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Research article

Geographical scattering in Italian inner areas, politics and COVID-19

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Abstract: In recent months, the COVID-19 pandemic has been fervently considered from the perspective of various disciplines in the scientific community. Many of the proposed approaches are tied to reflections on the imminent and future effects of the pandemic. This contribution begins with a study of the recent past in Italy, analyzing the hurdles in politics that came to light due to the wave of COVID-19 infections worldwide. Particularly, the research considers the criticality of the geographical scale of reference in Italy’s political actions. COVID-19 induced a need for the government to interact with people locally, especially through small municipalities in geographically central, inner areas, is emphasized. The main aim of this research is to attribute to this specific COVID-19 disaster the instrumental role of turning on the lights on the need to intervene in the inner areas of Italy, often very neglected. So the focus of the work is on inner areas and the probable catalysis of the political management dynamics that concern them, as an effect of the COVID's impacts. The pandemic is, therefore, only the contingent phenomenon which, in this case, can perhaps accelerate political interventions in inner areas. To explain the reason for this, we show how the vulnerability of inner areas, already generally risky, has become one of the weak links in the chain of protection from COVID-19 in terms of a geographical scattering phenomenon.

Keywords: inner areas; Italy; COVID-19; politics; geographical scattering

1. Introduction

In the literature (for example [1]) it is widely recognized that in a crisis a centralized decision-making system is more efficient than a multi-level political architecture of governance because centralized decisions allow urgent responses to be quickly implemented. However, the decisions that were adopted in Italy during the first wave of COVID-19 in undifferentiated form, did not take into account the diversity of the spread of the virus between the different territories. Therefore, very strong restrictions were imposed on all areas, also in particular on inland areas that recorded very low infections due to the morphological barriers and their inaccessibility which limited the spread of the pandemic. A scenario of "low resolution" and "low sensitivity" of the actions implemented by the central government thus emerged.

Several important studies [2–9] have demonstrated the influence of environmental factors in the spread of COVID-19. However, this contribution intends to add the specific declination to the case of inner areas as an incremental value of the research. This approach is developed from two perspectives.

First of all, we show how it is useful for these areas to add specific factors, and to this end we have considered profitable the use of a diffusive model valid for scattering phenomena.

Secondly, we highlight how due to the importance of the specificity of inner areas, amplified by the dynamics of COVID-19, it is even more necessary to intervene to solve some historical criticalities of these areas and to stop some policies that not addressed in the direction of their strengthening. An example that will be proposed is relative to the elimination of the Mountain Communities (particular Italian administrative bodies).

Many of the environmental factors that facilitate the spread of the virus are not very present in inner areas, such as pollution, or not very relevant compared to areas with greater population density, such as the correlation between wind and diffusion. This explains the low contagion phenomenon in these areas. However, the rapid and intense spike in infections in certain places in these areas remains to be explained. This peak, for what has been said, should not be attributed to environmental factors, but to specific factors of inner areas.

Zhu and Xin [10] have demonstrated that increasing temperature in regions or periods below 3 ℃ is related to the high risk of transmission, which provides useful information for policymakers if the novel coronavirus coexists with human for a long time. This is important for our study of Italian inner areas, where climatic conditions are often those described by Zhu and Xin. Particularly, the Italian inner area named Irpinia treated in our analysis, has an average winter temperature which is below this threshold temperature. However, given the low contagion data in the first period of spread of COVID-19, our model wants to highlight how other factors, as inaccessibility, highlighted in the following sections are also responsible for the specific spread of the virus in inner areas.

Wind-speed plays, in fact, positive role in spread of COVID-19 [11]. Irpinia is a region characterized by strong winds and in this case too the low number of infections highlights a specific influence of other factors in the spread of the virus. Again specific factor of inaccessibility could be able to explain the peculiarity of these inner areas.

Irpinia is historically considered a green lung with very low levels of pollution, therefore, according to the study by Bashir et al. [12,13], there should be no infections. Once again, therefore, our scattering model allows to correlate the peak of infections to other specific factors of table 1 of the internal area and not of an environmental type.

Therefore, here we want to reflect about the impacts: analyzing the situation (and as showed in next sections the data taken in an example are from the Italian Civil Protection) we want to highlight that, whatever are the variables of influence involved in the phenomenon, the current effect is a scattering effect. So we don't wont investigate the differences between inner—non inner areas respecting to the different parameters but an endogenous approach. That is, within the same inner area, a take off can be generated in these terms: from homogeneous all low contagion values deriving from the isolation of the inner areas, a peak value can be generated out of control.

Italian area of Irpinia really lends itself very well to this dynamic (we provide more information about this area in the revised text) because it is really an inner area that is not very accessible and therefore suitable for generating a two-stage dynamic: (1) COVID-19 does not go through the low accessibility; (2) If, however, COVID-19 spreads despite inaccessibility of these inner territories, the same inaccessibility hinders health services and creates a dangerous peak value.

Real data confirmed this sad scenario.

Therefore, in this paper we intend to highlight two aspects relating to the effects of a past in which the internal areas have been neglected.

The first aspect relates to the lack of targeted actions according to the different geographic scale, as already underlined above, while the second aspect concerns the negative impacts due to the absence of basic and health services which have always characterized these areas and which so far have not found a response from the government.

2. Critical issues of inner areas before COVID-19

A sort of political solidarity already existed in Italy before the COVID-19 pandemic swept the world; it is present at regional, provincial, and municipal levels for all parties. A common factor in each of these political spheres is a scarcity of economic, material, and human resources; administrators must solve problems utilizing the resources in their institutional buildings without relying on long and drawn-out government agendas.

During electoral campaigns, the representatives of the central government support their candidates in an identity manner. However, once a candidate has come to power, these same figures often find themselves alone in solving urgent daily problems alongside alternating regional policy conditions. This scenario is most often found in the inner areas of the country, with a fracture that has been growing for decades.

On the one hand, central politics' actions for inner areas are generally founded on sporadic funding call, or calls for bids, rather than substantial interventions and permanent allocations of investment funds. Whereas, on the other hand, in emergency situations or after catastrophic events, central politics often enters into the fray with rapid investments. This was the case in 1980 after the Irpinia-Basilicata earthquake struck southern Italy and after the Vajont dam's collapse in 1963.

In more tranquil times, inner areas of Italy are often logistically inaccessible. The locations are deprived of essential services and are subject to depopulation, especially from residents in or entering the labor force.

Macchi Jànica and Palumbo recently edited a volume [14] that summarized "abandonment" as a longue durée historical-geographical process that began during the agrarian crisis of the 1880s and which progressively increased in speed and range after the postwar period. The effect is widespread, even touching those flat-and-hilly areas that are not generally affected by urban growth and tertiary activities.

Tiziana Banini [15] recalled that this concept is also associated with responsibility. In fact, the term "abandonment" evokes emotional reactions through affective suggestions linked to something that is no longer present, be that something tangible or intangible, such as the individual and collective responsibilities of political representatives and parties. The "abandonment" depopulation phenomenon is of both national and supranational significance. In some European areas, a "new-type" of depopulation, based on reduced numbers of residents, has overlapped with the "old-type" of depopulation, which was based on migratory movements [16].

The profiles, and the relative dynamics, of the young people who remain, abandon, and eventually return to small villages have been well characterized by Carr and Kefalas [17]. They identified "permanent" workers struggling with the dying agro-industrial economy of the country's central territories, and the successful "makers" linked to academic careers in big cities (in most cases, these individuals definitively abandon their place of birth, only to return on special occasions and religious holidays).

The study of depopulation phenomena has enriched scientific debate, especially in the last two decades, both in Italy and abroad [18,19]. Various political responses to the phenomena in Italy's inner areas have been documented, ranging from opposition and trivialization to acceptance [20–22].

From a geographical-historical point of view, the great demographic changes that characterized the end of the twentieth century influenced both the size of Italy's population and its structure [23]. The reduction in births and the increase in life expectancy in European countries should have generated a negative or stable population growth rate [24], however, immigration has countered these changes, contributing to an increase in the population [25,26].

Actions must be taken to reverse the central areas' administrative deprivation phenomena [27]. In addition to accessibility issues, depopulation is linked to the availability of services, the integration and cohesion of scattered territories, and the ability to know how to exploit the landscape to attract tourists [28,29], or integrate with the local economy based on agriculture (agro-city) with value-added products [30,31].

3. The political problem of geographical scale before COVID-19

As an element of transition between old and new urban visions, the theme of scale was approached by Soja [32], who proposed the idea of urban growth as achieved through a phase of multiscalar regional urbanization. In another work, the same author coined the term "exopolis" ([33], p. 459) to highlight an urban representation that no longer exists and is, therefore, "ex".

But the COVID-19 pandemic has highlighted the total absence of an exopolis, contrasted by a great rift between urban and inner areas. The epidemic's impact has been far from geographically homogeneous, even within most infected zones [34]. Researchers found high mortality rates in municipalities associated with lower income levels, lower household dimensions, low employment levels in service and trade industries, and high percentages of workers in industrial sectors. This suggests municipalities located in peripheral areas (ibid).

A capitalist vision has arisen, seeing regionalism as a sort of redemption of global capitalism. This is based on political conjectures [35], on critical social constructs [36], and struggles in exclusion and development. The Chicago and Los Angeles schools of thought find that the relationship between regionalism and the conception of metropolises still assumes dichotomous forms, theoretically contrasting the urban core with inner areas [37].

New metropolitan growth is now destabilizing conventional territorial definitions, which did not adequately take into account the fluid multiscalar nature of urban areas.

Distinction between urban, rural, and non-urban and the traditional urban-inner area dichotomy, represent analytical categories that have been overcome by new interpretations and configurations of urban reality and centered on the existence of a regionalization process, in which the regions compete with cities in generating innovation. Today, urban areas face conflicts related to citizenship, the right to the city, and urban democracy [38].

Yet this leitmotif of dissolving old patterns does not correspond to overcoming socio-economic or technological differences between urban and inner areas. The process of "osmosis" between urban areas and Italy's interior has so far failed, also concerning the a-spatial digital theme. If on the one hand this osmosis was to be avoided in total form, in order to safeguard the identity and characteristic traits of the internal areas, on the other hand the politic has been totally loser towards the big technological players in the implementation of digital strategies in the inner areas to fill the gaps in existing services. Although inner areas are often considered "areas of market failure," they may still demonstrate a promise of capillarity through digital technologies.

This was the scenario, pre-pandemic. COVID-19 has acted as a catalyst for the above-mentioned phenomena; the particular dynamics of the contagion detected in Italy's inner areas has now forced the central government to deal with these areas and address their long-standing issues, linking central state actions with decentralized zones.

The contribution is organized as follows. The next section takes up the themes mentioned in this introduction, contextualizing differentiated regionalism in relation to pre- and post-pandemic scenarios. Subsequently, the peculiar dynamics of contagion that have affected the inner areas are illustrated in the context of scattering phenomena [39]. The lessons that have been taught by the pandemic are reflected upon, such as the transitioning of policies and inner "Mountain Communities"[1] into Unions of Inner Mountain Municipalities. Conclusions close the work.

4. Materials and methods

We have noticed that the scattering phenomenon taken from the data of the Civil Protection (of which we'll give in the following an example regarding the Italian area of Irpinia) follows the diffusion model that we have reported in the appendix. Therefore, we have not created an analytical model, but we have found an existing diffusion model that fits well with the COVID-19 situation in inner areas.

4.1. The phenomenon of "geographical scattering" in the spread of the contagion in inner areas

As noted in the above section, the problem of a geographical scale of reference for government actions pre-existed COVID-19. However, the pandemic has amplified the characteristics of the problem and given more urgency to finding solutions.

While, for instance, the United States has a federated system based on each state maintaining its own political decision-making independence, local administrators do not hold that role in Italy. The necessity to act, and quickly, regarding national and regional lockdowns have highlighted this contrast between the two countries. During the first wave of the virus, Lombardy and Veneto were severely affected by the infection, and divergences between central and local politics on a regional,

[1] A mountain community is an Italian local authority established by law no. 1102 and now governed by art. 27 of lex. 18 August 2000, n. 267 (consolidated act on local authorities): this is a public body with compulsory membership, established by provision of the president of the regional council between mountain and foothill municipalities, also belonging to different provinces, with the aim of enhancing mountain areas, for the exercise of its own functions, conferred, as well as the associated exercise of municipal functions.

provincial and municipal scale were limited. This was not so during the second wave, where divergences were frequent.

In some cases, the central government seemed late in intervening with the closure of all activities; in others, it was accused of untimely closings with enormous economic damage to all commercial activities. This second aspect emerged with particular emphasis in some inner areas unaffected by the contagion, which were also forced to close their activities. It is clear that there was not a high level of resolution of central policy actions, as the actions were not capable of discriminating between areas in relation to the risk to which they were subject, causing government and local cooperation to disintegrate.

In order for the government to resolve policy issues on a local scale, it is first necessary to fully understand the peculiar dynamics of the contagion in the country's inner areas. This begins by creating a geography of risk to represent the compass used for central policy actions. The knowledge of risk levels associated with certain geographical areas, suggested by thematic maps created in advance of a possible threat, is a fundamental prerequisite for effective efforts of disaster mitigation [40].

There are two perspectives regarding reducing natural and biological threats in a geographic context: endogenous and exogenous. Endogenous refers to an area that is the location of risky endemic phenomena, such as areas with foreseeable volcanic or seismic risk factors. Evacuation plans are drawn up to prepare for such events, and progressive levels of increasing risk are defined. Exogenous refers to external dangers that can be channeled into certain areas, such as occasions when COVID-19 was transported into the country's inner areas. The threat is not specific to a given territory in this circumstance, so the central government must evaluate the disease's virulence in relation to territorial characteristics that can hinder or favor COVID-19's spread and effects.

A series of well-known geographical phenomena may have constituted the basis of an information system to aid in central policy and emergency management choices.

For this reason, reviewing the scientific literature on diffusion models, we have identified a model suitable for describing the specific dynamics of inner areas. In these areas there has been a Boolean spread with either very low levels of contagion or geographically concentrated peaks. A suitable model for such a scenario is scattering model.

Certainly, geographical scattering, regarding the alternative two-stage spread (massive absence/presence) of the epidemic, has in fact characterized the country's inner areas. Scattering arises in a mainly physical field with reference to the modeling of particle phenomena of radiation-matter interaction in which abrupt changes in the direction of motion occur.

The condition of a rapid modification of the state in correspondence with the exceeding of a threshold has lent itself over time to the use of this modeling in very different areas, relating to economic, financial, social, and even geographical situations. In the context of COVID-19, the radiation-matter interaction ratio typical of scattering is defined in terms of the interaction between a generic phenomenon and the geographical characteristics capable of determining impulsive modifications and great intensity of variation in limited time intervals [41].

The literature in this area offers several studies based on the modeling of diffusion phenomena concerning the geographical context. Particularly, Carrillo and Gonzalez [42] underlined the evidence that the analytical growth curves, and in particular the logistic models [43], constitute discrete proxies that can describe the incremental trend of a variable (for example, the epidemic contagion rate) in a determined time interval, which then always evolves towards a saturation condition in which the curve asymptotically assumes a horizontal trend.

Based on these approaches, the fundamental model of the spread of the infection can be expressed through differential equations. The existing diffusion model that we believe fits well with the COVID-19 situation in inner areas, is shown in the appendix.

According to this model, two overlapping scenarios are possible: one with external influence and another with internal influence.

In the case of external influence, it is assumed that the contagion is induced by an external source from where the spread is located. This would indicate no correlation between the previously infected and the potentially infected in terms of their influence on the spread of the infection. Therefore, this model's validity finds good experimental confirmation precisely in the inner areas that, either as a result of geographical, cultural, or technological barriers, are isolated (i.e., in which individuals have low interpersonal relationships with the outside world).

The case of internal influence is the opposite of the prior case. It is based on a contagion dynamic foreseeing the diffusion of the virus due to the distribution of interpersonal relationships.

A joint model may better represent reality, with a synthesis of the previous two models incorporating external and internal influence parameters.

One of the first applications of the joint influence model was carried out in 1969 by Bass [44], who used it successfully in marketing elaborate sales forecasts subject to geographic gradients. In the first years of the model's formulation, the model was used in different ways. Webber in 1972 used it to investigate the trends of localization processes [45]; Lawton in 1979 used it to evaluate the diffusion of new teaching methods in schools [46]; Warren in 1980 used it to make a forecast of the market for new solar technologies [47].

This joint model best represents the "scattering" contagion phenomenology characterizing Italy's inner areas. As demonstrated in the vast scientific literature [48–52], these inner areas present factors that are normally considered critical, as shown in Table 1. The criticalities include physical inaccessibility and low network clustering in workplaces or external areas; they are usually resolved through infrastructural interventions carried out by private operators or marked as "market failure areas" by public entities. In the event of an epidemic, paradoxically, these factors prove to be a defense against the spread of the infection, as indicated with a "+" in Table 1.

However, this mechanism is characterized by two stages in which possible phases of the infection spread are recognizable. The infection either does not spread or is present in low levels in the first phase; the disease does not penetrate the area from the outside or trigger a spread. However, if the natural defense, often linked to the inaccessible inner areas' morphology, is overcome, a contagion is triggered. In this case, the possibility of reaching critical mass in the form of an epidemic outbreak is very high. In fact, the contagion may grow rapidly in inner areas, even outpacing the spread in other infected places.

Ghosh and other authors [53] consider saturated treatment function to describe the saturation phenomenon of the limited medical resources. This condition, taken into account in general form by the authors, is for us a specific condition of inner areas and is together with the inaccessibility the main triggering factor of the scattering phenomenon.

Table 1. Characteristics of Italy's inner areas. Source: authors' elaboration.

Inner areas	Value with respect to contagion	Example reference literature
Territorial fragmentation	+	[54,55]
Lack of work	+	[56–60]
Lack of essential services	–	[61,62]
Inaccessibility	+	[63–65]
Sense of community	+	[66–69]

Geographic scattering in inner areas shows a two-stage dichotomy of the growth profile, presenting an inversion inflection in the contagion curve (the "take off" point) in which the saturation condition of the curve has a high slope. From that moment on, the contagion is mainly induced by internal influences and augmented by the critical factors which, in the first phase, had proved to be a positive defense against external contagion (inaccessibility, absence of hospital facilities, lack of welfare services). These critical factors are reconsidered as negative and accentuate the infection diffusion rate (represented by a "–" sign in Table 1).

As an example proof, Irpina's inner areas demonstrate the reality of the COVID-19 situation and its adherence to the geographical scattering model (Figure 1).

Irpinia totally coincides with the Province of Avellino, in Campania, in Southern Italy. It is a landlocked Apennine area. The extension of the territory is approximately 2,806 km^2 which goes from the Municipality of Avella to the west, passing through the capital Avellino, up to Monteverde to the east. Inside it has a total of 118 municipalities and a population that slightly exceeds 400 thousand units. It is divided into three fairly distinct geographical parts with diversified views: Lower Irpinia, which largely coincides with the Avellino hinterland and also the most inhabited pole of the Province. Then there is Alta Irpinia, the area where the mountain development becomes higher. The other part of Irpinia is the Baronia, with its sweeter and hilly landscapes rather than the upper part and large expanses of cultivated fields.

Irpinia is a land of mountains and often unspoiled nature. The Partenio Mountains stands out to give protection to the capital, while inside we find the Picentini Mountains with some of the highest peaks in Campania.

In recent decades, Irpinia has suffered a great depopulation caused by various factors, among which they could be recognizable their inaccessibility conditions relative to its natural morphological barriers, and the great earthquake of 1980.

By analyzing the data made available by the Department of Civil Protection of the Presidency of the Council of Ministers[2], it is possible to highlight the presence of geographical scattering. This relates to an area covering many municipalities with very low levels of contagion, contrasted with the Ariano Irpino municipality, in which the contagion curve, reporting contagion data in absolute value in march 2020, followed the trend of the model (Figure 2)[3].

The case, in relation to the anomalous data[4], caused such a sensation that investigations by the

[2] https://mappe.protezionecivile.gov.it/it/mappe-emergenze/mappe-coronavirus.

[3] The contagion data are in absolute value, but as the considered municipalities are small and relatively homogeneous, the transition to percentage data referring to the total inhabitants does not significantly change the data.

[4] 51 deaths from COVID-19 of the 317 in Campania.

Prosecutor's Office are still ongoing. Although some institutional representatives have controversial positions[5], a paradigm created by the lack of services, materials, and human resources has clearly emerged. The lack of general practitioners and ambulances has hindered the municipality of Ariano Irpino and has created a situation of disproportionate infection growth in the inner areas.

Experts use these models to predict future pandemic hotspots, and policymakers should use them to avoid other instances of scattering phenomena following the lack of territorial medical services in inland areas. They must also take precise steps to avoid large-scale closures with disastrous economic effects.

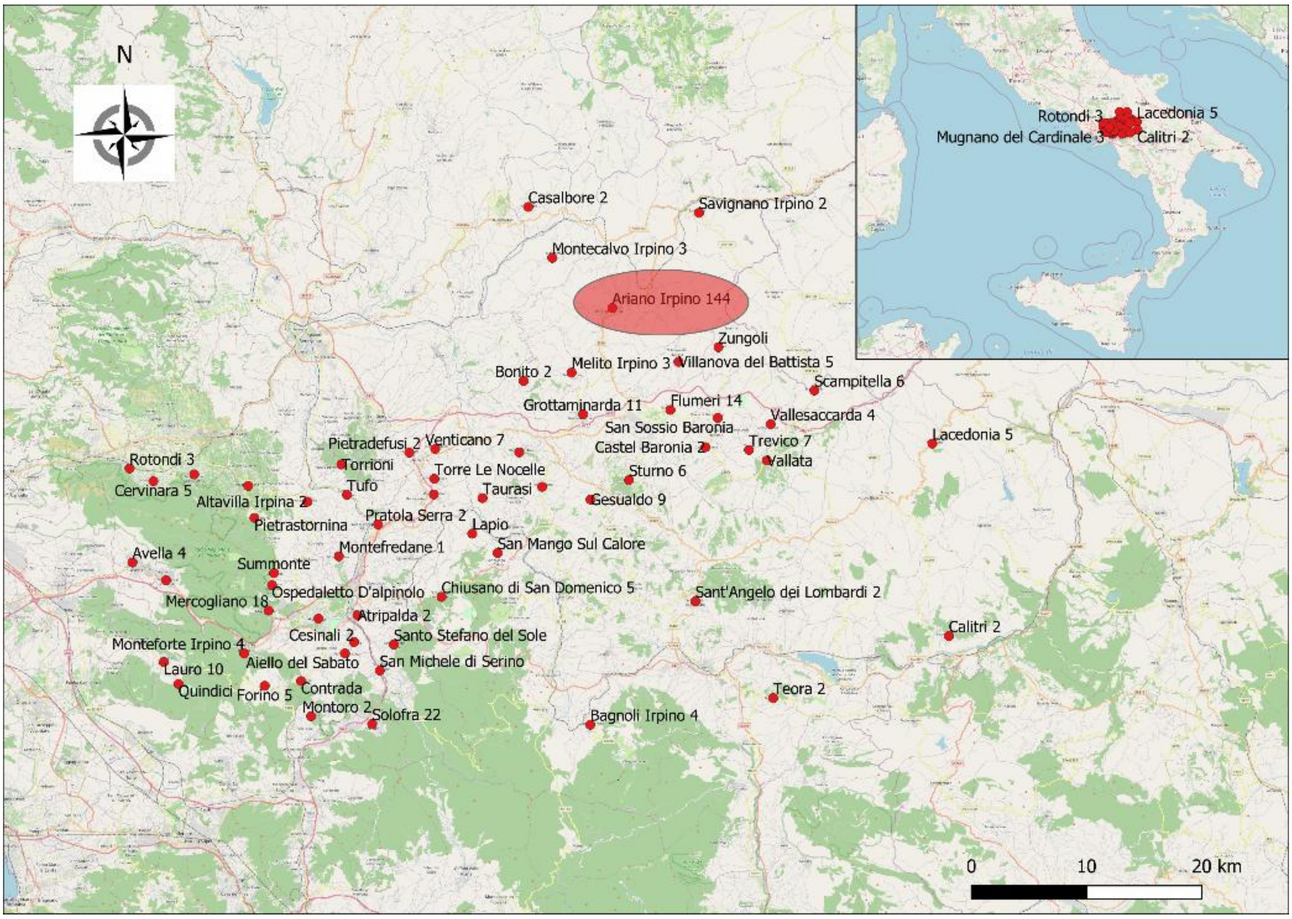

Figure 1. Distribution of the locations affected by the COVID-19 infection in Irpinia. Source: authors' elaboration on Civil Protection Department data.

[5] The contrasting positions between an Irpino deputy and the regional delegate for the inner areas have been reported in the main Irpinia newspapers.

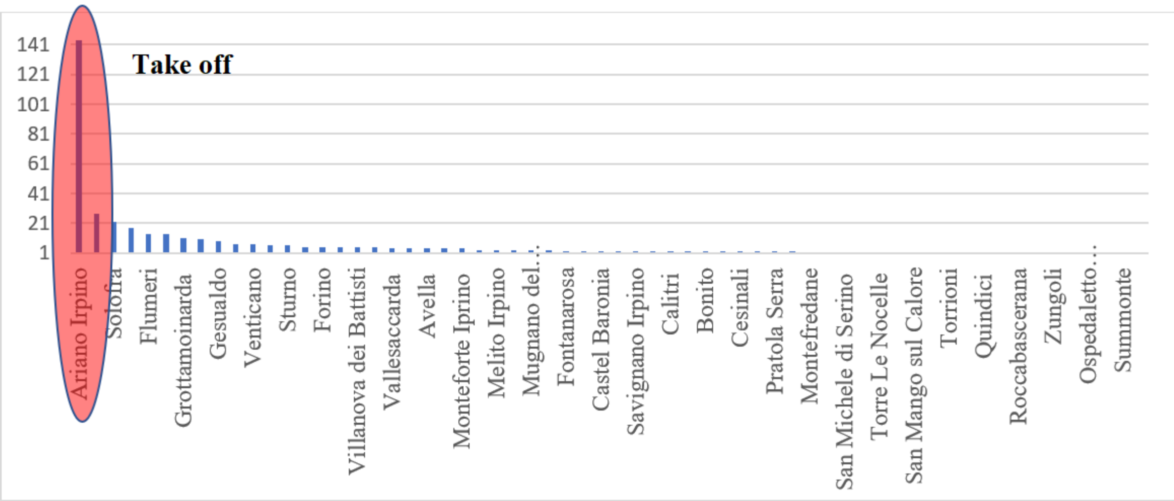

Figure 2. Geographic scattering relating to the COVID-19 contagion in Irpinia. Source: authors' elaboration on Civil Protection Department data.

5. Results. lessons from COVID-19: an invitation to system policy in inner areas

The case of (wrong) transition from inner Mountain Communities into Unions of Mountain Municipalities.

If anything good can be taken from this sad COVID-19 experience, it would be the turnaround of policy orientations undertaken before the pandemic. Among these was a roadmap launched by the central government to combat inner area concerns, including an organizational transition of particular inland mountain areas.

All of these areas have a common denominator in their inaccessibility and absence of services. This particular category of Italy's internal areas has been organized in an associative Mountain Communities (MC) system.

In accordance with the law that established the Mountain Communities (article 3, law 1102 of 1971), the MCs are local entities with legal standing and their own Statutes. They consist of mountain municipalities in inland areas, whose territories are included in a homogeneous area identified by regional law.

From the moment of their establishment until the early 2000 s, the Mountain Communities grew in number, reaching 355, totaling 4,320 Municipalities (53.3% of Italian Municipalities). Such a spread was due to both economic and political motivations. The substantial funding for mountain interventions provided by an investment fund and a specific national fund for current expenses, distributed, according to population and territory, to the municipalities belonging to the Mountain Communities, certainly had an impact. But the Municipalities also found an opportunity for new protagonism in the Mountain Communities. They not only participated in the determination of supra-municipal guidelines but also provided for their implementation [70].

The Law 267 (Consolidated text of local authorities), in 2000, transformed the Mountain Communities into "unions of Municipalities, local entities established between mountain and partially-mountain municipalities, also belonging to different provinces, for the enhancement of mountain areas for the exercise of own functions, functions conferred and for the associated exercise of municipal functions."

At the state level, the sector legislation remained, sanctioning the equation between a "municipality in a mountain community" and a "mountain municipality" (art. 2 of law 97/94). This was done to attribute benefits, such as access, through the association, to financial resources destined to the mountains. A classified mountain municipality could, then, individually benefit from a series of financial incentives, relating to pensions and taxes. However, economic benefits linked to the implementation of mountain enhancement rules are more closely connected to belonging to the Mountain Community that manages its use [71].

The current situation has evolved from a rationalization of the policy's costs through the introduction of the 2008 financial law (Legislative Decree 112/2008), which assigned savings targets for the regions. It also introduced criteria that regulate the municipalities' belonging within MCs and bind their survival to compliance with requirements, such as one for altitude. This is done with the scope of both achieving savings objectives and avoiding reorganization.

In this framework, a reduction of mountain bodies (EIM, 2009 and 2010) was required, so many regions proceeded to abolish or redefine the number and territorial structures. At the same time, the Legislative Decree 112/2008, in ordering cuts to state funding to the Mountain Communities, sanctioned the concept of "average altitude" of the MC as a parameter on which to measure the cuts themselves.

As a result of the aforementioned law of 2008, the CMs present in Italy today have fallen from the original 355 to 94, distributed throughout 6 Regions, namely Lombardy (23), Trentino Alto Adige (22), Lazio (22), Campania (20) and Veneto (2). The municipalities that compose the MCs total 1382 for over 40,000 square kilometers and a total population of just over 4 million inhabitants.

In most of the regions, the authority was partly suppressed and partly transformed into a Union of Mountain Municipalities or replaced with the establishment of program areas (as, for example, happened in Tuscany, Piedmont, Marche, Emilia Romagna, and Basilicata). Even in the Regions where the CMs remain, some downsizing has occurred. Campania reduced the number of CMs from 27 to 20 and Sardinia from 25 to 5. In Veneto, the majority of CMs were transformed into a Union of mountain municipalities (the two existing CMs are also being reformed).

Although the downsizing process of the Mountain Communities has occurred and is still in progress, new orientation frameworks that place the mountain in inland areas at the center of political action are struggling to emerge. Therefore, a situation has arisen in which new parameters overlap an obsolete legal classification that is still alive and operating, leaving a context of legislative uncertainty that can scarcely affect mountain territories' real development.

Italy's inland mountain areas have often constituted a field of investigation that has revealed some scientific instruments' inadequacies. They, therefore, form a domain for knowledge and research that should be explored from different perspectives. This especially regards geographical types, representing 35.2% of the Italian territory [72].

Under the stimulus of growing demand from local communities, policymakers, and development planners, multi and interdisciplinary approaches have been adopted to address perceived research deficits. Thereby, an attempt was made to combine the knowledge of environmental conditions typical of inland mountain areas with their inhabitants' economic and social development strategies.

Evidence that can already be found in the combined provisions of Presidential Decree 98 of 1955 and Law no. n 1102 of 1971 in which the mountain community was defined as an innovative, compulsory, second degree local body, having a programmatic and instrumental nature in reference to regional policies.

Precisely from the point of view of the mountain communities, this effort has resulted in adopting systemic models. A system is defined as a set of parts linked by interdependent functions in which the functions of the system itself are superior to those developed by the sum of the parts [73].

This general definition is particularized with a property functional to the Mountain Communities' role in ecological terms. An emergent property cannot be deduced simply in terms of the individual components' properties in these MCs. Therefore, the ecological difference between emergent properties (those of the system) and collective properties (referring to the individual components) is repeated in the relationship between mountain communities and mountain unions.

Recourse to mountain unions appears to be an operational artifice of managing various critical issues. Above all, it is linked to the Italian territory's morphology, which presents a pulverization of municipalities ranging from a few inhabitants to millions of inhabitants. This heterogeneity generates considerable difficulties in the exercise of administrative functions due to complex scenarios over large territories and the management of diseconomies characterized by small and very small territories. The union of municipalities, as a tool, provides services to small municipalities effectively through the associated management of administrative functions. However, this appears to be a compensatory solution for the phenomenon that embraces the legislator's interest.

The latest law concerning local authorities, with a profound impact on them, is law no. 56, from 2014. It was established to encourage the formation of unions of municipalities, as well as municipality mergers (Figure 3).

Although the law does not dictate a discipline for mountain communities, which are "cited" by the law in question solely with reference to unions and the mergers of municipalities, it introduces mountain provinces based on principles of differentiation, effectiveness, and administrative action efficiency; this has been guiding the legislation in recent years [74].

In this passage, a functional transition can be seen, which relegates the mountain unions to assume a role in purely managerial functions in the associated form. In this way the character of the planning and programming functions established by law no. 1102 of 1971 were lost.

Several studies highlight the criticalities of sharing urban, economic, and social functions [75,76]. These are based on Garrett Hardin's ecological scheme, which speaks of the "tragedy of the commons". However, just as many works highlight how, in some cases, sustainable use of resources requires collective action in and between user groups, government agencies, and other actors. Mountain Communities are fully included in this context, with their original functions and the systemic approach that represents the main differentials compared to the simple associative management recognizable in the Mountain Unions' strategy.

Mountain communities' systemic approach induces models of polycentric governance in which multiple and autonomous decision-making centers can share overlapping responsibilities within a particular coordination area managed by the MC [77,78].

The systemic behavior that characterizes CM is based on its ability to regulate actions functionally. This takes the form of a retro-control function to induce a convergent situation of stability accessed by the elements of the system (the single municipalities afferent to the MC) to shared resources and maximize resource distribution, according to an ecological process known as homeostasis.

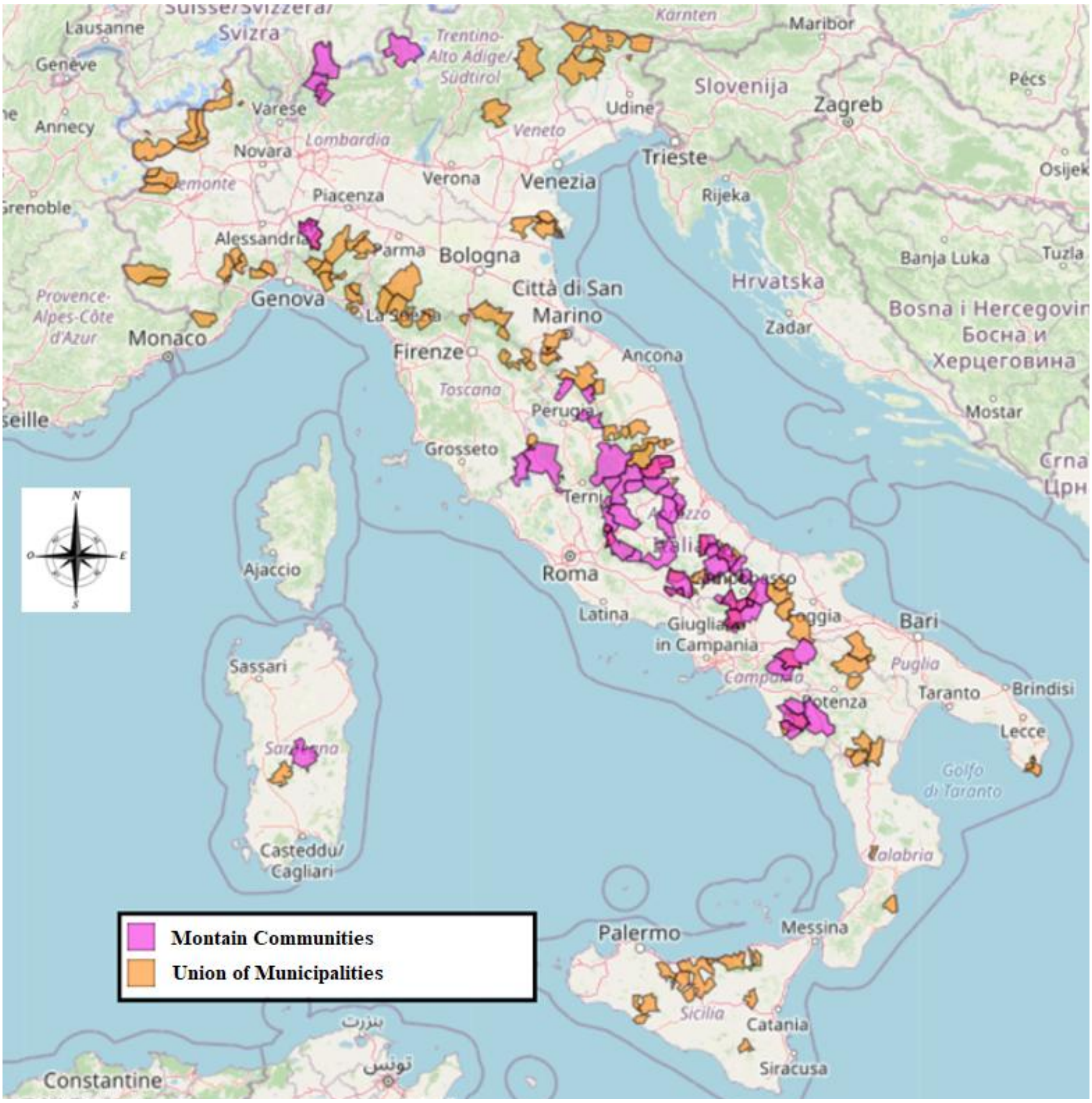

Figure 3. Mountain Communities vs. Unions of Municipalities, 2019. Source: authors' elaboration on data from the Territorial Cohesion Agency.

In a collective action, such as that of simple aggregates of municipalities or unions of municipalities that today are replacing mountain communities, conflicting scenarios arise concerning the single aggregated realities' subjective interests. In this, the mountain realities assume iso-marginal features with territories characterized by scarcity of resources [79]. Other problems of collective action free from forms of systemic governance, such as that of MCs, can occur when individual entities share common goals but have limited information on others' behavior, making coordination and mutual adaptation difficult [80].

Therefore, the adoption of a form of systemic governance proves to be functional for the shared planning necessary to contrast isomorphic scenarios of a scarcity of resources that characterize the municipalities belonging to the various Mountain Communities of the country's inner areas.

This could be a positive corollary of COVID-19, that of a returning to strengthen the systemic form of organization of these inner areas. The geographic scattering from COVID-19 in inner areas, and the data from the mountain area of Irpinia taken as an example in the previous section, demonstrate that precisely this form of system approach has been lacking in providing medical and other services.

6. Conclusions

Inner areas in Italy are defined by the government in an institutional document as areas affected by increasing depopulation, high rates of demographic ageing, geographic marginality, and various degrees and forms of inequalities in the provision of services and infrastructure.

Even before the pandemic, these areas showed the need for particular attention, never received in an exhaustive form, with respect to the problems of their marginality.

The pandemic has shown specific and particular dynamics in these areas, which have exacerbated the pre-existing criticalities.

Therefore, the proposed research has aimed to provide an overall picture of past, present, and future scenarios of Italy's inner areas in relation to the particular period that is being experienced.

The COVID-19 storm has highlighted very inhomogeneous spatial dynamics, especially regarding the contagion differentials and the differentials of territorial medical services between urban and inner areas. We showed that a particular physical phenomenon, such as scattering, could be well defined in terms of geographic scattering with respect to the dynamics of contagion in the country's inner areas. To highlight the particular focus that shoud be considered for inner areas, particularly in this COVID-19 era, we have not created an analytical model, but we have found an existing diffusion model that fits well with the COVID-19 situation in inner areas.

The lack of knowledge of such modeling has induced dichotomous negative effects on the part of geographical policies.

On one hand, although the inland areas were without major infections compared to other areas, in these areas all the activities with serious socio-economic inconvenience to the population were closed due to provisions of the national government.

On the other hand, where sudden, rapid and intense infections occurred according to the proposed model, the lack of territorial medicine services and the inaccessibility of inland areas has generated many risks and in some cases many deaths for the population of those areas.

These two political paradoxes have highlighted pre-existing gaps and criticalities in these areas, like rocks submerged by normality that have emerged in the pandemic's low tide.

Due to the pandemic, in fact, past errors came out, such as the transition of interior municipalities from Mountain Communities to Unions of Municipalities here described. This has highlighted a policy that was too attentive to economic efficiency and less attentive to system approaches' strategic utility in deprived areas.

The results of this research highlight some practical implications for politics, local actors and stakeholders involved inside phenomena of territorial connection between different scales.

First of all, it should be necessary to strengthen a multilevel policy that sees the national government, the regions and the local systems represented by the municipalities of the inner areas as an integrated system.

Secondly, a "place based" approach should be adopted, aimed at defining, through a partnership process, territorial development strategies against inaccessibility, depopulation and its causes, and enhancing the capital and capabilities of inner areas. In this way it could be possible to remove the factors limiting development and strengthening essential services (education, health, transport) for socio-economic and productive development.

Third, it could be useful encourage experimental approaches on some "pilot inner areas" that can inductively spread good practices to other similar areas.

Finally, considering the threat of COVID-19 as just one of the many threat factors able to raise the risk's level for these areas, it is necessary to consider this experience as a leverage towards a transition from a temporary attention towards these areas to a permanent one.

6.1. Appendix—an analytical model of the spread of the infection in inland areas

The spread of the contagion model can be expressed as:

$$\frac{dN(t)}{dt} = g(t)[\bar{N} - N(t)] \quad (1)$$

With the boundary condition: N (t = t_0) = N_0

Where: N (t) =$\int_{t0}^{t} n(t)$= cumulative number of infected people at time t. n (t) is the number of infected people at time t. $\bar{N}$= Total number of infected potentials at time t, i.e. the maximum possible number of infected, hence the asymptote of the diffusion curve. $\frac{dN(t)}{dt}$= rate of spread of the infection at time t. g (t) = diffusion coefficient. N_0 = cumulative number of infected people at time t_0.

The spreading model of the contagion presented in (1) is a deterministic rate equation in the sense that this rate, at a certain time, t turns out to be a dependent function directly proportional to the difference between the total number of possible infected persons detected at time t and the number of previously infected persons evaluated at the same instant of time $[\bar{N} - N(t)]$[6].

As a consequence of this formulation, as soon as the cumulative number of previous adopters N (t) approaches the total number of possible adopters in the social system, the diffusion rate begins to decrease (upper part of the diffusion curve). $\bar{N}$.

The relationship of proportionality between the diffusion rate and the number of potential adopters is linked to the nature of the diffusion coefficient g (t).$\frac{dN(t)}{dt}[\bar{N} - N(t)]$.

The specific value of g (t) depends on multiple factors: on the characteristics of the spreading process, on the nature of the contagion, on the geographical characteristics of the area in which it spreads. If the characteristics of the context g (t) are outlined, it can be considered a constant coefficient of proportionality.

Furthermore, the diffusion coefficient g (t) can be interpreted as the probability of adoption at

[6] The model does not take into account any issues related to the real effectiveness of the COVID-19 tests, which are supposed to be ideal with zero errors.

time t. According to this interpretation, the product represents the expected number of adopters n (t) at time t. $g(t) \cdot [\bar{N} - N(t)]$.

Furthermore, if n (t) is seen as the number of individuals of the social system who pass from the potentially infected state to the infected state at time t, then g (t) can be considered as an epidemic transfer mechanism, similar to a conductivity coefficient.

Two different approaches are generally used to represent g (t). The first considers g (t) as a time-varying function; the other considers g (t) as a function of the number of previously infected.

By evaluating this last approach in detail, we have:

g (t) can be expressed as a function of N (t) in these terms:

g (t) = a + bN (t) + cN (t) 2 + ...

But for analytical simplicity only one of the following 3 simplified representations is used:

g (t) = a

g (t) = bN (t)

g (t) = (a + bN (t))

where a and b are model parameters.

If g (t) = a the general diffusion model takes the form:

$$\frac{dN(t)}{dt} = a[\bar{N} - N(t)] \quad (2)$$

This form is known as the spreading model of the contagion with external influence.

If g (t) = bN (t) the general diffusion model takes the form:

$$\frac{dN(t)}{dt} = bN(t)[\bar{N} - N(t)] \quad (3)$$

This form is known as the spreading model of the contagion with internal influence.

Finally, if g (t) = (a + bN (t)) the general model of spread of the infection takes the form:

$$\frac{dN(t)}{dt} = bN(t)[\bar{N} - N(t)]\ [\bar{N} - N(t)] \quad (4)$$

This form is known as the joint influence diffusion model.

Model with external influence.

The general diffusion model takes the form:

$$\frac{dN(t)}{dt} = bN(t)[\bar{N} - N(t)]$$

The constant term “a” is defined as the coefficient of external influence with respect to a certain geographical area of reference assumed as an area of diffusion and represents the influence exerted by factors of influence on the process of spreading the infection that are not peculiar to the area. Examples can be represented by contagion carriers coming from outside the area, workers from the area residing in other areas, transporters, tourists, etc.

By integrating equation (2) member by member, this is obtained:

N (t) = which implies $\bar{N}[1 - \exp(-at)]ln\left[\frac{1}{1-\frac{N(t)}{[\bar{N}]}}\right] = at$ if N (t = t0= 0) = 0

The general shape of the curve of this model is such that as time increases the cumulative number of infected people increases in an anti-exponential way up to a maximum with constant “a”.

Internal influence model.

Such a model $\frac{dN(t)}{dt} = bN(t)[\bar{N} - N(t)]$ provides for the conditions that are totally opposite to the previous model, i.e., it is based on a paradigm of “contagion” which foresees the diffusion exclusively as a consequence of the existence, in the social environment, of interpersonal relationships.

Therefore, the spread rate can be expressed exclusively in terms of function between the previous infected N (t) and the potential infected in that geographical area. $\bar{N} - N(t)$

As in the previous case, integrating equation (3) member by member one obtains the cumulative distribution function of the infected:

$$N(t) = \frac{\bar{N}}{1 + \frac{(\bar{N} - N0)}{N0} \exp[-b\bar{N}(t - t0)]}$$

From which:

$$\ln\left[\frac{N(t)}{\bar{N} - N(t)}\right] = \ln\left[\frac{N_0}{\bar{N} - N_0}\right] + b\bar{N}(t - t0)$$

Where: N ($t = t_0$) = $N_0 > 1$ since for the model to be applicable, there must be the consistency of at least one initial infected, patient 0.

The constant b is defined as the contagion coefficient or internal influence coefficient by virtue of the fact that, as already highlighted, it reflects the degree of interaction existing between the previous infected N (t) and the potentially infected $\bar{N} - N(t)$.

Joint influence model.

The joint influence model:

$$\frac{dN(t)}{dt} = bN(t)[\bar{N} - N(t)]\ [\bar{N} - N(t)]$$

Author contributions

Conceptualization, SDF; methodology, SDF and GF; writing—original draft preparation, SDF and GF; writing—review and editing, SDF and GF; supervision, SDF and GF. Particularly, section 1, SDF and GF; section 2 and 3, GF; section 4 and 5, SDF; section 6, SDF and GF; Appendix, SDF. Authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare to not have any conflict of interest.

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