization.

The overall objectives of the UC at stake relate to different aspects, from the societal impact, i.e. transform low added value jobs in the vineyard in high added value ones, to the environmental ones, by reducing carbon and water footprint. Moreover, it is vital to increase the tools available for organic wine-production and marketing, so offering better opportunities to farmers; increase the competitiveness of all-range winegrowers (from low to high range), all through the deployment of the IoT technology solutions, validated by the same UC, more extensively at regional, national and European levels. As to pest management, in conventional vineyard (France), the challenge is to optimize, and possibly reduce, the use of chemicals for plant protection through a precise identification of moment, product and positioning of the treatments. As mentioned, the aim is to reduce environmental impact, reduce use of resources and efficiently protect grapes. The actions to implement in order to reach these objectives are the following ones: knowing accurate weather conditions (precipitation, humidity, wind, temperature) in real time on a specific area, a set of parcels or a complete vineyard; providing, by the control centre, application maps as a result of the real time processing of the weather and vine conditions. These data are essential to be used for precision viticulture activities such as site specific decision making, variable rate spraying, fertilization, selective harvesting, and so on. The solutions deployed refer to the use of a high integrated weather station network with long range transmission capabilities to know accurate weather conditions in real time, and to the equipment of tractors with a spray actuator controlled from the data centre, which will send

command to the same actuator, indicating where and the dose (e.g. fertilization, other treatments) to be applied.

As to selective harvesting, in conventional vineyard (France), it is vital to consider yield and grape quality, both at parcel and vineyard level; in order to reach this objective, vine conditions have to be analysed. TE sensor is dedicated for grape detection, phenological stages determination, disease status characterisation, all with the aim of performing a more automatic and quick processes in order to reduce the inspection time and to have accurate results. The use of image processing techniques based on video sensors with computer vision capabilities is deployed, with a twofold idea: firstly, to install fixed video sensors in relevant locations within the vines plots, that provide high temporal resolution measurements but at very low spatial resolution; secondly, to equip a tractor with the same kind of video sensors in order to get high resolution measurements but at low temporal resolution. In both cases, the image processing results (expressed in meta data, for instance fruit detection) are sent to the central station and then combined in order to make the decision process more reliable and accurate.

Furthermore, as regards the wine cellar monitoring, in conventional wine-making (France), in this specific part of the production chain, the activities performed and the scopes refer to: proper monitoring of temperature and humidity in different stages of vinification process in cellars as well as in bottle-storage warehouses, in order to avoid issues related to temperature (too high) and humidity (too low), and a consequent wine evaporation during summer time; strict controlling of the total dissolved oxygen level during bottle filling in order to optimize the wine aging; measurement of water and electricity resources used during production.

Shifting to organic wine production in Italy, the remote quality assessment refers to the possibility to frequently assess critical parameters on a large number of samples, that is vital all along the different phases of wine production, and also highly beneficial. These parameters refer to: polyphenols, sugar, organic acids and assimilable nitrogen in grapes during maturity; sugars, alcohol, volatile acidity, acetaldehyde, organic acids during fermentation; volatile acidity, color, acetaldehyde, and so on during barrel aging.

The transport of samples for testing procedures, from production sites in rural areas to laboratories for analysis would be economically and environmentally expensive; as a consequence, in most cases, presently quality assessment is performed only in punctual steps, with no preventive approaches that are essential for low-input and organic winemaking. In this context, the IoT challenge is to develop an uncoupled analytical system, preferably based on FTIR technology for multi-parameter analysis (already largely applied in wine sector), where inexpensive devices and simplified procedures allow the acquisition of the spectra at the production sites, and the elaboration of data to obtain the needed information and desired values is done remotely through internet data exchange. In this way, the unit cost per sample would strongly decrease, thus making it possible also for small wineries in remote areas to optimize their assessment system, with strong increase in quality and consistency of final products.

Furthermore, another IoT challenge, potentially developed in the most critical situation of organic winemaking but immediately transferrable in the conventional sector, refers to the control of wine quality during the last phases of the production chain, i.e. bottle transport and storage. In both phases a significant quality drop can occur because of long distance delivery and related exposure of wine cases to extreme temperatures and,

also, of long storage of wine in uncontrolled conditions, that can accelerate degenerative phenomena. The low or absent presence of preservatives makes organic wine more exposed and sensitive compared to conventional one, though in both cases there is a joint interest of the producer and of the reseller to preserve brand image and reputation by avoiding that faulty bottles are purchased by final consumers. It is vital to perform a continuous assessment of some key parameters (e.g. temperature and wine absorbance at specific wavelength), at fixed intervals during the shelf life period, and to convey through internet and to elaborate obtained data in a central system. This is achievable through the development of a device able to automatically measure, in a non-destructive way, the mentioned key parameters as relevant indicators of the quality state of the product. The same central system, managed by and under the control of the producers, allows for early identification of problems and of the period when they originated; as a consequence, necessary measures to prevent such events resulting in quality reduction can be adopted in due time.

As far as IoT System components description is concerned, the technology at the core of the analysed UC covers the complete IoT value chain, i.e. it includes the three main domains: device domain (edge), network and application (Verdouw et al., 2016; Vermesan et al., 2015). The integration of all these three domains is vital for the successful implementation of the described system; for the sake of privacy issues, in some cases the processing in the network domain is performed in the device domain/edge.

Just to mention some concrete examples of the cited components, in the conventional sector (France), in the device domain, weather and crop conditions are monitored through the use of sensors (e.g. temperature, humidity, precipitation sensors), and the related collected data are sent through the internet and/or through a local network, and analysed for different purposes, especially for pests and diseases infestations. This allows the user to adopt effective decisions regarding spraying application, fertilization and other treatments for all selected fields. In the winery, sensors monitor the conditions during vinification process; data are sent and analysed again through the internet and/or through a local network, and the installed actuators are used to control the vinification process through the same platforms in an automatic or manual way.

As to the sensor node (= sensor + microcontroller + connectivity) and to the actuator node (=actuator + uC + connectivity), a multi-sensor/actuator node is integrated and deployed in the vine and the cellar. This solution supports the following operations modes: Weather station sensor node, Disease actuator node, Cellar sensor nodes. This solution includes several sensors (precipitation, humidity, wind, nitrate, brightness, etc.), computing, long range connectivity, and GPS capabilities are also supported. In addition an IBUS interface is provided and 150 multi-sensor/actuator nodes are considered. Fixed inspection sensor nodes based on video sensors with “embedded computer vision capabilities” to know the vine conditions (vine phenological stages, vine vigour, diseases, grape maturity, etc.) are deployed. This type of sensor node is installed in appropriated location within the vine plots (sampling).

As to the economic and social impacts foreseen for the end-users, they concern essentially two aspects:

- Reducing the costs of pesticides and fertilizers for the vine growers. As a consequence of simple and automated monitoring, both in the vineyards and the cellar, productivity gains are realized; the more the mentioned IoT solutions are implemented on other vineyards, the higher the economic impact would be

at national and EU level. The remote assessment system of both must and wine allows a thorough control of critical phases of production as well as an accurate prevention of accidents, leading to an overall increase of wine quality and final value. This enables users to avoid losses due to faulty products, losses or strong depreciation of a lot of wine, in addition to advantages in commercial relationships. Moreover, for the industrial companies involved in the project for both the conventional sector and the organic one, the economic impact consists also in the development of a new market, with a relevant additional turnover generated by the sales of the IoT solutions, even within years after the end of the project. As argued above, the technology at stake is very easily extendible to other wine regions, with further increase of economic impact (ICT-Agri, 2012). Another aspect to consider is related to the fact that the implemented IoT system allows the monitoring of consumption of potable water and electricity, resources that are both very demanding in the wine production. It is, therefore, possible to carry out a detailed analysis of power consumption and, consequently, implement a sound investment strategy in renewable energies (auto-generation and consumption) by calculating the possible volumes of synchronous electricity consumption with solar energy. Moreover, the decrease of use of pesticides improves wine areas biodiversity as well as air, water and soil quality. It is possible to observe wider potentials to organically manage the vineyards, and this allows more farmers to convert to organic, thus improving their environmental performance. As already mentioned, remote analysis of musts and wines avoids all environmental costs of sample delivery to laboratory (on average 10 KgCO2e/sample), together with avoided back transportation of refused lots of wine, that represents a significant saving in GHG emission (9 kgCO2e/case).

- Transform jobs in the vineyard with low added value in high added value ones, thus enhancing the interest in the new generations of young people towards the work in the farms/wine domains, by offering more attractive jobs involving new technologies. The intergenerational issue is a vital issue to keep into due consideration, together with the reduction of risks associated with low inputs wines and the offer of really innovative products on the market.

It is vital to note how the implementation of the described systems based on IoT devices and solutions, in order to centralize the data, coming from different vineyards and cellars, and perform data analysis, system and risk management and decision making is strongly capable of improving the vine yield and wine production. This provides middle and small winegrowers and producers with new tools to optimize resources (manpower, fertilizers, materials, electricity, water, and so on) and contributes to preserve the environment by reducing the use of pesticides, chemicals and production resources. The deployment of a cost effective precision viticulture management and a global vineyard control system, in order to increase competitiveness, allows as well the optimization of the use of inputs in wine-making by controlling all environmental factors affecting the process (temperatures, humidity, oxygen, and so on). Considering a long term approach, the benefits would be multiple, and differ depending on the value chain actors:

- End-users. The adoption of the mentioned system will reduce costs (manpower, fertilizers, materials, electricity, water, and so on), improve the vineyards management by allowing real-time decision making thus increasing the vine yield and wine

production. Furthermore, the described IoT system strongly contributes to the environment preservation, with huge benefits related to the potential numbers of winegrowing and wine producers who can adopt these systems, with a strong economic and environmental impact at regional, national, European and global levels.

- Services suppliers. They can develop new markets through the provision of high added value services and benefits for end-users.
- Technology suppliers. They enter in new markets involving IoT technologies, addressing the needs expressed in them.

It is fundamental to consider the creation of a new ecosystem composed by the mentioned actors; the cooperation between them and the potential common synergies allow the provision of integrated solutions and the setting up of new business models. The IoT solutions developed in the UC at stake, as already mentioned, hold a high potential to be used and deployed in other applications dedicated to the agriculture and farming, particularly in the fruit sector and beyond it; in order to create business opportunities, it is important to provide a global and integrated system solution and create an ecosystem and a strong partnership between all partners.

4. Conclusions

Digital tools and devices are increasingly present in agriculture; as argued in the present contribution, they prove particularly useful for designing and supporting an effective agroecological transition in rural areas. By allowing synchronized or unsynchronized exchanges among farmers and other actors in the value chain, producing and disseminating knowledge without spatial and temporal limits, helping all decision-making processes, ICTs are all resources capable of consolidating agroecology. At a global level, a significant work is ongoing aimed at developing and fine-tuning tools that are both relevant and effective, and beneficial from an economic, environmental and social perspective. The so called digital revolution must demonstrate its relevance, it requires social acceptance as well as an appropriation of its use. As mentioned above in the context of the IoF project, this acquisition of new skills is not self-evident; it is, therefore, fundamental to investigate, understand, guide and propose schemes on the use of this diversity of tools, and broaden the boundaries of each project to involve different territories and experiences as best practices for the near future.

Lastly, it is important to consider whether ICTs potentially save or consume renewable resources. As a matter of fact, whatever ICT is considered (sensor, database, website, and so on), their design, their use and then, possibly, their recycling are all activities with an environmental cost in terms of consumption of raw materials and non-renewable energy. As above argued, agroecology is based on the principle that agricultural production must be exemplary from an environmental point of view, particularly in relation to the consumption of fossil products; as a consequence, a sort of contradiction might be raised between the use of ICTs and agroecology. It is vital to resort to the Life Cycle Assessment (LCA) approach, that measures the environmental cost of an ICT. LCA, thus, can help to distinguish ICTs with a positive environmental balance and impact from those with a poor or even negative ones. A more systematic use of the LCA would have a positive impact by stimulating the production of tools that fit into the circular economy, as well as sobriety and energy efficiency (Duru et al., 2015b; Moraine et al., 2017). In addition to the environmental

approach, the life cycle analysis of an ICT must also focus on economic issues with the "Life Cycle Cost" (LCC) method, as well as on social aspects with the "Social Life Cycle Assessment" method (sLCA). The three dimensions of sustainable development thus assessed contribute to establishing the relevance of the use of ICTs in agroecology, and represent the path for future research.

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LESIONS AND PATHOLOGIES OF THE CENTRAL AND PERIPHERAL NERVOUS SYSTEM: EPIDEMIOLOGY AND RELATED SOCIO-ECONOMIC COSTS

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Abstract

Every year, nervous system injuries and disorders affect millions of people worldwide, causing a significant and, unfortunately, rising incidence of social and health costs among all the countries. The present contribution is focused on the analysis of the data concerning the predominance and the incidence of severe injuries affecting the nervous system caused by accidents, car crashes and by the main pathologies affecting the nervous system. Finally, there will be provided data regarding the burden that countries have to carry, which concern both social and health costs that are steadily increasing in recent years and are expected to rise in the next decade.

1. Introduction

This research is focused both on the analysis of the nervous system injuries and disorders and on the consequences they have in terms of social and health costs arising from treatments and therapies. Moreover, these costs have grown significantly in recent years, they are increasingly piling on public budgets and are expected to further soar in the next decade.

Chronic-degenerative diseases, whose incidence is alarmingly spreading worldwide, determine a significant commitment of financial resources, due to the continuous need for assistance which often lasts for long periods of time and requires a strong synergy between health and social services, as well as adequate residential and territorial services.

According to recent studies, around 70-80% of health resources are spent globally on the management of chronic and degenerative diseases. These data become increasingly alarming, considering that epidemiological projections report in 2020 that individuals affected worldwide by these pathologies will be the 4/5 of sick people.

For over a decade, the European Union has been launching a number of initiatives in order to develop actions of contrast to neurodegenerative diseases - such as Alzheimer and Parkinson diseases - so as to allow the Member States to deal with these emergencies in a more efficient and effective manner, especially by sharing research activities, useful to avoid unnecessary duplication of work. Furthermore, these initiatives focus on increasing investments in research, on the interaction between the

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European government bodies and those of the Member States, on promoting the comparison between the scientific and industrial worlds and, finally, on prevention and on the promptness of therapies.
At a national level, noteworthy initiatives include the adoption of the National Chronicity Plan (NCP), approved in Italy by the State Regions Conference in September 2016: the NCP was born from the need to harmonize interventions in the field of chronic diseases and aims both at identifying standard approaches used in care and assistance measures and at guaranteeing a better organization of services offered to patients, in order not only to contribute considerably to the improvement of the protection and the quality of life of patients suffering from chronic diseases, but also to relieve, to the extent possible, the burden on sick people, their family members and society.

2. Lesions and trauma to the central and peripheral nervous system: causes and epidemiological aspects

According to the data released by the Società di Medicina e Fisica Riabilitativa (Society of Medicine and Rehabilitation Medicine), every year 250,000 to 500,000 people suffer from spinal cord injuries (SIMFER, 2013). Traumatic injuries to the central nervous system show worldwide an incidence of 200 cases per 100,000 inhabitants with a mortality rate of 10%. Although there is full awareness of both the causes and the social and economic consequences of the traumas affecting the nervous system, their incidence remains very high worldwide and continues to rise in developing countries. Spinal cord injuries are particularly significant due to the consequences that they entail; moreover, their incidence has a variability range between 14.5 and 57.8 cases per million inhabitants (Ackery et al., 2004). Mortality rates are bimodal and particularly afflict individuals under 25 and over 65.
The incidence of traumatic spinal cord injury exhibits a broader range worldwide: the cases vary from a minimum of 3.6 to a maximum of 195.4 per million inhabitants, indeed (Jazayeri et al., 2015). This type of lesion affects almost 10-20 people out of a million in Finland, Norway, France, Australia and Turkey; 20-30 people out of a million in Spain and Romania; 30-50 people out of a million in the United States, up to peaks of 80 in Alaska (Singh et al., 2014).
According to the National Spinal Cord Injury Statistical Center data, in 2017 the number of individuals, living in the United States, that present a spinal cord injury is between 250,000 and 350,000, while every year about 17,500 new cases with an incidence of about 54 cases out of a million individuals are observed.
The Federazione Associazioni Italiane Paraplegici (Federation of Italian Paraplegic Associations) (FAIP) estimates that in Italy in 2016 people with spinal cord injury were 90,000, with an annual increase of about 3,000 with an incidence of 50 cases out of a million. According to a recent research undertaken within the GISEM (Gruppo Italiano Studio Epidemiologico Mielolesioni) – which involves the 37 major specialist centers of spinal cord injuries – over a period of 2 years 1014 new cases of spinal cord injuries were found, with an age range that in the 80% cases is between 10 and 40 years. Most cases are of traumatic causes (67.5%), even if those of non-traumatic causes are continuously increasing (Figure 1 and Figure 2).

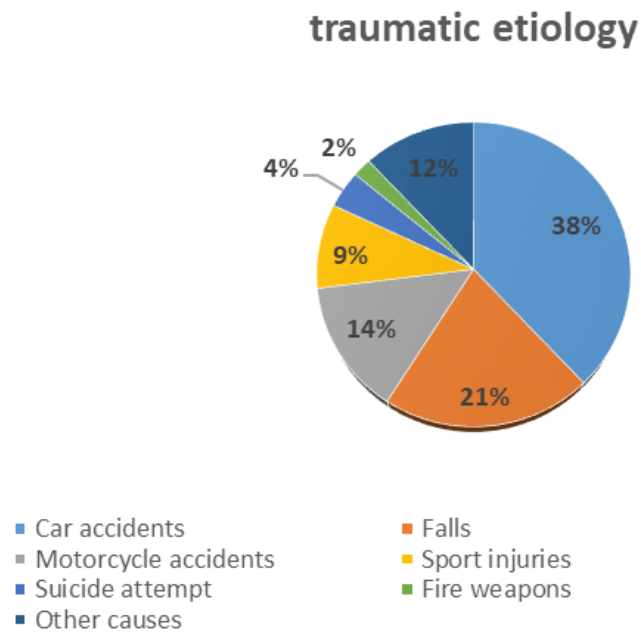

Figure 1: Traumatic etiology; our elaboration on traumatic etiology of spinal cord injuries in Italy. Source: Studio GISEM.

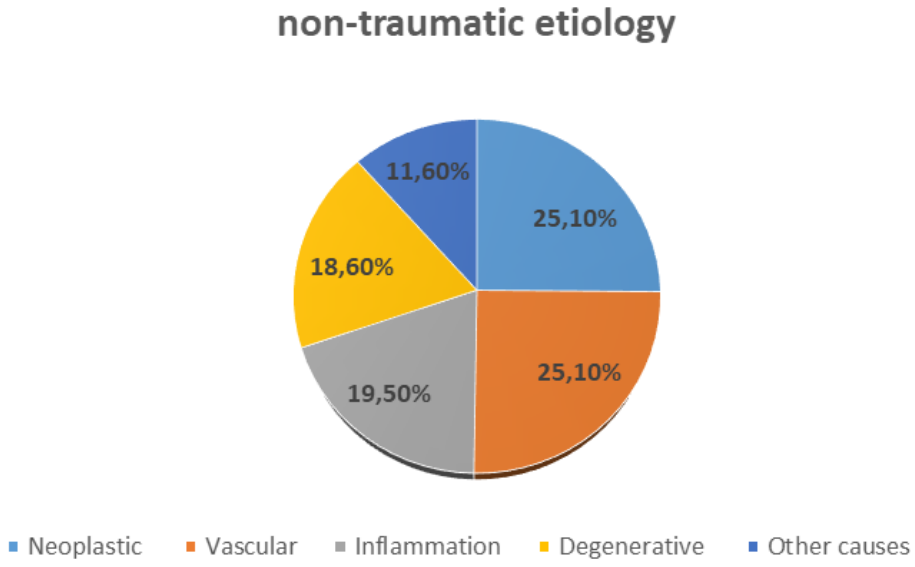

Figure 2: Non-traumatic etiology; our elaboration on non-traumatic etiology of spinal cord injuries in Italy. Source: Studio GISEM.

Patients with traumatic injury are on average younger than those with non-traumatic injury (34 versus 58 years); a general prevalence of male subjects (F:M = 1:3) is found and it is even more clear within the traumatized group.
In both patients groups, a prevalence of paraplegic patients is found: they represent the 56.6% of patients with traumatic injury and the 76.4% of those with non-traumatic injury. Furthermore, more cases with complete injury are found within the traumatic etiology group: the 51.5% suffer a complete injury compared with the 24.2% of the non-traumatic injuries. In Italy, compared to the rest of Europe, there is still a lack of

a suitable number of Spinal Units, the specialized and adequately equipped centers for the care and assistance of people suffering from spinal cord injuries: the total number of beds reaches 350 compared to over 800 in Germany. A census of healthcare facilities identified the presence of 22 Spinal Units across the Italian territory, 9 of which are Unipolar, offering in a highly specialized manner a care pathway for people with spinal cord injury. First, there is a substantial inhomogeneity between the central-northern regions, where more than 90% of the centers are gathered, and the southern ones, where only 4 spinal units have been fully operational (Ospedali Riuniti of Ancona, Policlinico of Bari, Ospedale Cannizzaro of Catania and Villa delle Ginestre of Palermo) (FAIP, 2019). In 2009, Marini and Reale carried out a research regarding the subjects that provide assistance to the patient (caregiver). These subjects are predominantly female gender: this datum finds evidence of studies conducted under the Fondazione ISTUD and those reported in literature, which show that the percentage of women taking care of loved ones is close to 80%.

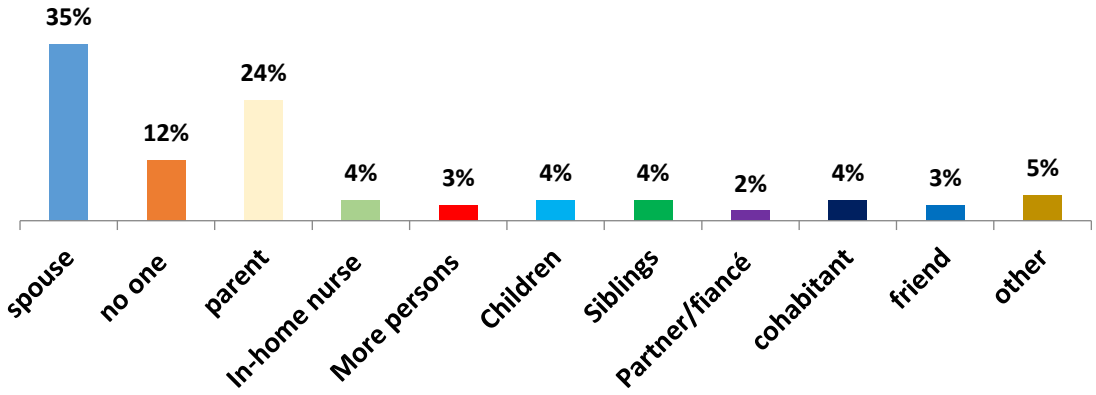

Figure 3: Main caregivers of the patient suffering from spinal cord injury.

The average age is 45, a lower value than other studies already mentioned that report a datum equal to 55: this gap can be ascribable to the fact that people suffering from spinal cord injury in the 80% of cases are between 18 and 40-year-old, as argued above. Accordingly, caregivers are mainly parents or young partners unlike other pathologies where the average age of patients is significantly higher and in most cases the spouse is the main assistant.

The "cost" section would deserve a separate discussion: in the USA it has been estimated that the expenses for intensive medical and rehabilitation treatments in the first year for subjects suffering from spinal cord injuries amounted to over 1000 million dollars in 2017, a figure far higher than that necessary for tumors, heart attacks and strokes (American Spinal Injury Association). Furthermore, according Health Department of the United States the research expenses on spinal cord injuries amounted to about 71 million of dollars. In Italy, according to the study conducted by Martini and Reale as well, the average yearly expense amounts to about 15,000 euros per patient fully charged to the family.

The management of spinal cord injury entails costs that can overturn the family's economic and social balance in the various stages of the disease: in this regard, significant costs are incurred to make the house accessible to the patient. In the first year alone, the costs can amount to 27,000 euros fully charged to the family; the

estimated costs to modify the housing patterns fluctuate considerably, as shown in Figure 4: the 62% of people suffering from spinal cord injury spends less than 20,000 euros, while the remaining 38% bears higher costs.

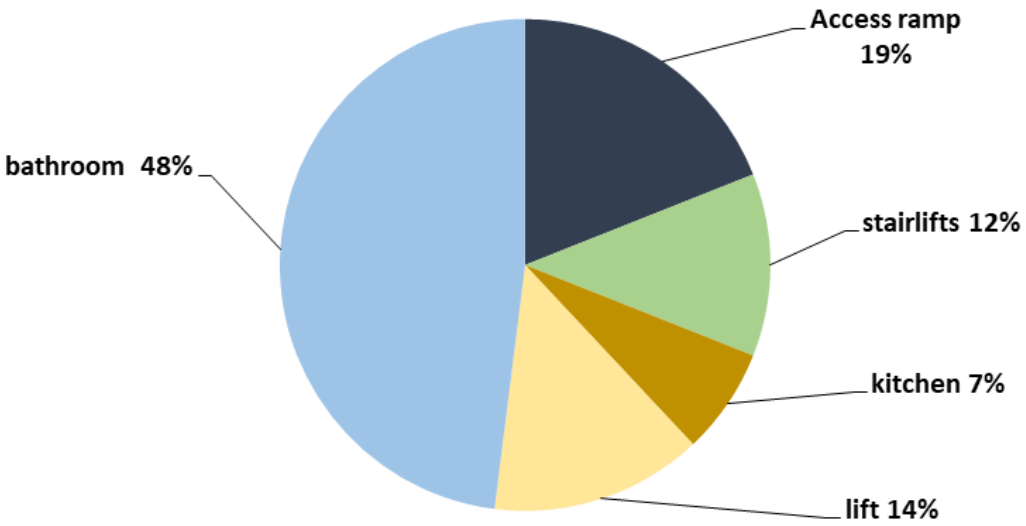

Figure 4: Percentages of costs per home.

Despite the awareness of the causes and the human and economic costs of trauma affecting the nervous system, the rate remains severely high worldwide and keeps rising in developing countries. In 2017, according to the World Health Organization (WHO), the estimated road fatalities were 1.35 million, while subjects suffering a serious injury for the same reason can amount to 50,000 million. Car crashes are the main cause of both spinal cord injuries and road trauma and between 30% and 40% of these accidents cause injuries to the nervous system (Ackery et al., 2004).
The datum relating to the mortality rate in the EU in 2017, equal to 49.7%, shows significant variations and trends between the various Member States: in Sweden and in the United Kingdom, the rates of road deaths are lower – the 25.3 % in the former and the 27.1% in the latter per million inhabitants – while in Romania and Bulgaria the rates raise to 99.3% and 96% per million inhabitants (Fig. 5). The 90% of the patients going in a hospital center in the United Kingdom has minor injuries, the 5% moderate ones while the 5% are serious. The majority of patients suffering from minor injuries fully recuperates but many suffer after-effects and disabling symptoms. According to a research carried out by Thornill, in 2000 minor injuries present posthumous symptoms in a rate of 51% while moderate ones in a rate of 54%. Specifically, with regard to minor injuries, those are identified with persistent headache among the 79% of the population and with memory loss in the 59%.

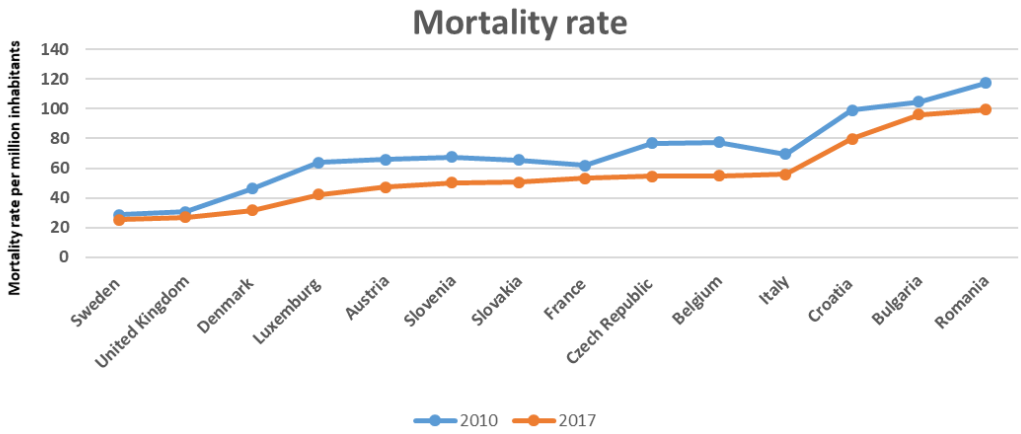

Figure 5: Our elaboration of road accident mortality rate in Europe. Source: ISTAT.

With regard to Italy, the rate (55.8%) is slightly higher than the EU average, but it has significantly reduced if compared with 2010 when it was 69.4%. Lastly, with regard to seriously injured in car accidents, in 2017 in Italy there were 17,309 cases with a ratio of 5 out of 1 death (report from ISTAT regarding car accidents) (Fig. 6).

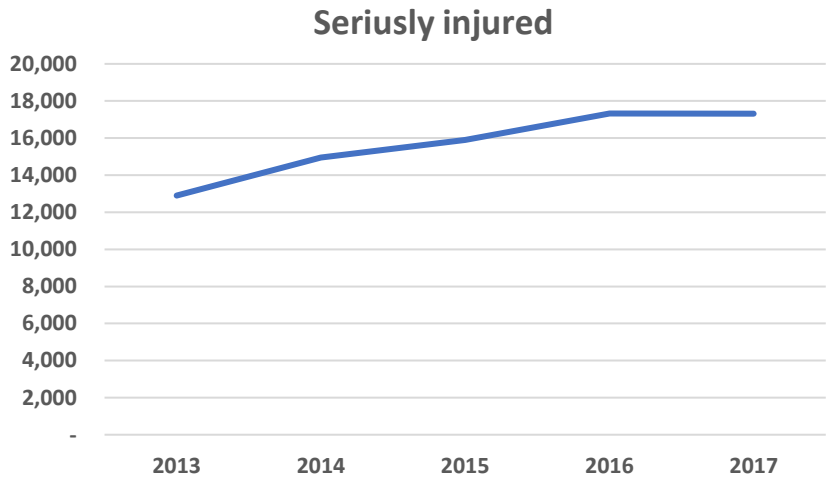

Figure 6: Our elaboration of seriously injured in car accidents in Italy. Source ISTAT.

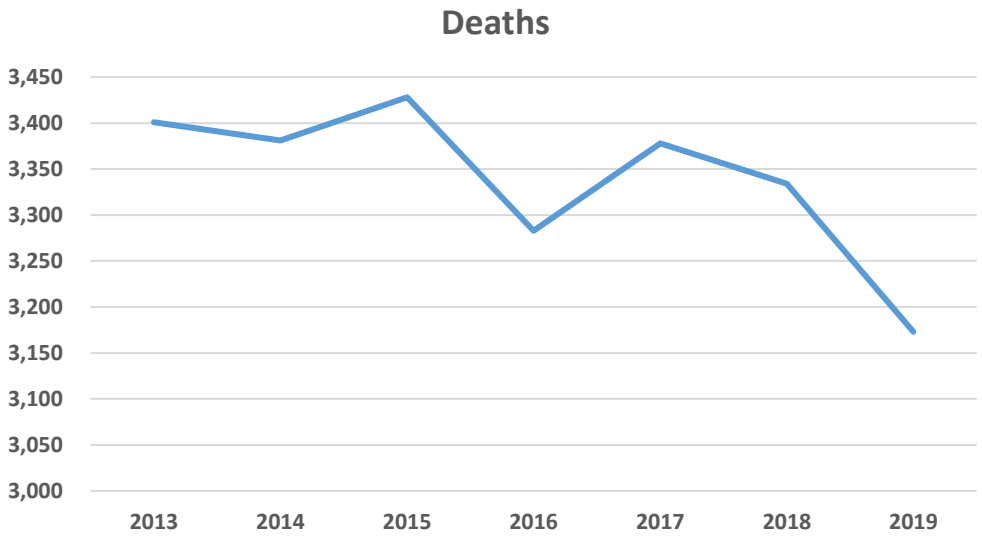

Figure 7: Our elaboration of deaths in car accidents in Italy. Source: ISTAT.

In Italy, the main cause for spinal cord injury of traumatic origin are car accidents: in greater detail, car accidents represent the 45% of the incidence of this trauma, followed by accidents at work that represent the 20%, sport injuries that represent the 10% and those owing to other causes, for example fire gun accidents that are the 25%. In Italy, 75,000 inhabitants are estimated to suffer a spinal cord injury, whose 80% is between 10 and 40 years old; this situation has consequently a very high social cost (Federazione Associazioni Italiane Paraplegici, 2019).

The definition of costs is a key issue to evaluate the prevention and treatment policies of the phenomenon. In our country, this analysis hasn't been provided, but reference can be made to the one developed at European level. A research carried out by Olesen and partners in 2010 shows that in Europe more than 64,054 million euros are spent to minister to 8.2 million subjects suffering trauma. The expenditure is subdivided in 42,353 million euros for direct patient care, 16,769 million euros for direct non-health care and finally 4,932 million euros for indirect costs.

Traumatic brain injury (TBI) represents an extremely frequent occurrence in today's reality and rests on high social costs because affects mainly young people; TBI is one of the major health problems due to its frequency and use of resources. The estimated TBI rate in all industrialized countries is of around 300 cases per 100,000 inhabitants per year. In Europe, cases are slightly below the world average, 262 per 100,000 people (Peeters et al., 2015).

It is difficult to acquire accurate epidemiological data, in Italy at least, due to the dispersion of the health system and the typology of the hospitals recovering patients suffering TBI. According to a quite recent and detailed study carried out in Lombardy region, 35,000 new cases are registered per year, with a ratio of 410 cases every 100,000 inhabitants. Comparing this data to the domestic population, an incidence of around 5% is obtained: considerably higher is the male rate which reaches 70%, the most affected age group is between 15 and 40 years old.

However, for some time now, a progressive decrease in mortality due to traumatic brain injury has been recorded; the decrease is ascribable to the development of

vehicles that are much safer if compared to the past[39]. Finally, the ever more widespread presence of emergency services, which allows faster intervention of vehicles and dedicated personnel directly at the accident site, contributes significantly to the reduction in the mortality due to TBI.
In recent years, Italian first aid units have gained more efficiency even thanks to increasingly widespread presence of neuroradiological departments and intensive care. The mortality rates inferred from the literature data are rather discordant because they are clearly linked to the patient's selection criteria: when considering all the patients suffering TBI, the mortality rate is roughly between 2% and 6%, while the mortality rate is roughly between 30% and 45% if considering coma patients caused by cranial trauma with brain injury.
Peripheral nerve injury represents the most prevalent cause for trauma, registering more than 300,000 cases per year only in Europe, while in developing countries those trauma are estimated to affect 13-23 people per 100,000 inhabitants every year (Ruijun et al., 2014). Injuries to the peripheral nervous system originate mainly from road accidents, fire guns, incisions due to different type of surgery (Kouyoumdijan et al., 2017). Today, vehicle accidents are the first cause of injuries to the peripheral nervous system in the world (Eser et al., 2009) and according to the data released by the World Health Organization, 3,200,000 people suffer disabilities due to this type of trauma every year (Gin-Shaw and Jorden, 2002).
Lesions to peripheral nerves can be combined with traumas to the central nervous system, so that it might be problematic to identify the lesion to the peripheral nerve, worsening the degree of disability: about the 60% of patients with peripheral nerve lesions suffers cerebral trauma, indeed; for these reasons, a peripheral nerve lesion can me classified in the context of trauma to the central nervous system.
Lesions by severing peripheral nerves, for instance caused by glass and blade weapons are less widespread than compression lesions and they are often combined with lesions to adjacent structures (for example to tendons). Although nerve injuries represent only the 3% of traumas affecting hands – this type of accident has a range that varies from 7-37 cases per 100 inhabitants per year in Europe (Dahilin and Wiberg, 2017) – the total cost impacting on society of a worker suffering a lesion of the median nerve of the forearm might amount to 50,000 euros, particularly linked to the productivity loss (Rosberg et al., 2008).
The most common accident injury affects the digital nerve: it can be total or partial (incidence: 6.2/100,000 inhabitants/year) and it mainly affects men (75%) of productive age (Dahlin, 2008).
A research carried out in Sweden has analyzed the factors affecting the costs of median and ulnar nerve injuries: it has quantified both the sanitarian costs and those related to the productivity loss on a sample of about 70 patients with results equal to 51,238 euros for injuries affecting the median nerve and 31,186 euros for ulnar ones, of which slightly less than 90% due to the productivity loss (Rosberg et al., 2008).

[39] Monocoque, greater diffusion of airbags and therefore more and more passengers deemed to have belts; the obligatory nature of the helmet certainly guarantees greater safety while driving two-wheeled vehicles.

3. Pathologies of the central and peripheral nervous system: the Parkinson and Alzheimer diseases and Multiple Sclerosis (MS)

The Parkinson's disease (PD) is classified as a primary degenerative disease affecting the nervous system which implicates a process of programmed cell death, in particular the nerve cells. The incidence of PD within forty-years-old people is equal to about 41 subjects per 100,000 individuals, rising to more than 1,900 cases per 100,000 among elderly subjects over the age of eighty (Cacabelos, 2017). These rates identify the PD as one of the biggest age-related health problems (Zou et al., 2015; Hirsch et al., 2016; Savica et al., 2016). Considering people who are under 50 years of age, the Parkinson's disease affects men less frequently than women (ratio M/F <1.2%), while this disease occurs 1.6 more times among men than among women, considering people who are over 80 years of age (Moisan et al., 2016).

According to a study carried out by Pringsheim, a close correlation between the distribution of the disease and some specific geographical areas is observed: in North America, Australia and Europe 1,601 cases out of 100,000 are registered, while in Asia a huge decrease has been recorded with a rate of 346 cases out of 100,000. According to other researches, in the 15 most populated countries in the world, which represent the 2/3 of the global population, the number of people suffering from PD varies between 4.1 and 4.2 million. This rate is expected to rise in the coming years, reaching values between 8.7 and 9.3 million in 2030, registering peaks in China were rates are evaluated to rise from 2 to 5 million by 2030. (Dorsey et al., 2007).

In Italy, despite the lack of recent data regarding people affected by the Parkinson's disease, 230,000 patients are estimated to suffer this pathology today. The average age of onset of the Parkinson's disease is 60 years old: in 5-10% of subjects this disease occurs before the age of 50 and, in some cases, before the age of 40 (juvenile onset). The incidence of the PD fluctuates from 5 to 10 new cases out of 100,000 inhabitants per year, but the Italian data may be underestimated. Recent studies carried out by Valent and partners show an incidence rate in the Friuli Venezia Giulia region of 389 cases out of 100,000 people, with a rise of 28 new cases per year; those data are data far superior compared to the European ones, where incidences of 15-20 out of 100,000 inhabitants per year are recorded (Valent et al., 2018; Campenhausen et al., 2005).

People affected by PD experience particular difficulties entering and remaining active in the labor market and represent lower revenue capacity than general population. Welfare to PD patients generates significant costs for healthcare services: on the one hand, Britain's National Health Service spends more than 383 million pounds per year; on the other, in Italy, according to data of a research conducted in five of the Italian regions, the average annual cost per PD patient charged to the National Health Service fluctuates between 3,500 and 4,800 euros while that charged to the patient fluctuates between 1,500 and 2,700 euros; finally, the average annual cost per patient for the community varies between 10,000 and 11,000 euros. These rates let us understand the importance of monitoring the costs related to the disease, since it may be possible to reach suitable choices in identifying the care priority thanks to precise analysis.

The total costs are estimated to rise in the coming years due to the progressing aging of the population. Infact, it is assumed that in the next few years the Italian population residing above 50 will increase from about 21 million (2001) to about 30 million (2030) and that PD registered cases will increase from today's 5,800 to 8,000 per year, causing an increase of annual expenditure from the current 2,344,700,000 to 3,199,200,000 euros.

The Alzheimer disease is the most common cause of dementia and consists in a degenerative process that slowly and progressively destroys brain cells: this disease affects memory and mental functions (e.g. the thinking and speaking capabilities), but might also cause confusion, emotional changes and spatial and temporal disorientation. According to the World Alzheimer Report of 2018 drafted by the Alzheimer Disease International, the total number of people that lives with this disease reaches slightly less than 50 million: the Alzheimer disease affects a new person every 3 seconds; those data are expected to rise in the coming years reaching about 82 million cases by 2030 and 152 million by 2050. The data referring to the worldwide distribution of Alzheimer's patients, deduced from the 2015 report, shows a particular concentration in Asia: there less than half of the patients are gathered (about 23 million), the remaining are equally distributed among Europe (10.5 million) and Americas (9.4 million), while in Africa are estimated to be about 4 million cases. In Italy, according to a research carried out by the CENSIS in collaboration with AIMA (Associazione Italiana Malati di Alzheimer) (Italian Association for Alzheimer Patients) in 2015, patients suffering the Alzheimer disease were about 600,000, 2/3 of which are women.

Today in Italy 800 thousand people are estimated to be affected by dementia and every year there are about 120 thousand new cases, 3.2% of which are old people between 70 and 79 years old while the 10.8% are over 80 years old. The treatments and cares intended for Alzheimer patients entail high direct and indirect healthcare costs: again, according to the World Alzheimer Report (2018) approximately 1 trillion dollars is estimated to have been spent globally and this amount is expected to double in 2030. In Italy, the recorded incidence per capita related to the annual costs for treatments and cares of Alzheimer patients is about 70,600 euros, 19,000 euros of which are direct costs charged on the National Health Service while 51,600 euros are direct costs fully charged on families (data recorded by CENSIS).

The disease indirectly affects those who assist the patient on a daily basis, mainly members of the family nucleus, the so-called caregivers: given that about the 80% of the patients receive assistance at home, caregivers suffer depressive symptoms, insomnia, psychophysical stress and increase their consumption of medical products (about the 30% begins taking medicine after the disease onset). The 60% of caregivers experience the worsening of the quality of life while the 25% has a direct impact on working life (Bianchetti et al., 2002).

Multiple sclerosis (MS) is a central nervous system disorder that results in damage and loss of myelin in different areas of the central nervous system: the causes of the onset of the disease are attributed to a single triggering event but often the disease affects genetically predisposed individuals as a result of environmental exposure. Considering that genes are necessary for the onset of the disease, the prevalent role of the environment in determining the risk of Multiple Sclerosis and in particular of latitude cannot be ignored. Some data concerning the geographical distribution of the disease can be explained with ethnicity and genetic factors, but latitude represents the highest risk factor after ethnicity. In fact, in regions with a temperate climate, the incidence and prevalence of the disease increases with latitude (Kurtzke et al., 1980): in this regard, the case of Australia can provide a clear example of this effect if we consider that the prevalence of MS in Hobart (south Australia) is 75.6 per 100,000 compared to a prevalence of 11 per 100,000 in northern Queensland (Hammond et al., 1988). However, the geographical distribution of the disease is sometimes connected to other

causes: in Norway, for example, the risk for the occurrence of MS does not increase due to latitude but seems to be closely connected to the coastal areas dedicated to fishing and to the consumption of fishery products (Kampman et al., 2008). Recent studies show that the prevalence of MS among low-risk regions in areas closest to the equator is in the Americas.

According to the data contained in the Atlas file regarding the MS and published by the Multiple Sclerosis International Federation (MSSIF) and the World Health Organization in 2008 (data updated in 2013), the number of patients suffering MS in the world would be about 2,300,000: 600,000 are located in Europe; as regards the distribution in Europe, the higher incidence rate are recorded in Denmark (227 cases for every 100 thousand inhabitants), Sweden (189), Hungary (176) and United Kingdom (164), while in France, Spain, Portugal and Western European countries MS prevalence data are lower than average.

In Italy patients suffering MS are estimated to be between 68,000 and 75,000 with 1800-2000 new cases every year (Istituto Superiore di Sanità, 2018; Totaro et al., 2000): the situation seems particularly worrying in Sardinia where, according to studies published by the Associazione Italiana Sclerosi Multipla (AIMS) (Multiple Sclerosis Italian Association), the incidence reaches the value of 299 new cases per 100,000 inhabitants per year.

The WHO recognizes the MS among the diseases with the higher social costs: among the neurological disorders it has a higher incidence compared to Alzheimer's disease and stroke, firstly since it mainly affects the working-age population, secondly as it reveals itself with disabilities of various degree and, above all, progressive, finally due to the expectation of life of the patient, which can reach up to 40 years after its onset. In 2001, in Europe about 15 billion euros were expended compared to the 2 billion estimated to be spent in Italy: the average social cost per patient is 38,000 euros per year, with a range that varies between a minimum of 23,000 euros up to a maximum of 63,000 euros, depending on the severity of the disease.

4. Conclusions

On the basis of the above, it is clear that the social cost of diseases affecting the central nervous system has become a significant component of the nation budgets: according to a research on European social-economic costs, in 2010 just under 800 billion euros were spent (the average cost per inhabitant is 5,550 euros), risen compared to the data previously recorded; approximately the 37% is spent on direct costs in healthcare, the 23% on non-medical direct costs and the 40% on indirect costs.

As regards to the costs of the Multiple Sclerosis and the Parkinson's disease, they amount for the former to 14.6 billion euros 5.3 billion of which represent the direct costs for the patient's care, 4.6 billion the non-medical direct costs and 4.7 billion the indirect costs – and to 13.9 billion euros for the latter (7 billion of which represent the direct costs for the patient's care, 5.5 billion the non-medical direct costs and 1.4 billion the indirect costs) (Olesen et al., 2012).

According to the World Alzheimer Report 2018, the social and economic costs related to this disease were 604 billion dollars in the world, representing the 1% of the global GDP, while in Europe the cost deriving from this disease was about 175 billion euros. Almost ten years later, the worldwide cost of the disease has been estimated to increase from 1,000 billion dollars in 2018 to two thousand billion dollars in 2030 (World Alzheimer Report, 2018).

Focusing on Italy, it is possible to highlight an increasing trend of pathological incidences and related costs: specifically, the National Health Service spends 2 billion euros for multiple sclerosis, 2.4 million euros for the Parkinson's disease and 1.8 million for the Alzheimer's disease.
Finally, it is considered appropriate to reiterate that only through targeted prevention measures and a continuous and constant synergy between the various institutional subjects involved will it be possible to achieve the dual objective of containing social and health costs and improving the quality of life of people suffering from chronic degenerative diseases.

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HOW DO EARNINGS MANAGEMENT PRACTICES DISTRACT INTERNATIONAL ENVIRONMENTAL FUNDS? EMPIRICAL EVIDENCE OF EUROPEAN DEVELOPMENT FUNDS IN ITALY

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Abstract

This study offers empirical evidence showing that Italian private firms manipulate their financial reporting process in order to benefit from capital subsidies. This attitude appears more emphasized for firms located in the Southern areas of Italy and intensifies as the amount of contribution increases. These findings are robust to alternative tests and support the arguments we elaborated to identify our hypotheses. Our first working hypothesis is that large companies discourage investment projects from smaller companies. Instead our second hypothesis is that companies in southern Italy have a higher pressure to distract Regional Development Funds than companies in northern Italy. In both hypotheses, the phenomenon of obscure accounting of European Development Fund is relevant. In recent years, both aspects of this phenomenon have been studied as a shadow in European Affairs not only by the European authorities but also by the Bank of Italy. They may be interpreted as the effects of several changes in the EU aid policy: the central role that assessing financial performance has assumed to select beneficiary firms, the EU radical trim of the total pie devoted to assisted areas coupled with a downsized role of the Italian central authorities to ensure regional cohesion has brought to light the tricky result that firms located in the poor South enjoy an even lower stake of resources as compared both to the North and the past.

Keywords: Accountability Methodology, Capital Subsidies Scheme, Earnings Management, Earnings Quality, European Development Fund, Distraction Model of Public Grants

1. Introduction earnings management practices in International Environment Funds

Capital subsidies supporting the entrepreneurial system of disadvantaged European Regions drastically dropped during the 2007-2013 European Union (EU) programming period due to the combined effect of several changes: the EU 2004 enlargement, stricter criteria to identify the beneficiary regions and areas, lower percentage of investment subsidies and a new method of aid's computation. At the same time, the EU commission imposed to beneficiary firms the requirement of

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additionality: that is firms are expected to undertake investments that would not otherwise be made in the assisted areas. These relevant changes in the EU membership and rules have implied for beneficiary firms a greater effort both to compete for a lower share of public resources and to integrate the residual unsubsidized stake of their investments either through their own internal resources or by external financing. The EU guidelines on regional aid (2007-2013 programming period) neatly express the need of "ensuring viable and sound investments with a real and sustained contribution to regional development". This EU general provision binds granting authorities of member States to define a set of criteria in order to channel public resources towards firms that are able to achieve high investment returns, as predictable by analyzing their ex – ante performance. Thus evaluating firms profitability and financial solidity becomes central for granting authorities in order to select beneficiary firms. The informativeness of firms financial accounts and the credibility of investment budgets and forecasts play an essential role to accomplish this task, as actual and future earnings, net assets and cash flows are fundamental statistics to predict firms performance. Firms, in turn, may be plausibly tempted to manipulate their accounting figures to reassure and convince granting authorities on their ability to realize fruitful investments as well as to collect and pay back integrative financial resources. The extant literature (Mura and Mulas, 2017) on public subsidies has largely analyzed their impact on firms performance, though the results are not uniform. At the same time, a large body of literature that originally focused on earnings management practices in public firms has now extended its interest also to privately held firms (Kosi and Valentincic, 2013). While recent studies on earnings management in public and private firms find that European publicly held firms exhibit lower levels of earnings management due to a monitoring effect by market forces, accounting discretion in private firms is less likely to be influenced by management contractual motives or market pressure. Conversely, financial reporting in private firms appears to be affected by other conflicting reporting objectives that include loss avoidance, tax minimization, earnings smoothing, leverage (Szczesny and Valentincic, 2012) and employee relations. In this respect, several studies (De Nichilo, 2020a) show that financial and tax incentives trigger a major conflicting behavior on earnings management in private firms, with tax incentives inducing them to moderate their taxable income to minimize the tax burden while financial incentives push them to manage earnings upwards in order to influence the perceptions of lenders about their financial performance. For the purpose of this study, showing a solid financial performance may represent a fundamental objective to take into account in the reporting process in order to increase the likelihood of benefitting from both capital grants and integrative external financial resources, as the stake of subsidized investments significantly dropped during the 2007-2013 programming period. Yet very few studies analyse earnings management practices finalized to gain capital grants and they all relate to either non - profit organizations or public firms (Verbruggen, 2012; Jegers, 2012). The immense world of for-profit private firms is still unexplored in this respect. Thus, this research aims to narrow this gap. Specifically, the purpose is to investigate whether Italian private firms manipulate their financial accounts in order to benefit from governmental subsidies after the European Union (EU) introduced a new regional aid policy for the 2007 – 2013 programming period. The endemic historical dualism between the rich North and the poor South of Italy – whose solution has always been a priority for policy makers – is another important feature of this setting. This offers the chance of observing

private firms under different incentives that may influence their financial reporting process as they operate under very different economic and cultural conditions within the same country. These studies reach the common conclusion that beneficiary firms show a higher profitability and size (Bernini and Pellegrini, 2011; Bondonio et al., 2012). Nevertheless, these studies often present analyses that overlook the accrual basis accounting rules behind the data along with an omitted neutralization of capital grant mechanical effects on operating revenues and costs (Mura et al., 2012). These limits cast some doubts about the real profitability and financial solidity of beneficiary firms as the results in these studies might also be expression of a potential commitment to earnings management aimed at receiving capital grants. In addition, the extant literature (De Nichilo, 2020b) on capital subsidies normally focuses either on a specific program or a specific geographical area at a time and rarely the analysis is simultaneously extended to both the entire territory of a country and multiple programs; when this happens generalizability and validity of the findings become an issue as the analyzed samples are small and qualitative information at firm's level poor (Mura et al., 2012). The results of our analysis strongly support our predictions showing that Italian private firms manage earnings upward and exercise accounting discretion on specific revenues and expenses in order to receive capital grants. This phenomenon is even more emphasized in the South of Italy, where firms compete for a lower stake of capital subsidies, showing an increasing manipulative behavior as the level of subsidization grows. More dramatically, beneficiary firms appear to significantly outperform their not beneficiary counterparts in terms of profitability after grant's receipt.

The structure of the paper is as follows: the introduction is an Italian literature review of earnings management practices in European Affairs, the section two gives a evidence of European conceptual framework and performance management with the main control activities. Then follows the sections on research design, results of economic modeling and conclusions.

2. EU Guidelines on National Regional Aid and capital grants recognition

Italy and private firms have been chosen as the institutional setting of our analysis for several reasons. First of all, Italy ranks as the fourth-largest economy in the EU and the eight-largest in the world (International Monetary Fund (IMF), World Economic Outlook Database, 2015) with unlisted small-medium sized enterprises (SMEs) representing the vast majority of the Italian entrepreneurial system as it happens in the main European countries (Italy 99.99%, Germany 99.98%, France 99.97% and UK 99.89%; World Bank, Eurostat Business Demography Statistics, 2014). These firms operate in a codified legal environment and heavily depend on banks and other financial intermediaries for funding their investments (Mura, Emmanuel and Vallascas, 2013). A high level of corporate taxation and a high alignment between accounting and taxation provide strong incentives to minimize the tax burden. Secondly, within the 2007 - 2013 EU programming period, Italian SMEs benefitted from about 74% of the overall investment subsidies (National Report on Governmental grants, Italian Ministry of Economic Development, 2014). In this respect, private firms turn out to be a more representative setting than public firms to evaluate whether entities engage in earnings management practices to get capital grants. Moreover, the endemic historical dualism between the rich North and the poor South of Italy –

determining a different applicable regime under the EU regional aid policy – offers the chance of observing whether private firms operating under very different conditions within the same country reply differently to a same reporting incentive. To investigate the existence of earnings management practices aimed at benefitting from capital grants under the new EU regional aid policy for the 2007 – 2013 programming period, we first describe the EU general discipline with its related aid regimes and we then focus on its application to the Italian setting in accordance with our research objective.

The Guidelines establish the permissible aid intensity, recognizing higher subsidization ceilings for regions with relevant development shortfalls and in favors of small and medium-sized enterprises (SMEs). In fact, for the 2007 - 2013 EU programming period, the Guidelines (along with the related Regulation no. 1628/2006 on the application of Articles 87 and 88 of the Treaty to national regional investment aid) set different levels of aid intensity in relation to the specific derogatory regime and to firm size (large, small and medium enterprises).
Specifically, regions and areas fulfil derogation under Article 87(3)(a) (sub 1) with a per capita gross domestic product (GDP) below 75% of the EU–25 average, including outermost and statistical effects regions. Within this group, the maximum investment aid intensity must not exceed the following thresholds:

- regions with a per capita GDP below 75% of the EU–25 average, outermost and statistical effects regions: 30%, 40% and 50% respectively for large, medium and small - sized enterprises;

- regions with less than 60% of average EU-25 per capita GDP: 40%, 50% and 60% respectively for large, medium and small – sized enterprises;

- regions with less than 45% of average EU-25 per capita GDP: 50%, 60% and 70% respectively for large, medium and small – sized enterprises.

Comparing the discipline for the 2007 – 2013 period with the previous programming period (2000 – 2006), it clearly emerges a significant change in the generosity of investment subsidization due to two combined aid features:

1) reduction in the level of aid intensity for both derogation regimes;

2) shift from Net Grant Equivalent (NGE) to Gross Grant Equivalent (GGE) in the aid intensity calculation.

The GGE (Gross grant equivalent) and NGE (Net grant equivalent) represent the amount of a capital grant as a percentage of the subsidized investment, respectively before and after the related corporate taxes.

Under the same aid intensity, GGE percentage leads to a reduced level of subsidization due to the impact of company taxes charged on the grant. Along with the lower ceilings, the reduction in the aid intensity thresholds is significantly due to the shift from NGE to GGE determination of investment subsidies. In fact, NGE represents the

residual amount of a subsidy that a beneficiary firm enjoys after paying on it the related corporate taxes, and this configuration was adopted by the EU in the aid intensity calculation for the 2000 – 2006 period in order to take into account the different taxation regimes among member States. Technically, the NGE percentage is calculated as the difference between the nominal amount of a capital grant and the company taxes charged on the benefit, divided by the assisted investment. For the subsequent programming period, the EU has opted for a nominal determination of the aid ceilings (GGE), regardless of any consideration about corporate taxation, thus leading to a less favorable subsidization. Indeed, GGE represents the nominal amount of a capital grant as a percentage of the subsidized investment, before paying on it the related company taxes, with the effect that, ceteris paribus, a firm enjoys a smaller subsidy if the ceiling is expressed in terms of GGE instead of NGE. Following the Guidelines, each EU member State must draw up a Regional Aid Map to be approved with an EU Commission decision, delimiting the regions and areas in which the investment grants are subject to a specific aid intensity. Taking into account the EU 2004 enlargement, which has decreased the main benchmark for aid intensity determination (average per capita GDP among the EU member States), reports the effects of the 2007 – 2013 EU general provision on subsidization ceilings for the Italian regions, comparing them to the previous programming period.

The Italian Southern regions (Abruzzo, Apulia, Basilicata, Calabria, Campania, Molise, Sardinia and Sicily) historically belong to the "disadvantaged areas" group in which the whole regional territory (Apulia, Basilicata, Calabria, Campania, Sardinia and Sicily) or its vast majority (Abruzzo and Molise) enjoys the derogation regimes under the art. 87(3)(a) and (c) due to their endemic economic and social shortfalls. In line with the objective of regional cohesion as prescribed by the EU aid policy, firms located in this macro area have always received more generous aid intensities than the rest of Italy (i.e. Centre – Northern regions).

In contrast the Northern and Central areas did benefit from a slight increase in the aid intensity under both the derogation and non – derogation regimes. Indeed, the marked drop in the aid intensities for the Italian Southern regions between the two periods is due to the cumulative impact of two effects. The first effect relates to a change in the aid's calculation: that is shifting from the Net Grant Equivalent (NGE) to the Gross Grant Equivalent (GGE). More specifically, according to the NGE the various ceilings of allowable aid are expressed as a percentage of the subsidized investment after excluding any corporate tax that may have to be paid on the aid grant by the beneficiary firms, while according to GGE the amount of grant is expressed as a percentage of the subsidized investment, before the related corporate tax is deducted. In a high-tax country such as Italy this implies, ceteris paribus, a corresponding reduction of the aid intensity in effective terms. The second effect is associated with the calculation of the average European Union's GDP and unemployment rate relating to 25 member States (after the 2004 enlargement). As the ranking position of the Italian Southern regions in terms of GDP and unemployment rate – as a percentage of the EU-25 average – has improved due to the entry into the UE of more underdeveloped countries, that has resulted in a fall in the two benchmark criteria for aid ceilings determination. These relevant changes in the EU rules have implied for beneficiary firms a greater effort to compete for a lower share of public resources as well as to integrate capital subsidies

in order to cover the residual unsubsidized stake, either through their own internal resources or by external financing. Comparing again the Guidelines related to the two programming periods, the 2007 – 2013 rules state an additionality requirement in order "to undertake investments which would not otherwise be made in the assisted areas" (art. 38) with the related need of "ensuring that the investment makes a real and sustained contribution to regional development" (art. 40). These two relevant requirements for aid entitlement place greater emphasis on evaluating firms profitability and financial solidity in order to recognize the subsidies. In other words, the EU general provision binds member States' granting authorities to define a set of criteria in order to channel public resources towards firms capable of achieving higher investment returns, as predictable by analyzing their ex – ante performance along with their future profitability prospects. As regards the granting procedure, this analysis is mainly focused on a consistent regional source of investment grants, namely those financed under the European Regional Development Fund (ERDF), which accounted for about 54% of the total resources for capital grants related to the 2007 – 2013 period (19,045 million of Euros, Opencoesione.gov.it).

As regards the institutional setting of our analysis, only Apulia, Calabria, Campania and Sicily fall within the Convergence scheme – with Basilicata in a transitory regime (i.e. phasing out) – while the other Italian regions are included in the Competitiveness and Employment objective. Following the Community Strategic Guidelines (CSG) and the National Strategic Reference Framework (NSRF), as a high – level strategy indication, each region is required to issue an Operational Program (OP), setting out the specific priorities of regional aid ("priority axes"), the single actions to achieve a sub - level objective in an axis with some indicators to assess the policy results.

Given the overriding discipline on regional aid assistance, notably the requirement that "the investment makes a real and sustained contribution to regional development" and the additionality effect, from a deeper analysis of selection criteria and the requirements for applying for a capital grant call (documents to attach and duration of projects' appraisal, among the others) relating to a single operative objective for each Italian region it clearly emerges that ex – ante evaluation of financial performance – along with future profitability prospects - represents an important feature of the granting procedure. Indeed, as regards historical accounting information, the vast majority of public calls for capital grants in the Italian regions requires to attach the financial statements related to the last approved operating year - or the last two in some cases. In addition, applicant firms have to finance the residual unsubsidized stake of an investment either through their own internal resources or by external financing – in a form free of any public support - in accordance with the EU regional aid regulation (art. 39 of the Guidelines). In this respect, several calls for capital grant in the Italian regions include as mandatory documents for the eligibility of an application either a copy of a loan contract demonstrating the financing of the residual stake of the assisted investment or a statement to declare the recourse to external or internal funding. With respect to the granting procedure, financial statements and successful external funding provide useful information on the ability of an applicant firm to financially sustain a new investment (financial viability) by anticipating the necessary liquidity to implement it before its related future revenues are realized, while the capacity of an investment to generate fruitful returns is generally assessed by requiring an investment

budget. Moreover, past performance (profitability and financial solidity) helps lenders assess a firm's capacity of paying back integrative financial resources and improves granting authorities' evaluation of beneficiaries' reliability.

As it will be widely discussed in the hypotheses development section, as the informativeness of firms financial accounts plays an essential role in the external evaluation of performance, firms in turn may be plausibly tempted to manipulate their accounting figures to reassure and convince the granting authorities on their ability to realize fruitful investments as well as to collect integrative financial resources (De Nichilo, 2019a). In addition, this behavior may be potentially encouraged by a more intense competition for public resources due to a reduced level of investment grants. Indeed, due to worsening economic conditions, the overall amount of national and regional subsidies dropped dramatically in 2007 – 2013 compared to the previous period. Given the dramatic drop in the total level of subsidization between the two periods, it is evident that the Italian Southern regions have borne the weight of the reduction in public aid resources compared to the Centre – Northern areas. This regional reallocation of public resources in favors of the Italian Centre – Northern regions stems from a downsized role of the central authorities in adopting incisive regional cohesion policies in order to narrow down the economic gap between the wealthy North and the poor South of Italy (Mura and Emmanuel, 2010). In fact, the overall level of investment grants in 2007 – 2013 lowered substantially in the national component of public aid measures to the detriment of the Southern regions, while the regionally - financed aids slightly counterweighted for this reduction trend, in spite of the consolidated capacity of Centre – Northern regions to channel more local resources to investment aids. All these institutional features related to investment grants will support our hypotheses development in the attempt to disentangle diverging earnings management behaviors at a macro – regional level.

3. Research Design

The analysis will focus on a vast sample of Italian private firms that comprises a group of subsidized firms during the programming period 2007 – 2013 and a control group of non – subsidized firms. As regards beneficiary firms, our research is mainly focused on a consistent regional source of investment grants which accounted for about 54% of the total granting amount during the 2007 – 2013 period (19,045 million of Euros, Opencoesione.gov.it). Previous studies often analyze either specific region and multiple programs, or a specific program relating to a large territory. As we needed to ensure rich and detailed information at firm-level (on the nature of the subsidy, the granting program, localization, financial data, etc.) relating to a large number of firms located in the entire Italian territory, our final sample reflects various selection criteria and is the result of a patient and accurate procedure. First, the group of subsidized firms is drawn from the list of SMEs benefitting from the EU Regional Development Fund that each Region has to publish on its website in accordance with the EU Commission Regulation no. 1828/2006, specifying the nature of the activities, the recognition year and the amount of public funding allocated to them. Second, from each regional Operational Program Funds we have thus managed to distinguish capital grant beneficiaries from other types of beneficiaries according to the identification code that matches single activities in a priority axis with investment subsidies. Third, after excluding beneficiary firms that are not in the form of limited - liability

companies (as they are not required to publish their financial accounts in Italy), for each beneficiary firm we have incorporated in our database information on the purpose of the investment subsidy (Innovation, Development, Research), the type of assets financed (Material, Immaterial or mixed) and the beginning year of the related project. This further information has been collected from other databases publicly available under the open data system. At this stage, we have then incorporated financial accounting data from year 2005 to 2014 as extracted from the database AIDA (Bureau Van Dijk), including some additional qualitative information about the geographical location (according to the registered and operating office), industry, ownership, year of incorporation and auditing information. To avoid the inclusion of homonyms in the process of financial statement collection, each beneficiary firm has been precisely identified with its own registration number as provided in various websites (Opencoesione.gov.it, Kompass.com and Infoimprese.it). From AIDA database we have finally gathered the financial statements of non – subsidized firms, identified among those with no amount of operating grants during the period 2008 – 2014, as separately reported in item A-5 of the Income Statement (art. 2425 Civil Code). All these steps have led to an initial sample composition of about 8,000 beneficiary firms and 31,200 non-beneficiary firms, subject to a subsequent shortening due to specific variable requirement and outlier eliminations as adopted in the empirical analysis.

The aim of our empirical analysis is to investigate whether Italian private firms manipulate their financial accounts in periods prior to the application for capital grants as a way to increase the probability of having their request accepted. The analysis of public calls for capital grants in each Italian region revealed a short duration of the period for requests' assessment – from 2 to 10 months after deadline for applications – with a tightened period for requests submissions. This leads us to infer that applicant firms may engage in earnings management practices in the financial statements related to the financial year prior to the submission of a capital grant application for two main reasons:

1) the vast majority of public calls for capital grants requires to attach the last approved financial statements at the very least;

2) the terms for submitting the application may still be open after the approval of financial statements (within the end of April), giving potential room for opportunistic accounting manipulations before the participation to a specific public call.

As regards the choice of the multivariate model, we adopt a Probit specification (probability model) in order to determine the likelihood of receiving a capital grant conditioned on several explanatory variables capturing the presence of earnings management and its intensity at regional level – as main variables of our interest – and the effect of size, leverage and profitability as suggested in prior research. Indeed, previous studies related to the impact of capital grant on firm's performance in the Italian setting indicates profitability, firm's financial solidity, size and sector as factors influencing the probability of being subsidized. Hence, our Probit model is as follows:

$$\Pr(BEN_{i,t} = 1) = \beta_0 + \beta_1 \Delta IA_{i,t-1}/TA_{t-1} + \beta_2 \Delta IA_{i,t-2}/TA_{t-2} + \beta 3 \Delta IA_{i,t-1}/TA_{t-1}*South_i + \beta_4 \Delta IA_{i,t-2}/TA_{t-2}*South_i + \beta_5 EBITDA_{i,t-1}/TA_{t-1} + \beta_6 QuickRatio_{i,t-1} + \beta_7 LEV_{i,t-1} + \beta_8$$

$SIZE_{i,t1} + \beta_9 \Delta Debts_{i,t-1}/Debts_{t-2} + \beta_{10} \Delta Equity_{i,t-1}/Equity_{t-2} + \beta_{11} IntangibleAssets_{i,t-1}/TA_{t-1} + \beta_{12} AGE_{i,t-1} + \beta_{13} FullFinancialStatement_{i,t-1} + \beta_{14} AUDITOR_i. + \varepsilon_{it}$
where:

$BEN_{i,t}$ = Dummy variable taking on the value of 1 if firm i benefits from a capital grant in year t (recognition year) and 0 for non-beneficiaries, with a missing value for beneficiaries in the periods other than the recognition year;
$\Delta IA_{i,t-1}/TA_{t-1}$ = Change in income accruals on total assets for firm i in year t-1;
$\Delta IA_{i,t-2}/TA_{t-2}$ = Change in income accruals on total assets for firm i in year t-2;
$\Delta IA_{i,t-1}/TA_{t-1}*South_i$ = Interaction term between change in income accruals on total assets for firm i in year t-1 and a dummy variable taking on the value of 1 if firm i is located in the South of Italy (Islands included) or 0 otherwise;
$\Delta IA_{i,t-2}/TA_{t-2}*South_i$ = Interaction term between change in income accruals on total assets for firm i in year t-2 and a dummy variable taking on the value of 1 if firm i is located in the South of Italy (Islands included) or 0 otherwise;
$EBITDA_{i,t-1}/TA_{t-1}$ = Earnings before interests, taxes, depreciation and amortization (EBITDA), calculated as operating income plus amortization, provisions and bad debt expense, on total assets for firm i in year t-1;
$QuickRatio_{i,t-1}$ = Current assets (except inventory) on current liabilities for firm i in year t-1;
$LEV_{i,t-1}$ = Total debts on total assets for firm i in year t-1;
$SIZE_{i,t-1}$ = Natural logarithm of total assets for firm i in year t-1;
$\Delta Debts_{i,t-1}/Debts_{t-2}$ = Percentage change in long – term debts for firm i in year t-1;
$\Delta Equity_{i,t-1}/Equity_{t-2}$ = Percentage change in equity for firm i in year t-1;
$IntangibleAssets_{i,t-1}/TA_{t-1}$ = Net intangible assets on total assets for firm i in year t-1;
$AGE_{i,t-1}$ = Natural logarithm of firm i's number of years in period t-1;
$FullFinancialStatement_{i,t-1}$ = Dummy variable taking on the value of 1 if firm i files a non – abridged financial statement in year t-1 or 0 otherwise;
$AUDITOR_i$. = Dummy variable taking on the value of 1 if firm i is subject to auditing or 0 otherwise;

Table 1: Descriptions variables. Source: Our elaborations.

The dependent variable BENi,t for the beneficiary group takes on the value only for the year corresponding to the recognition of a capital grant while the remaining years report a missing value given that our analysis aims to investigate whether beneficiary firms have manipulated their financial accounts in the years close to the recognition year – i.e. one and two years prior to it - by including in our set of covariates the lagged variables of the change in income accruals for one and two years.

H_1	A positive sign of the coefficient of ΔIAi,t-1/TAt-1 and ΔIAi,t-2/TAt-2 indicates that firms reporting – from one period to another - higher positive differences in the values of income accruals components (by overstating the valuation of inventories or reducing the other expenses subject to accounting discretion) are more likely to benefit from capital grants influencing the probability of having their application accepted. In line with our hypothesis H_1, we expect a positive sign of the coefficient related to this variable,

	resulting in an intertemporal upward earnings management behavior of beneficiary firms aimed at receiving capital subsidies (De Nichilo, 2020a). Our first working hypothesis is that large companies discourage investment projects from smaller companies.
H_2	The interaction term ΔIAi,t-1/TAt-1*Southi and ΔIAi,t-2/TAt-2*Southi determines whether firms located in the South of Italy engage more in earnings management practices than those located in the other areas in the near periods prior to their application for capital grants. In line with our hypothesis H_2, we expect a positive sign of the coefficient of this variable (De Nichilo, 2020b). Instead our second hypothesis is that companies in southern Italy have a higher pressure to distract Regional Development Funds than companies in northern Italy.

Table 2: Hypotheses. Source: Our elaborations.

The variable EBITDAi,t-1/TAt-1 should capture the importance of profitability as a requirement to benefit from capital grants in light of the EU and national provision as discussed in the institutional framework section. Hence, we expect a positive sign for the coefficient associated with EBITDAi,t-1/TAt-1, resulting in a higher probability of receiving capital subsidies for firms more profitable. The variable QuickRatioi,t-1 indicates whether firms that show stronger liquidity conditions increase the likelihood of getting capital grants.

This is also in line with the firms objective to persuade lenders to cover the unsubsidized stake of the assisted investments with external financing. In line with prior research on capital subsidies in the Italian institutional setting (Bernini and Pellegrini, 2011), we expect a positive sign for the coefficients of variables LEVi,t-1 and SIZEi,t-1, indicating that more indebted and bigger firms are more likely to benefit from capital grants.

The variable IntangibleAssetsi,t-1/TAt-1 proxies for the attitude of a firm towards innovation and allows to control for the innovative propensity of beneficiary firms and their assisted investments as a requirement particularly appreciated in most capital grant schemes related to R&D and innovation technologies.

Table 3 A and B shows descriptive statistics for the set of variables used in our model, respectively for beneficiary and non – beneficiary firms.

Variable	N. Obs	Mean	Median	Std	Min	Max
$Ben_{i,t}$	7,187	1	1	0	1	1
$\Delta IA_{t-1}/TA_{t-1}$	7,187	0.0080	0	0.0664	-0.5746	0.5413
$\Delta IA_{t-2}/TA_{t-2}$	7,187	0.0116	0	0.0738	-0.5341	0.6001
$\Delta IA_{t-1}/TA_{t-1}$ South	7,187	0.0038	0	0.0371	-0.3614	0.5413
$\Delta IA_{t-2}/TA_{t-2}$ South	7,187	0.0052	0	0.04489	-0.3893	0.6001
$EBITDA_{t-1}/ TA_{t-1}$	7,187	0.0946	0.0825	0.0854	-0.3923	0.5049
$QuickRatio_{t-1}$	7,187	0.5847	0.5794	0.2482	0.0007	3.2830
LEV_{t-1}	7,187	0.6386	0.6703	0.2084	0.0117	1.9579
$SIZE_{t-1}$	7,187	14.8574	14.9292	1.4096	9.6881	17.7641

$\Delta Debts_{t-1}$ /$Debts_{t-2}$	7,187	0.0268	0	0.1756	-0.8063	1.6332
$\Delta Equit_{t-1}$ /$Equity_{t-2}$	7,187	0.1696	0.0444	0.6795	-3.8326	7.7657
$IntangAssets_{t-1}$ /TA_{t-1}	7,187	0.0495	0.0124	0.0894	0	0.5966
AGE_{t-1}	7,187	2.686	2.7726	0.8069	0	4.6540
$FullFinStat_{t-1}$	7,187	0.3156	0	0.4647	0	1
AUDITOR	7,187	0.3334	0	0.4715	0	1
$Subs_t/TA_t$	7,187	0.0156	0.0104	0.0148	0.0001	0.0550

Table 3A: Beneficiary. Source: Our elaborations.

Variable	N. Obs	Mean	Median	Std	Min	Max
Ben	156,740	0	0	0	0	0
$\Delta IA_{t-1}/TA_{t-1}$	156,740	0.0004	0	0.0794	-0.6379	0.4242
$\Delta IA_{t-2}/TA_{t-2}$	156,740	0.0018	0	0.0868	-0.6389	0.4242
$\Delta IA_{t-1}/TA_{t-1}$ South	156,740	0.0005	0	0.0384	-0.6347	0.4237
$\Delta IA_{t-2}/TA_{t-2}$ South	156,740	0.0007	0	0.0417	-0.6348	0.4239
$EBITDA_{t-1}$/ TA_{t-1}	156,740	0.0507	0.0322	0.1054	-0.4699	0.5167
$QuickRatio_{t-1}$	156,740	0.5195	0.4427	0.4687	0.0001	3.7200
LEV_{t-1}	156,740	0.5917	0.6535	0.3234	0.0001	2.0813
$SIZE_{t-1}$	156,740	13.0709	13.0496	1.4636	9.0852	17.7695
$\Delta Debts_{t-1}$ /$Debts_{t-2}$	156,740	0.0138	0	0.2100	-0.8415	1.6990
$\Delta Equit_{t-1}$ /$Equity_{t-2}$	156,740	0.0779	0.0133	0.7019	-3.8524	7.8849
$IntangAssets_{t-1}$ /TA_{t-1}	156,740	0.0237	0	0.0717	0	0.5976
AGE_{t-1}	156,740	2.6408	2.5649	0.6338	0.6931	5.3706
$FullFinStat_{t-1}$	156,740	0.0611	0	0.2394	0	1
AUDITOR	156,740	0.0498	0	0.2175	0	1
$Subs_t/TA_t$	156,740	0	0	0	0	0

Table 3B: Non-beneficiary. Source: Our elaborations.

4. Results

This section discusses the results of our Probit regression model by determining the probability of getting capital subsidies conditionally on a set of covariates including the change in income accruals, the regional location and several firm's characteristics (profitability, leverage, size and governance). Our primary concern is to gain insights on how changes in income accruals are associated with the likelihood of receiving a capital grant in order to verify the prediction of hypothesis H_1. Our second concern is to focus on the Southern area of Italy in line with our hypothesis H_2, in order to determine the existence of a more emphasized upward earning management practice in the pre – granting period (De Nichilo, 2019b).
We now move into a multivariate setting to verify hypothesis.

Explanatory Variables	Coefficients[40]	Robust Standard Error
Constant	-8.039***	0.1148
$\Delta IA_{t-1}/TA_{t-1}$	0.5007***	0.1094
$\Delta IA_{t-2}/TA_{t-2}$	0.3464***	0.1052
$\Delta IA_{t-1}/TA_{t-1}$ South	0.5489***	0.2125
$\Delta IA_{t-2}/TA_{t-2}$ South	0.6677***	0.2005
$EBITDA_{t-1}/ TA_{t-1}$	2.6358***	0.0869
$QuickRatio_{t-1}$	0.1762***	0.0139
LEV_{t-1}	0.4210***	0.0277
$SIZE_{t-1}$	0.4625***	0.0070
$\Delta Debts_{t-1}$ /$Debts_{t-2}$	0.0664**	0.0336
$\Delta Equit_{t-1}$ /$Equity_{t-2}$	0.0005	0.0096
$IntangAssets_{t-1}$ /TA_{t-1}	1.8263***	0.0782
AGE_{t-1}	-0.2343***	0.0142
$FullFinStat_{t-1}$	0.2491***	0.0214
AUDITOR	0.3109***	0.0253
N. Obs	163,927	
R^2	0.4084	

Table 4: Probit regression for the likelihood of getting a capital grant Probit Regression. Source: Our elaborations.

As expected according to hypothesis H_1, our accrual variables show a statistically significant positive coefficient, indicating that firms with an increasing positive change in income accruals in the periods prior to the recognition of a capital grant have a higher probability of benefitting from it. In other words, firms tend to overstate revenues in the valuation of inventories and/or reduce the amount of bad debt expense, provisions or deferred taxes from one period to the other with the aim of improving the representation of their financial performance in the pre – granting period. In line with our hypothesis H_2, this intertemporal upward earnings management turns out to be more significant for firms located in the Southern part of Italy, revealing the existence of a stronger incentive to engage in accounting manipulations in an area heavily affected by the relevant changes in the EU regional aid policy and in the distribution of national subsidization funds over the 2007 – 2013 period. As discussed in the institutional framework section, the relevance of financial performance as a requirement to benefit from capital subsidies is captured with the highly significant signs of variables measuring profitability (EBITDAt-1/TAt-1) and financial solidity (QuickRatiot-1), showing that more profitable firms and with a sound financial structure have a higher probability of receiving a capital grant. In line with prior research on capital subsidies, regression results confirm that beneficiary firms show higher levels of leverage and size in the period prior to the recognition of a capital grant, as it has emerged in the descriptive analysis. This may be interpreted as a financial signal of a past creditworthiness reputation in collecting external complementary funds for the unsubsidized stake of investments.

[40] * Significance at 10%;
** Significance at 5%;
*** Significance at 1%.

5. Overall Conclusion

In line with our expectations, this study offers empirical evidence showing that Italian private firms manipulate their financial reporting process in order to benefit from capital subsidies. This attitude appears more emphasized for firms located in the Southern areas of Italy and intensifies as the amount of contribution increases. These findings are robust to alternative tests and support the arguments we elaborated to identify our hypotheses. They may be interpreted as the effects of several changes in the EU aid policy: the central role that assessing financial performance has assumed to select beneficiary firms, the EU radical trim of the total pie devoted to assisted areas coupled with a downsized role of the Italian central authorities to ensure regional cohesion has brought to light the tricky result that firms located in the poor South enjoy an even lower stake of resources as compared both to the North and the past. In addition, as business plans and investment budgets represent further documents for selecting beneficiary firms, results on firms' profitability after grant's receipt show that beneficiary firms significantly outperform their non-subsidized counterparts, confirming that capital grants do not trigger efficient investments capable of enhancing existing financial performance. These findings shed new light on the productivity of governmental subsidies in contrast with the results of prior research on capital grants impact in the Italian setting by taking into account the manipulations on some components of firm's profitability and the mechanical effects of its related accounting treatment. In accounting terms, this evidence suggests that financial reporting quality in private firms presents another potential deviation from reporting true firm performance as the incentive to manipulate earnings to get capital subsidies appears to be prevailing with respect to other conflicting financial reporting objectives under a tax-non tax costs/benefits evaluation of adopting an income-increasing choice (De Nichilo and Pedone, 2009). This in turn generates two relevant implications: on one hand, this finding potentially explains the reason of so many conflicting results in the capital subsidy literature that analyses the effect of capital subsidy on firm's performance. After all, firms performance is based on hard accounting data that our analysis shows that may be influenced by an opportunistic exercise of accounting discretion aimed at getting governmental subsidies not previously investigated in the literature relating to private firms. On the other hand, users of private firms financial statements – notably granting authorities and lenders - should carefully rely on this set of reporting to infer information on firms financial performance. Nonetheless, in terms of implications of the new EU aid policy, it still remains central the need to improve the selection process of the beneficiary firms in order to channel public resources in favors of firms that are really capable of realizing fruitful investments. Some efforts should be addressed to mitigating the adverse impact of the 2007 – 2013 EU Regional aid policy at the expense of the Italian Southern regions with a countervailing role of central authorities in the distribution of public resources among macro-areas coupled with a stricter ex-post assessment of the assisted investments in terms of congruous returns to society. In this respect, further analyses on the distribution of beneficiaries value added among the various stakeholders (workers, lenders and owners) may represent a useful room for future research. As regards limitations, this study has focused exclusively on a specific European country as Italy that presents some uniqueness in its institutional framework thus complicating the extension and generalizability of our results to other settings (De Nichilo and Regogliosi, 2011). In addition, as the contents of investment budgets are not publicly available the analysis

has not allowed to univocally determine the reasons of the drop in profitability of beneficiary firms after grant's receipt.

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