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ANNs AND GEOGRAPHICAL INFORMATION FOR URBAN ANALYSIS EVIDENCE FROM THE EUROPEAN FP7 SECOA PROJECT

1. Introduction

The need to collect and compare data so that social scientists could study urban development began to be addressed in the 1960s, when UNESCO set up the ISSC (International Social Science Council) to interpret increasingly global urban phenomena and satisfy the need to identify models capable of describing the evolution of these phenomena. The advantages and disadvantages of comparative analysis with regard to the quantity and quality of available data were taken into consideration from the outset (Montanari 2012a). While the natural sciences have similar problems, the methods used do not require total comparability so much as repeated tests using the same procedures, and possibly the same approach (Montanari 2012b). The need to identify a shared interpretive model for all the world's cities derives from the fact that the economic and cultural impetus behind the growth of these cities has a common matrix, which is stimulated by communication and information exchange. In Calvino's poetic interpretation (Calvino 1972), every city derives from a common model. This general model contains all the standard features of a city; as a good public administrator, Kublai Khan, who is conversing with Calvino's fictitious Marco Polo, must take the model into consideration and envisage necessary exceptions to the rule, calculating the most probable as well as the most convenient combinations.

The writer Calvino's theory (Calvino 1974) was used as a reference point by the geographer Berry (1976), in marked contrast to the position adopted at the time by the International Geographical Union (IGU) regarding the fundamental differences between countries with free market and planned economies (Montanari 2012a). The existence of a common reference model has been confirmed by a number of studies over the past few decades. Cities will continue to grow, and to spread the impact of the changes they are undergoing to the surrounding territories in a number of different ways that, however, always derive from a shared model. Therefore, identifying a benchmark urban model – however complex the task – must continue to be the objective of research so as to understand processes, create a framework for policy intervention and anticipate possible future scenarios. Traditional inference methods were generally used to construct these models. This was possible as long as there was a relatively small quantity of data. In recent decades, however, new variables have been added to the earlier ones to correlate environmental changes with economic and social development as well as the significant amount of geographic data generated by contemporary society. From the 1992 Rio de Janeiro conference onwards, it was agreed that all countries would take environmental concerns into account for all human activity. This principle has gradually become entrenched within the fields of analysis, programming and research. In Europe, Framework Programme 7 (FP7, 2007-2013) has made it a factor in all EU-funded research projects. The new requirements that emerged as a result of the 1992 conference include that of dissemination, i.e. the need to communicate the results of complex computational procedures to the various categories of stakeholders that make up civil society.

This article looks at two elements of geographic analysis applied to urban processes: GISystems, software for analyzing geographic information, and GIScience, theories and methods to interpret geographic information. Self-Organizing Maps (SOM) are a type of Artificial Neural Network (ANN), initially studied by Kohonen, Hynninen, Kangas and Laaksonen (Kohonen *et al.* 1995), capable of automatically organising data within an artificial space in such a way as to group together data with similar characteristics while distancing dissimilar data. They are therefore able to preserve the topological relationships of archived data and produce output maps that can be analysed using a GISystem.

Because the "Solutions for environmental contrasts in coastal areas. Global Change, human mobility and sustainable urban development" project (SECOA) used data originated from the experiences of the natural and social sciences, the data collection and processing stages were complex. Complexity is characteristic of our society and, to explain phenomena related to us, it is increasingly necessary to analyse all the available data, whatever their origin: if these phenomena exist, they are relevant in one way or another to the formation of reality. So they must be identified and measured using the expedients that make it possible to subsequently include them in the rest of the information. SECOA considered two levels of phenomena: global ones such as climate change and human mobility, and local ones that emerge in the form of conflicts, the dynamics of urban growth, and natural, environmental, social and economic characteristics at the local level. The local is reliant on the global in that it is the positive or negative result of decisions taken and policies applied at a higher level. But the local level also concentrates all the consequences of improper management at the global level while contributing, through its errors and positive behaviours, to changes at the global level.

2. Methodological reflections

2.1 *From data to knowledge*

The results of the bibliographical research (Viaggiu 2013, 56-76) imply that up until the first ten days of the year 2000, little work had been done on the application of SOMs to GISs. Indeed, if we consider the articles published in scientific journals over the last thirty years, it is clear that twenty per cent of these publications concerned theories and models, ten per cent concerned urban analysis, and almost as many GIS and spatial analysis applications, while fifty per cent of the articles deal with medicinal applications. Moreover, around ninety per cent of this work has been published within the last ten years (Montanari 2013).

Skupin and Agarval (2008) remind us that in order to better understand the phenomena behind economic development and degradation of the environment, it has been necessary to produce a large quantity of geographical data. This process has further accelerated in recent years, during a period of economic crisis and climate change that has led to a reciprocal cause and effect situation in the local-global relationship. At a local level, the geographical data immediately showed, and continue to develop, a quantitative acceleration, the size of the pixels, as well as a qualitative acceleration, thanks to the use of satellites and GPS. At the same time, this further global-local relationship allowed refinement of the quality of the data at the local level, and greater comparability at the global level. This volume of data changed the methods of analysis and interpretation. Lacayo (2011) holds that the current volume of available data makes impossible to organise them by traditional methods, since the type of information that is necessary for knowledge of the phenomena is held in databases that can exceed hundreds of terabytes. The great potential for knowledge represented by the further increase in the quantity of data available remains bound by the fact that knowledge is ever more difficult to reach in relation to the complexity of the data. Ackoff (1989), and later Bellinger, Durval and Mills (Bellinger *et al.* 2004), and Bernstein (2009), developed a series of theories known by the term Data, Information, Knowledge, Wisdom (DIKW), for moving from the data-gathering stage to the information and then knowledge phases.

The practice of gathering and then processing data in what has become known as the Internet age has found further application and development in research into Data Mining (DM) and geographical knowledge (Giannotti, Pedreschi 2007; Buscema 2013), and on the subject of file sharing (Aigrain 2012). Berry and Linoff (1997) define data mining as the process of exploration and analysis of large quantities of data, with the end goal of identifying the hidden correlations between the pieces of information and making them visible. Alongside data mining, we should also remember the processes of Business Intelligence (BI), a term that indicates a series of processes for gathering and analyzing strategic information, the technology used to implement these processes, and the information they draw out. The relationship between data mining and statistical tools is constituted by their aptitude to a learning process that takes the data as a reference in order to convert them into information. Skupin and Agarval (2008) consider that in a situation with numerous data and complex phenomena, traditional methods of inference are ineffective or even constitute an obstacle to interpretation of the geographical entities, their relationships and meaning. Specifically, statistical analysis found an application in the field of spatial autocorrelation and in solving some problems linked to the traditional approaches. The use of computer-aided processes such as DM and knowledge discovery in databases (KDD) represented a solution that was not decisive. Lacayo (2011) proposed using GISystems as spatio-temporal and non-spatio-temporal components, turning them into pseudo-spatio-temporal components with SOMs.

2.2 *Knowledge and geographical information*

Skupin and Agarval (2008), in order to better position the relationships between SOMs and GIScience, consider it necessary to differentiate between supervised and unsupervised neural networks, and between feed-forward and recurrent ones. The type of SOM they took into consideration is one they consider traditional, used in clustering and display, presupposing an ANN type with competitive learning and no hidden layers (Londei 2013a).

The relationship between SOM and GIScience has occurred above all in one direction, the latter using the former for analytical purposes, with the reverse occurring relatively rarely. Lacayo (2011) points out that after the work of Kohonen, Hynninen, Kangas and Laaksonen (Kohonen *et al.* 1995) and the presentation of Li (1998), developments in the combined use of SOMs and GISystems were limited despite the separate progress made in the two methods. With Skupin and Agarval's volume, a new phase was opened in the use of SOMs and the possibility of them interacting with GIScience. Bação, Lobo and Painho (Bação *et al.* 2008), faced with the presence of large quantities of available data, introduced the need to reduce their number to quantitative and qualitative dimensions which are able to contribute to knowledge of the phenomena.

Lacayo (2011) also spent time on the difficulty of moving from data to information and from information to knowledge. Data are the primary and specific values of each object, while information is their structural form, which responds to questions such as who, what, when, where, and how many? The answer to these questions allows further information to be acquired and therefore knowledge of the phenomena.

Skupin and Agarval posed the problem of how SOMs can be adapted to the needs and paradigms of GIScience. Numerous researchers have tried to contribute to the creation of an industrial product, but this has not been fully realized yet and therefore it is still necessary to continue research in order to try to adapt SOMs to the needs and functionalities of GIScience. In many scientific fields, classification of objects is based on the similarity of their attributes. In GIScience, the concept of similarity considers both the "attribute space" parameter and geographical space, and the concept of similarity therefore assumes the value of proximity.

2.3 *Data values and their geographical representation*

Goodchild (2008), who introduced the concept of GIScience around twenty years ago (Goodchild 1992), notes that the SOM algorithm describes objects which are not necessarily located in the geographical space and makes no reference to their location. On the contrary, GIScience starts with the assumption that all objects are georeferenced. For this reason, the worlds of SOM and GIScience researchers have had few interests in common, and therefore little contact. Bação, Lobo and Painho (Bação *et al.* 2008) propose incorporating the First Law of Geography (FLG) into the SOM system so as to check for a possible balance between geographical proximity and the proximity of the values of attributes (Tobler 1970). The FLG is based on the concept that each variable is connected to all others, but those referring to phenomena which are close together are much more so than those which are distant. Some have criticised the FLG inasmuch as it appears to be a simplistic interpretation of geography in a situation which seems much more complex than can be explained by the simple relationships established between objects which are close together. In particular, it would seem impossible to explain complex ecological and socio-economic situations simply by looking at the spatial relationships established between the different entities. Despite these observations, the FLG is a reference for many scholars of geography and the social sciences, who consider it useful and satisfactory for their research. From a general point of view, the FLG distinguishes geography from the other disciplines as it assigns a specific and relevant meaning to the spatial component. Certainly the FLG cannot be considered in and of itself an exhaustive concept, but on the basis of this principle it is possible to extrapolate geo-spatial interpretation systems to better understand the present and anticipate what may happen in the future. Longley, Goodchild, Maguire and Rhind (Longley *et al.* 2005) assert that it is impossible to imagine that two maps of the same area, even though they may illustrate different phenomena, do not reveal some kind of similarity.

They therefore conclude with the assertion, based on numerous methods of statistical inference, that a spatial autocorrelation equal to zero is in contradiction with what seems evident based on the TFL. Complex Adaptive Systems (CAS) theory suggests that proximity may be a sufficient parameter. This happens because the interactions that occur at the local level, while simple, can contribute to the formation of global behaviors, often much more complex, which are not completely predictable or manageable. Montello, Fabrikant, Ruocco and Middleton (Montello *et al.* 2003) introduced the concept of displaying the semantic content of non-spatial information, such as documents in libraries. The principle of spatialisation is based on the "distance-similarity" metaphor. On the basis of the FLG, it is distance that determines similarity. The metaphor is based on assumptions analogous to the FLG, but arrives at opposing conclusions in that it is similarity that determines the distance in spatialisation, and this principle was named the First Law of Cognitive Geography (FLCG). The FLCG is based on empirical research in which the participants evaluated the similarity between documents depicted as points in spatialised displays. Further inspiration into the use of SOMs in GIScience came from the work of Tobler and Wineberg (1971), which referred to the use of cuneiform tablets to identify the location of the ancient urban settlements in Cappadocia. This analysis was performed on the basis of the number of tablets found in a settlement, which referred to other settlements.

The authors expressed their conviction that mathematical models based on contemporary urban structures have a temporally and geographically invariant structure and could therefore be used for Cappadocia. The research did not make reference to roads that existed at the time, only to the distance between the settlements. It was therefore then possible, solely on the basis of the distance, to identify the relative position and thereby hypothesise the geographical co-ordinates of the settlements to identify.

Tobler (2004), on the basis of observations and criticism of his work, explains that in the case of Cappadocia, the spatial gravity model was overturned to identify the missing settlements. Or, additionally, that spatial autocorrelation does not always have to be positive, as is evident from the effects of NIMBYism (Not in My Back Yard) in contemporary society.

2.4 *Geography and ANNs*

Bação, Lobo and Painho (Bação *et al.* 2004), starting from the assumption that one of the objectives of spatial research is the construction of uniform and homogeneous regions, considered the possibility of creating a Geo-Self-Organizing Map (Geo-SOM). Geo-SOM constitutes a tool to identify homogeneous regions for which it is possible to perform predictive analyses using tools that allow positive and negative correlations to be displayed. Bação, Lobo and Painho warn that in many scientific fields, classification is aimed at grouping different entities based purely on the notion of similarity of their attributes. In GIScience, classification is a compromise between the similarity understood as "attribute science" and that which identifies the "proximity" of the geographical space. An example of this theory is the application of Geo-SOM to the data from the 2001 Portugal census, composed of 70 attributes for 250 counties, categorised in relation to the number of inhabitants. Kropp and Schellnhuber (2008), on the other hand, used SOMs to examine the relationship between climate, soil type and global distribution of vegetation. In their case, the SOMs were used to analyse a large, multidimensional database using an algorithm that provides quantitative measurements for the topological ordering (SOMTOP model). When the data analysed are also georeferenced, it is then also possible to create maps with the classes indicated. Skupin and Hagelman (2005) relate the processing of the socio-economic variables for all of the 254 county units in Texas for the years 1980, 1990 and 2000.

A method is proposed for the spatialisation of the multitemporal and multidimensional trajectories using SOMs and GISs to represent them. The experiment provided good results, although the difficulty of integrating the corresponding software components remains, which the authors described as "loose coupling of SOM and GIS components". Fincke, Lobo and Bação (Fincke *et al.* 2008) explained the function of the SOM algorithm to present a number of frequently used display techniques. They also showed a method for importing the data processed with SOMs into a GIS environment, so that operations intended for spatial analysis may be applied to data which are originally non-spatial. Yi-Chen Wang and Chen-Chieh Feng (2011) report research performed on around 700 articles published between 1987 and 2007 in seven specialist publications concerning "land use/ cover change" (LUCC). The analysis of these papers was performed with SOMs whose results were then presented in visual form in order to contribute to better understanding of LUCC research activities. Li and Shanmuganathan (2007) applied a "social area analysis" model to Beppu City, a town in Japan. The authors noted that this type of analysis, particularly frequent in the preceding decades, has been performed little recently, for two main reasons: (i) The excessive simplification of the complexity of the residential urban structure, particularly through the use of linear correlation methods which often gave trivial results and (ii) The large quantity of work necessary to view the spatial characteristics of the phenomena. Combined use of SOMs and GISs allowed socio-spatial divisions in Japan to be identified as being above all in relation to age, or more precisely to the different periods in the life of each individual. Beppu City was therefore identified as being divided into two macro-areas, in turn divided into 6 and 2 sub-areas, for a total of 8 social areas.

Goodchild (2008) holds that SOMs do not consist of a trivial complement to the spatial analytic toolbox, but rather constitute a new paradigm for Exploratory Spatial Data Analysis (ESDA) and for spatial data mining. The ever-increasing use of SOMs and the good results this method provides poses major questions of GIScience in general and of its research agenda. At the same time, it is a positive signal for the writers of GIS software, in that they will have to consider the need to create a stand-alone toolbox rather than simply integrating part of the GIS functionality.

2.5 *Modelling and GIS*

Beginning with the work published in the first years of the new millennium (Openshaw, Abrahart 2000; Batty 2005), elaboration of urban models has been influenced by the new processing abilities and increasingly widespread use of GIS by civil services. Diappi (2004) examined the theory of Multi-Agent modeling, which refers to: (i) The processing architectures deriving from the application of artificial intelligence; (ii) A system which is able to extract rules from data and therefore interpret macro-phenomena by turning the top-down system on its head and (iii) The interest in a description of phenomena on a micro-urban scale. The behaviour of individuals is no longer interpreted in isolation, but also as interaction between themselves and with the context in which they live and operate. Diappi, Buscema and Ottanà (Diappi *et al.* 2004) delved deeper into the study of interaction between social systems, economic systems and the environment, highlighting its complexity. This requires the use of new scientific analysis methods, like ANNs. Diappi, Buscema and Ottanà (Diappi *et al.* 1998) state that in ANNs the rules are defined *a posteriori* on the basis of the variables, problems and objectives, unlike the traditional approach which is based on rules defined *a priori* for general parameters providing for a top-down system. Torrens (2010) considers that in the current situation of data availability, the social sciences are required to use IT tools to recognise the forces driving change in economic and social systems. It is precisely the progress in our capacity to process information that has further grown the role of geography, a discipline which is able, by its very nature, to manage complexity.

But why has the need arisen to describe individuals' behaviour in their physical, economic and social environment with a model? According to van der Leeuw (2004), models are useful to describe, succinctly and precisely, that large dimension of relationships which would otherwise have to be described, in an approximative manner, with words. He considers this reflection in the area of multidisciplinary research. In this type of activity, each discipline is presented using its own parlance, while the model offers a tool which can be acceptable to all disciplines and at the same time able to acknowledge all contributions that the individual disciplines are able to provide. Diappi, Bolchi and Buscema (Diappi *et al.* 2004) highlight a further characteristic of ANNs, represented by the possibility of increasing knowledge of urban dynamics by multiplying the information capacities of GISs and therefore offering a new methodological approach to creating models.

3. Empirical evidence: the SECOA Project

3.1 *The European FP7 SECOA Project*

The SECOA Project (http://www.projectsecoa.eu/) funded by the European Commission as part of the FP7 programme (2009-2013) studied new human mobility flows, whether the production-led kind also known as economic migration, or consumption-led, such as mobility for purposes of tourism and leisure, which have grown as a result of urban and regional restructuring policies following the 1970s economic crisis. SECOA noted that the most problematic situations occur in coastal areas because of a more fragile environment, space constraints and more concentrated phenomena. The availability of cultural and natural resources being more limited in coastal areas, the competition to use them is more acute. Problems in these areas are

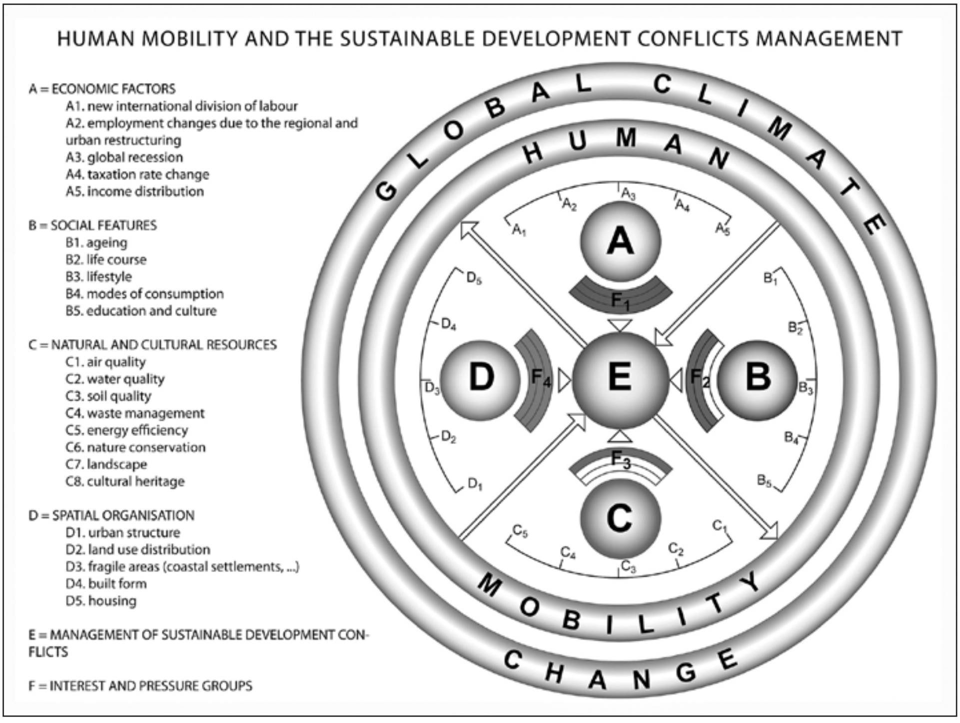

Fig. 1 – The SECOA methodological model: from global to local and vice versa.

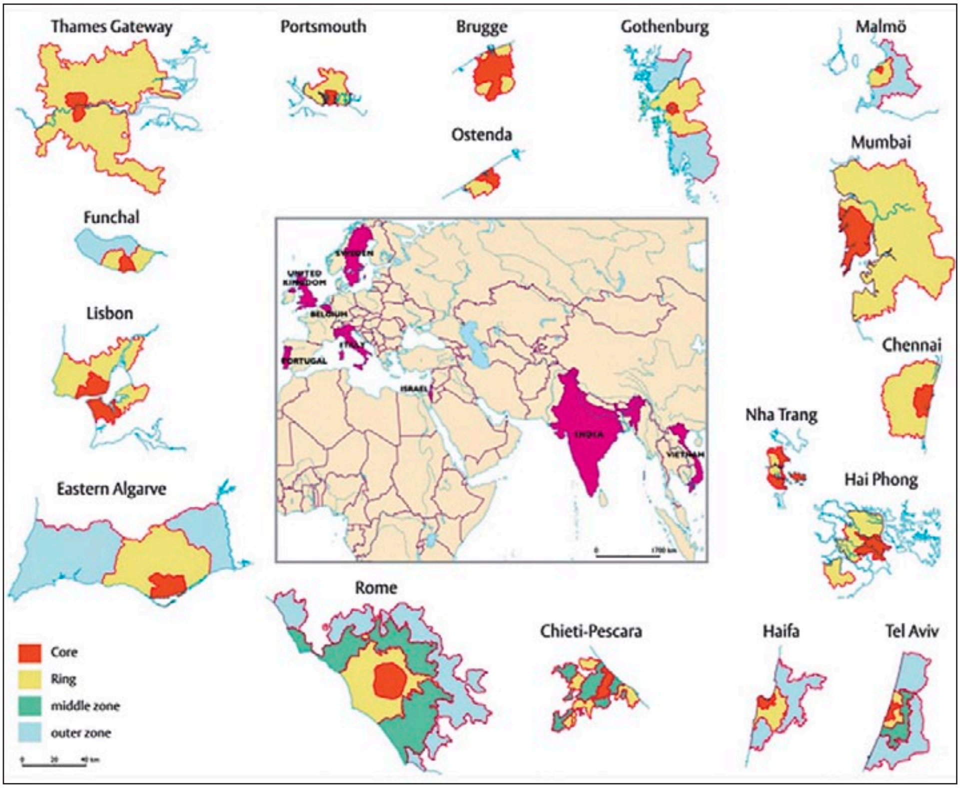

Fig. 2 – SECOA case studies.

intensified by global climate change, which enhances the risk of flooding and sea level rises in highly urbanised zones (Fig. 1).

Coastal areas are points where three elements – earth, sea and air – meet and interact, and therefore where the local encounters and clashes with the global, including from a physical standpoint. This particular situation is a prime observation point from which to view local-global environmental conflicts. SECOA identified these conflicts, analysed how they impact solutions to environmental problems, created interpretive models to summarise the quantitative and qualitative aspects of the conflicts in relation to the complexity of the environmental, economic and social systems, and compared the priorities of each type of conflict. The project examined eight coastal metropolitan areas of global significance and eight of regional significance in Europe and Asia (Fig. 2).

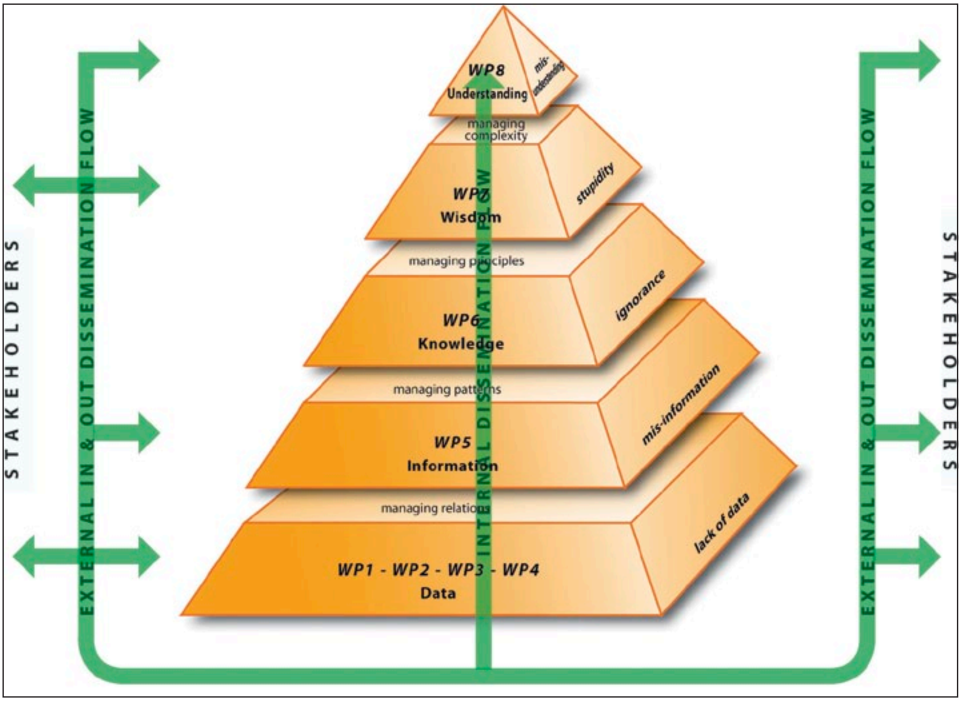

Fig. 3 – SECOA internal and external information pyramid. Source: adapted from Ackoff 1989; Bellinger *et al.* 2004

3.2 *From information to knowledge; SECOA's internal and external relations*

SECOA's logical path was based on two kinds of information. The first kind was applied within the project, with the objective of involving research groups that were not necessarily familiar with scientific collaboration (because of their culture and training) in a shared process. Despite the diversity of these groups and their dissimilar disciplinary approaches, the project had to include as many as possible of the fields that are familiar, at their individual level, with issues related to the development of coastal settlements.

There was also the need, explicitly requested in the European Commission's call for proposals, to include Pacific Rim countries. The second kind of information related to the various components of civil society that could serve, in each of the countries, to supply data, supervise the interpretation of data, carry out tests on the findings and be final users of the scientific findings (Fig. 3).

3.3 *Internal information and the continuity of the research activity*

SECOA's logical system for internal information was organised along the DIKW hierarchy model, with the meanings of each level of available information – totally comparable, only partly available, or missing and therefore comparable only after a series of qualitative interpretation processes – being entered into the model. The non-comparability of data when operating internationally was taken into account right from the design phase of the project proposal, and remained a constant throughout, as it is impossible to know in advance what data – because of cultural, social, economic and linguistic differences – will not be available, or only partially available, or available but relating to only superficially analogous phenomena. In fact, there can be different translations of the underlying meanings typical of each culture even when a common language is being used. A consistent information pyramid was obtained through the temporal and thematic organisation of SECOA into an operating sequence of eight work packages (WP). The information levels could therefore be matched to the objectives of the individual SECOA WPs, and to the comprehension and interpretation processes used to switch from one cognitive level to the next (Fig. 4).

The data to measure natural, environmental, social and economic phenomena were collected using different disciplinary and cognitive approaches; this was among the tasks of WP1-WP2-WP3-WP4. After being processed the data were collected, for WP1-WP2-WP3, in alphanumeric form, with numeric titles and values, and georeferenced form. WP4, for its part, classified conflicts using qualitative parameters, depending on how they were perceived by stakeholders in each of the areas studied. The subjects of the environmental conflicts taken into consideration were: (i) Projects for economic growth and plans to develop industry, ports and tourism; (ii) Protecting areas of environmental and cultural value and (iii) The changes that human mobility flows have brought about for the host society. These are conflicts that emerge because of environmental scarcity – as in the case of coastal areas – as a result of the over-utilisation of these areas due to their potential for economic development and ability to attract human mobility flows. Although the very nature of these conflicts makes them impossible to resolve, they can change and evolve, depending on the characteristics of each reference society, in more or less markedly different ways, despite the presence of common elements that are the result of cultural globalisation. The second level of the pyramid, WP5-WP6, required the creation of parameters capable of answering questions such as who, what, where and when. Knowledge includes the conscious use of data, and must be able to confirm the logical consistency of the research. The knowledge phase is the junction through which any research project, national or international, must pass. Without an appropriate rationale, and

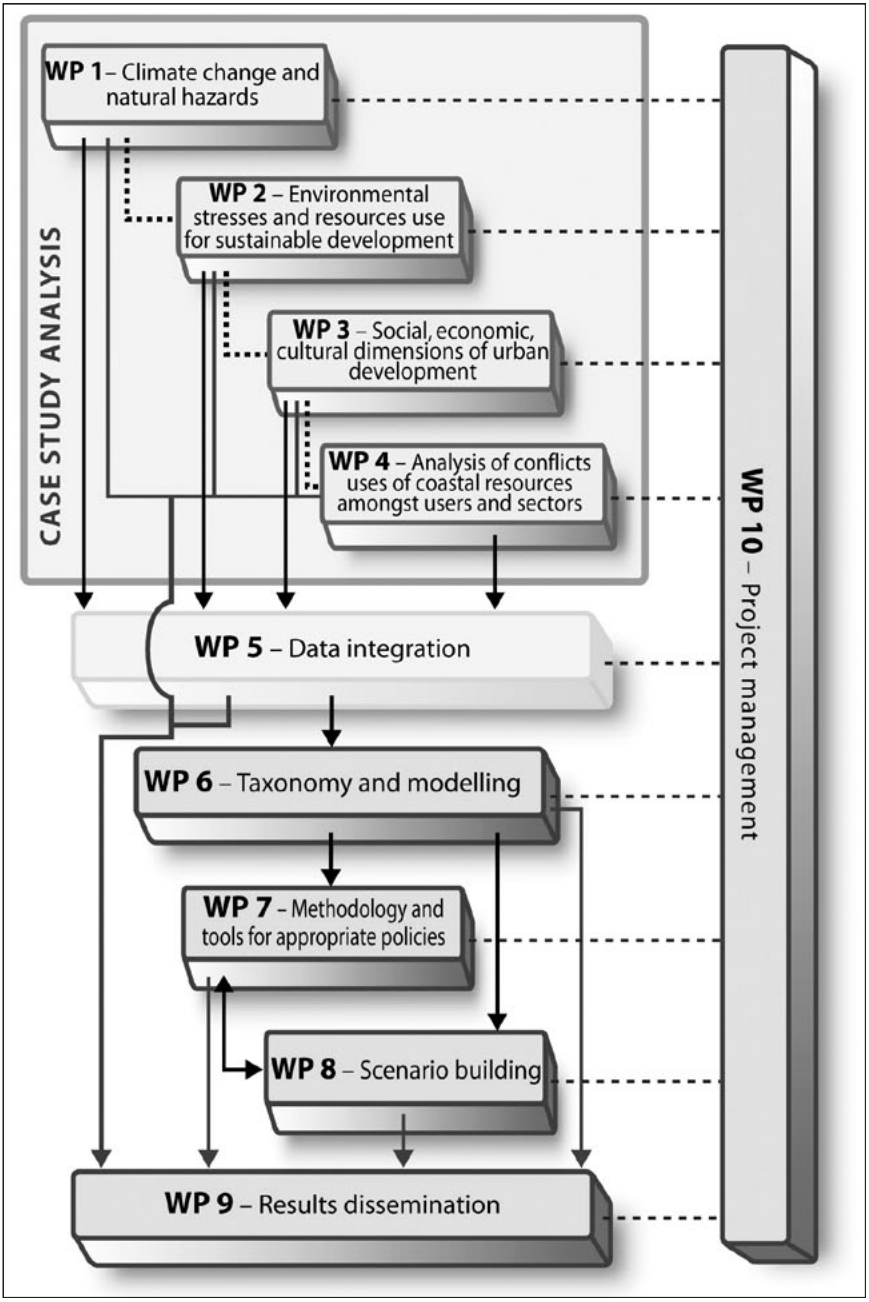

Fig. 4 – SECOA's work organisation and the information pyramid.

subsequent processing phase, data collection would be a banal process, and wholly unscientific: the question, after all, is how and why data is organised and can thereby offer added value.

The phase of discernment and wisdom – SECOA WP7 – drew up evaluation criteria for policies that can be applied on the basis of knowledge processes. Wisdom is particular to human beings; it presupposes an ability to reason with a soul, a heart and a mind. The SECOA WP8 stage of understanding phenomena was the final process in the project – a simultaneous stage of knowledge and analysis. A civil society that has correctly understood environmental conflicts in coastal areas is capable of taking the most appropriate initiatives because it is able to put the new knowledge it has acquired into practice. The knowledge in itself is not new; it is new because it results from an original way of processing known and published information.

3.4 *Communication and dissemination*

Fig. 4 also shows another level of information within the relationship between the various phases of the pyramid and civil society, represented by its stakeholders. These can be information flows that the project gathers through stakeholders; outgoing information flows – generally called dissemination – and flows that are both incoming and outgoing. Information that merely transmits the findings of scientific research to stakeholders cannot be defined as dissemination. This creates two problems for stakeholders: being relegated to a solely passive role, and not being fully aware of what data is being processed. For SECOA, dissemination was a process of mutual information-sharing rather than a one-way activity. At the data collection stage, in particular, stakeholders contributed to interpreting data and approving the way they were used by the research project.

In this way, the data were a means of communication, not merely a way for one side to dominate the other: one side gathers data using its own parameters, and the other interprets the data according to its culture and the purpose of its work (Montanari 2012a). In the knowledge phase, although stakeholders cannot take an active part in the research (which can occasionally be based on methods that might be considered abstruse), they can contribute to ensuring that data are correctly verified within the interpretive freedom of each part of the process. It was only at the apex phases of the pyramid that information was produced by research and then transmitted to the stakeholders, who then used it to adjust their policies and behaviours. The use of GISystems was a key dissemination tool at every stage, and with all the variables considered. Georeferenced data has an advantage over alphanumeric data: it can be subjected to a preliminary verification with the territory to which it has been assigned, and is more easily understood. Meanwhile, civil society too has acquired greater familiarity with the spread of GPS in most of the equipment used in everyday life.

3.5 *The descriptive model*

In the project planning phase, which also drew on existing literature and previous experience, the urban areas to be studied were divided into two categories: (i) Metropolitan areas of international significance that are being hugely impacted by global phenomena and (ii) Urban areas of regional significance that are impacted by global phenomena as experienced on a national scale. Including countries from within as well as from outside the EU enriched the research, but it also made comparing the data a more problematic affair. So the data were processed following these criteria:

1) All of the data collected for the research programme were used, even without a uniform level of comparability. When it came to data collection for SECOA WP1-WP3-WP3-WP4, the coordinators were specifically chosen for their skills in the environmental, economic or social fields, depending on the information required. Using ANNs made it possible to give data, not algorithms, the key role, thereby enhancing the ability of each individual piece of data to contribute to explaining phenomena. This process was chosen over the traditional one of first selecting an algorithm, then inserting the data required to make it work.
2) Rather than carry out a comparative analysis of each variable for each case study – which we might define the horizontal approach – the data for each country were pre-emptively verified using a longitudinal approach in order to identify coherence at the national level.
3) The data for all the urban areas were compared only after they had been processed and had expressed their specificity in the aggregate.
4) The variables of conflicts were considered together with all the other variables of the same urban area.
5) Therefore, conflicts were examined within their territory of relevance, in the place where they started and continue.
6) Each case study was considered within the context of the interaction of its environmental, economic and social issues, and only then were the various metropolitan and urban areas compared.

For the EU countries, it was possible to obtain georeferenced data for all the urban territories; this was not always possible in such detail for the other countries. It was therefore decided to use a GISystem raster with 1 km cells. As Fig. 5 shows, storing data within a GISystem dataset allowed for easier and more significant transfer to an SOM to organise and structure metropolitan areas into a sequence of qualitative parameters that were grouped by type. Further elaboration into an SOM of the SOMS made it possible to identify eight types of situations in the metropolitan areas used as case studies. The conflict data produced by SECOA WP4, on the other hand, were processed using another SOM, and resulted in the identification

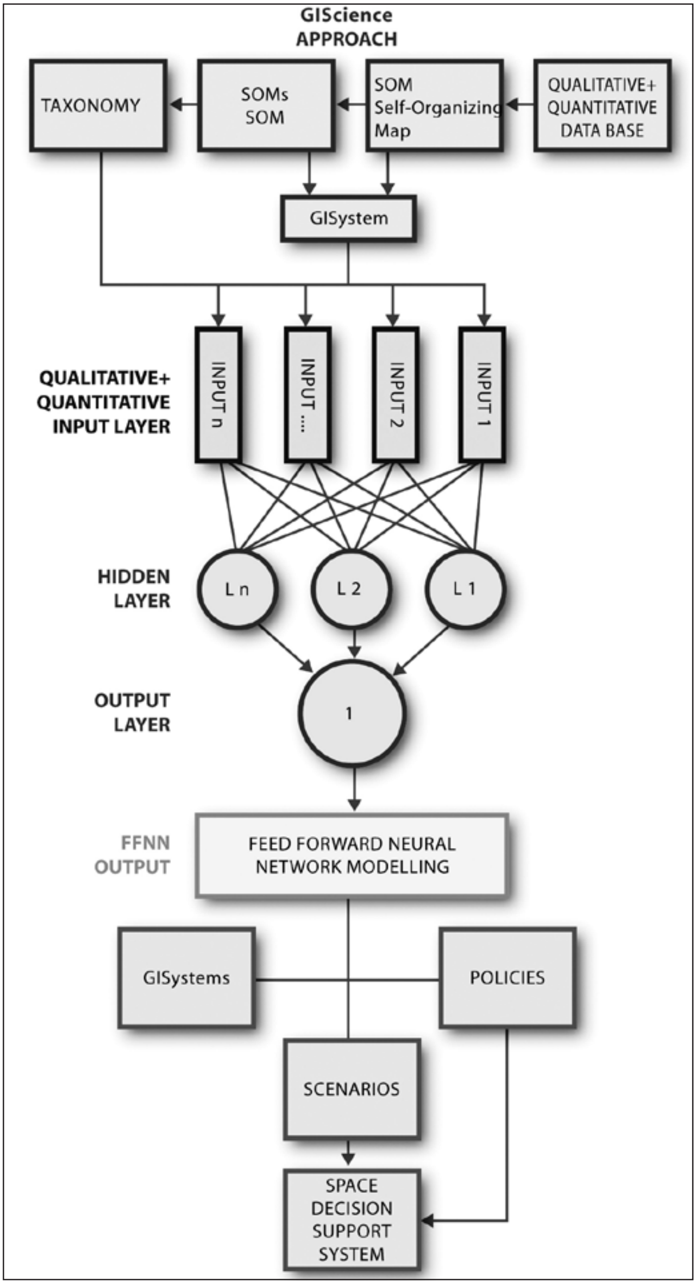

Fig. 5 – From environmental, economic and social variables to a descriptive model.

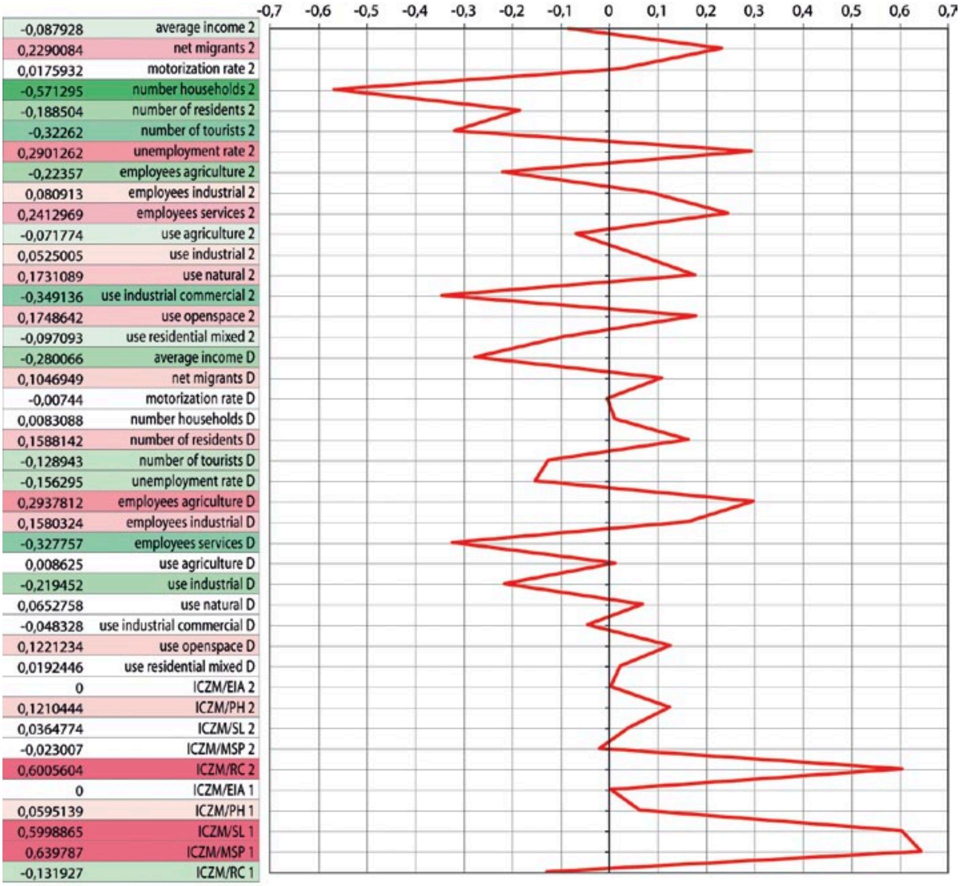

Fig. 6 – Descriptive model: the Civitavecchia (Rome) fingerprints. The variables marked in red indicate a positive trend. In this case, the generalised parameter of the conflict will tend to increase, thereby contributing to worsening its characteristics. The variables marked in green indicate a negative trend. In this case, the generalised parameter of the conflict will tend to decrease, contributing to its mitigation.

of five types of conflictual situations (Londei 2013b). As can be seen in Fig. 5, the SOMs and the SOM of SOMs were further elaborated using GISystems to make them easier for end-users and stakeholders to read and understand (Deravignone 2013). To proceed from the taxonomy to the interpretive model, a linear process was drawn up using a feed-forward neural network (FFNN).

The relevant areas of an environmental conflict in coastal areas vary from one case study to another. Even if the conflict is seemingly restricted to a small area – the place of intervention – there is also a larger area in which the characteristics of the conflict emerge and develop. SECOA identified three reference areas:

1) The direct area of the conflict – the place causing the conflict, where the environmental, economic and social variables are all 100 per cent relevant, and therefore contribute to understanding and describing the conflict.
2) The closest area to the conflict – the surroundings of the conflict area, including areas that are at least partially concerned by the reasons for the conflict. In this area, 20 per cent of the variables were deemed relevant. If the problem generating the conflict is industrial production, the areas affected by pollution from such production while simultaneously benefiting from it in economic terms are also taken into account.
3) The metropolitan area of the conflict: the wider area within which the conflict develops. Many problems in coastal areas emerge and develop inland – rivers contribute to flooding the coast when there is heavy rainfall, or lead to coastal erosion when river sand is overexploited. In this area, five per cent of the variables were considered to be relevant (Staniscia 2013).

An FFNN was built for each of the 17 case studies, with 52 output layers, 30 hidden layers, and descriptive modeling as the output: an identification code that supplied the greater or lesser importance in the emergence of the conflict of each of the 44 conflict themes and 52 social, economic and environmental variables taken into consideration.

This result was illustrated via a kind of vertical barcode providing the fingerprints of each case study (Fig. 6). Current or programmed policies that affect each variable either positively or negatively can contribute to increasing or reducing the intensity of the conflict.

4. Conclusions

SECOA has confirmed that environmental conflicts, like social conflicts, can never be entirely resolved. However, SECOA's interpretive model makes it possible to find tools to envisage ways to reduce the intensity of conflicts. Specifically, it has identified the variables that contribute most to conflict, and the intensity with which they contribute. Attentive policies can therefore work on particular components of the conflict to attempt to reduce their intensity. Research projects are increasingly multidisciplinary.

Contemporary society is increasingly developing along parameters of complexity, which require the use of research tools able to resolve problems related to large amounts of available data and the multiple relationships that have been established between them. The SECOA project's use of ANNs combined with GIS has demonstrated that it is possible to answer the following questions:

1) How do the environmental, economic and social variables interact? Are the characteristics of environmental conflict to be found among them?
2) How do these variables influence the characteristics of environmental conflicts?
3) How intense are these influences?
4) What variables are primarily responsible for the conflict?

Moreover, the use of ANNs together with GIS highlighted a series of advantages:

1) The option of using bottom-up methods that make it possible to be more closely connected to the issues to which the data point.
2) The enhanced flexibility of algorithms and models when it comes to the specific characteristics of individual data.
3) The field of geography has a natural tendency to connect seemingly disparate approaches, for which the territory can function as an instrument to help understand similarities in data.

By announcing upcoming calls for proposals for the Horizon 2020 research programme, the European Commission has, among other things, foreseen that, in order to meet to the needs of society, there will be greater call for multidisciplinary research capable of verifying subjects from different points of view. Moreover, public investment in research will have to envisage an immediate spillover to European society through increasingly sophisticated dissemination tools suited to the demand for knowledge. The geographical information provided by the ANN-GIS combination is undoubtedly in a position to contribute to this research.

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ABSTRACT

The Artificial Adaptive Systems (AAS) have had several applications in different technical and scientific fields, in medical research, life sciences, and financial and insurance studies. These systems have had, so far, poor implementation in social sciences. Among the latter, the main examples can be found in research about urban models in which AAS are usually used together with GISystems. By their nature, neural networks are suitable for interpreting complex phenomena like the social ones. Their limited use is, therefore, surprising. It is just to explain a complex phenomenon that AAS have been used in the SECOA project. The project deals with the study of environmental conflicts in coastal areas. Environmental conflicts are, by nature, complex phenomena, multidimensional and multiscalar. In SECOA 26 conflicts in 17 regions were analysed. The AAS were used to generate an explanatory model that would allow to describe, through its essential elements, the relationship between conflicts and territories. AAS are not only an ordinary complement to the spatial analysis toolbox but a new paradigm for spatial analysis and mining. In particular Geo-SOM (Geo-Self-Organizing Map) is a tool to identify homogenous regions for which predictive analysis can be done using tools that make the visualisation of positive and negative correlation possible. Increased use of AAS and GIS, and the good results this method produced, contributed to a more precise identification of a GIScience in general and its research agenda in particular.