Hybrid MAS GIS Mediterranean Backcountry Tourism Economy Modeling Methodology

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ABSTRACT
Submitted to the combination of the sun immigration pressure and the decline of their traditional economy, the Mediterranean islands are in a paradoxical position. Indeed, while the populations on the shores are growing, the countryside is endangered involving the desertification. In this paper we shall present a methodology to build a distributed artificial intelligence based model dedicated to the countryside economy and its interactions with the growing touristic coastal areas through the flow of tourists. Organizing the economic system into a hierarchy, following a multi-agent approach, we build a generic model of each system's stakeholders from our observations. We propose a methodology to model the exchanges between the countryside's visitors and the local economy's players. Using a geographic information system, we explicit how to take advantage of the spatiotemporal ground data to fit the simulations to the specificities of each targeted site. Finally we present a first application on a Corsican case.

Categories and Subject Descriptors
I.2.11 Distributed Artificial Intelligence: *Multiagent systems*; I.6.5 Simulation and Modeling: *Model Development*; J.4 Computer Applications: *Social and Behavioral Science*; H.4.2 Information systems application: *decision support;* I.6.8 Simulation and Modeling: Types of Simulation – *Gaming*.

General Terms
Modeling, Distributed Artificial Intelligence, Economics, Experimentation, Human Behavior, Support System, GIS, Tourism, Mediterranean.

Keywords
Distributed artificial intelligence, multi-agent system, model, simulation, geographic information system, environmental system, tourism, decision support system, tourism, Mediterranean, Corsica.

Simutools'09, March 2-6, 2009, Rome, Italy.
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1. INTRODUCTION
In this paper we study and model the situation of the Mediterranean islands' countryside in the aim to support decision makers.

This paper is organized as follows. In Section 2 we present the context of our works. Section 3 presents our methodology based on the use of a framework for hybrid decision support system using a multi-agents system and a geographic information system. Next we develop our agents based model of the Mediterranean countryside. In Section 4 we explain how we use spatiotemporal data. Section 5 presents the system's modes of uses and the first experimentations. Finally, Section 6 concludes the paper.

2. CONTEXT
The Mediterranean north shores have been confronted to a growing population for the last decades [1]. This phenomenon results from the development of the leisure industry and the migration of north European people looking for a sunny and warm climate. Unfortunately this growth remains confined to the coastal areas while the countryside declines severely.

The whole Corsican context is a typical case of such a dynamic growth in the coastal areas and an advanced economic and demographic depression in the countryside [2] [3].

The stakeholders are looking for ways to take advantage of the coastal boom and stop the desertification of the inland region. Their new policy aims to build a new economy based on both the development of the current tourist supply, and sustains the traditional agricultural activities [4]. These two axes are complementary: tourists are an opportunity to sell the countryside productions while traditional activities make up major attractions for the people visiting Corsica.

Today, the development of the tourism industry in the countryside increases the demand for local production and lead to a limited renewal of the traditional activities that attracts more visitors looking for authentic societies and preserved ecosystems.

The players concerned by this economy are in quest of tools to understand and to foresee the possible consequences of the public interventions on their business [1]. These tools could be useful to find new ways to take advantage of the coastal growth and help decision makers to stop the countryside decline and initiate a renewal.

In this paper we propose a methodology based on a distributed artificial intelligence paradigm to model the interactions between tourists, tourism industry, and traditional activities in the Mediterranean countryside.

Digital Object Identifier: 10.4108/ICST.SIMUTOOLS2009.5607
http://dx.doi.org/10.4108/ICST.SIMUTOOLS2009.5607

We build multi-agents system (MAS) model taking into account the interactions of the visitors with the services providers (hotel, camping, restaurant, bar, and entertainment), the farmers, the highly attractive spots (wildlife, lake, landscape, museum, festival), and the coastal system. We propose to use a geographic information system (GIS) to take into account the specific spatiotemporal data of the targeted sites.

Our model is designed to be used in future works to build a simulator and a decision support system to help the decision makers to take advantage of the coastal boom, to grant investments and traditional activities, and to prime the renewal of the Mediterranean countryside.

3. METHODOLOGY

The modeling methodology exposed in this paper is a continuation of our works on the SMAG (Système Multi-Agents Géographique) platform architecture dedicated to the development of hybrid MAS-GIS decision support systems [5]. This architecture, based on a multi-agents approach, was specially fitted to model and to simulate heterogeneous systems with a strong spatial component and complex interactions between numerous stakeholders [6].

SMAG is a modular hybrid architecture based on 2 units:

The first unit is dedicated to model the behaviors of the systems and the stakeholders according to a multi-agents system (MAS) approach.

The second unit based on geographic information system (GIS) enables to take into account the spatiotemporal data of each targeted sites. It provides tools to define scenarios of simulations and plan the experimentations.

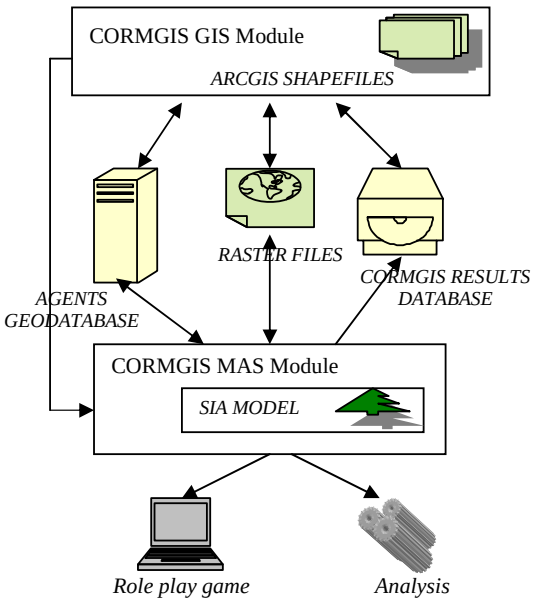

Figure 1. CORMGIS platform

In this paper, we use CORMGIS, the first operational SMAG compliant platform, to implement the agents of the coastal systems.

CORMGIS is a modular operational development platform dedicated to decision support systems focused on natural renewable resource management, environmental and societal systems. It's based on the Visual Works programming environment which allows the development of applications in the object-oriented programming language Smalltalk.

The CORMGIS multi-agent module is based on extensions of the Agricultural Research Centre for International Development (CIRAD) CORMAS (COmmon-pool Resources and Multi-Agent Systems) multi-agents platform [7][8], whereas its GIS module is implemented by ArcGIS, the ESRI company [9] GIS software suite. The CORMGIS extensions of CORMAS we developed enables to plan experimentations, to connect its core simulator to the geographic databases, and to provide graphic interfaces dedicated to the interactions with stakeholders, experts and decision makers.

CORMGIS pre-defined entities are Smalltalk generic classes from which, by specialization and refining, developers can create specific entities for their own model.

The dynamic link between the MAS and GIS CORMGIS modules of enables to fit the simulations to each situation [10] [11]:

1. Geodata are used to instance the agents and the elements composing the model.
2. The simulator can take into account the predefined events supposed to occur during the simulation. These events constituting scenarios are predefined by the experimenters using the dedicated toolbox joint to CORMGIS. Thus it makes possible to plan experimentations and explore numerous hypotheses.
3. The data generated by computations are stored in the geodatabase for further analysis.
4. Each event occurring during the digital experimentation is stored by the GIS. Scenarios, agents, and experimenters are both at the origin of events.

We previously used CORMGIS to build a decision support system dedicated to the fresh water problem and to highlight the influence of the social interactions during the water shortage in the north of Corsica [12]. Furthermore we developed a DSS dedicated to the interactions between watershed and activities in coastal areas focused on sea farming [13].

3.1 Mediterranean backcountry modeling

We build our Mediterranean backcountry multi-agents model taking into account the basic elements enabling to simulate the economic activities. This approach is based on observations of tourists' behaviors and stakeholders' practices.

Our work consists in developing a library of models representing the different types of stakeholders: day tripper, camper, hiker, hotel host, motel host, bicycle touring, packaged tour, camping-hotel-motel manager, bar-restaurant owner, village council, county council. This library will be use to simulates and to evaluate the policies of local authorities and stakeholders' strategies.

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This modeling task follows a typological organization into a hierarchy of backcountry's society. Analyzing the system we go from tourists to economic players such as village and county councils in a bottom up approach.

We build a model with three levels of abstraction fitted to the available data and the territories' specificities. In the first level of abstraction, the agents are built reusing existing well-tried behavioral models and ground behavioral observations. Restricting our works to the fundamental elements of the backcountry economy, we propose a generic framework usable to study most of up-country situations.

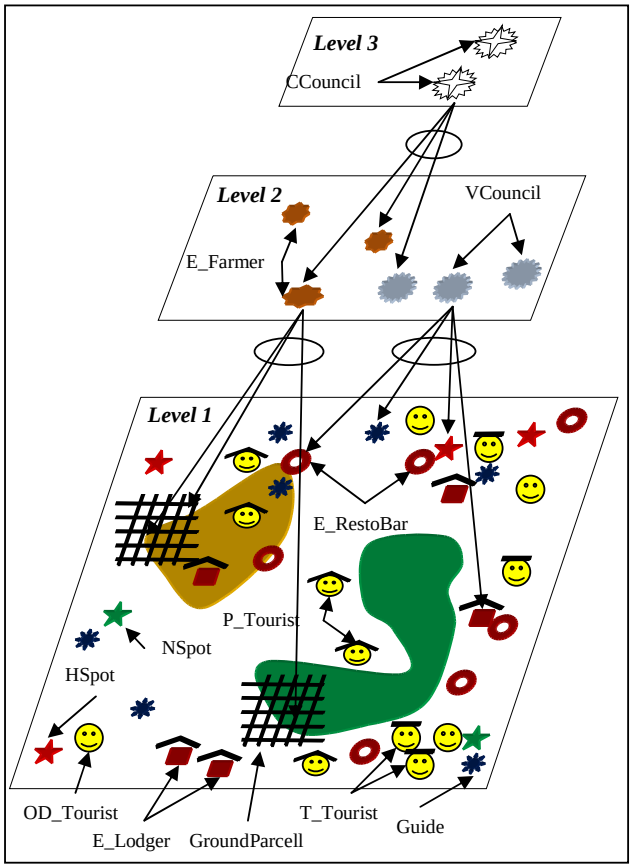

Figure 2. Hierarchical backcountry model

We organize the backcountry system model in hierarchy three levels of abstraction as shown in Figure 2:

1. The first level includes the sightseers, economic players, ground parcels, touristic spots, and the elements of the information system toward tourists.

2. The second level includes the farmers exploiting many ground parcels, and the villages councils managing the sightseeing spots and some economic players in the village territory.

3. The third level is composed of county councils managing the system, influencing it by its subsidies to farmers and in charge of the evolution of the backcountry potential number of visitors.

To build faithful and trustable models, we finely observe the backcountry's economic and touristic system. Historically the economy in these areas resorts to agriculture while the industries never soar. Nowadays, the industry remains rachitic, agriculture achieves its decline due a combination of poor natural conditions and competition, whereas a seasonal leisure industry having grown slowly for four decades is now the economic lung of the Mediterranean backcountry. In spite of its weakness, agriculture still has very important sustaining activities during the low tourist season. Maintaining the landscape and the traditions make up the main attractive points for travelers.

We model an archetype of the agro-tourist up-country's economy from the observations of the Sia representative area (figures 3&4). This region is located in the western side of Corsica, bounded by the Palmarella pass (north), Vergio pass (east) and the "Dog Head" corner (south).

Figure 3. Map of Corsica Island

The coastal villages Ota, Porto, Partinello, Serriera, Osani are fully dedicated to the tourist industry (more than 6000 beds) the beaches and seaboard of which attract tens of thousands of visitors each week during the summer. They constitute the main source of visitors for the up-country.

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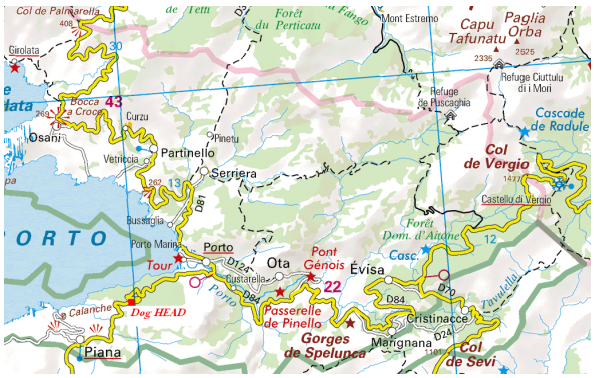

Figure 4. Map of SIA area

In the backcountry there are three mountains' villages (Evisa, Marignana, and Cristinacce) emblematic of the agro-tourism economic systems. We build our models from the observations of the people's behaviors visiting Evisa during July and August 2008.

3.2 Mediterranean backcountry Agents Identification and Modeling

The CORMGIS based agents implementing the basic models of the backcountry agro-tourism activities can be classified in three categories:

● People visiting the backcountry have various behaviors. We select 4 archetypes representing 90% of visitors.

1. The OD_Tourist pattern agent describes a "one day" visitor coming from the coastal villages to visit the main spots. His behavior is linked to the weather condition: numerous when coastal temperature remains below 27°C, becoming scarce with rains.

2. The T_Tourist agent archetype describes a sightseer staying one or two nights in the backcountry. These visitors stay in hotels or camping, moving according to the weather: when the seashore is warm (t>28°C) they are numerous to look for the mountain's night freshness. When it's cold (t<21°C) or rainy in the backcountry 80% of them move to the coast.

3. The H_Tourist agent pattern describes a hiker. These agents stay one night in the backcountry's villages. They walk along the long path from side to side of Corsica, and to complete their trip they must move every day.

4. The P_Tourist agent archetype describes a visitor staying one week or more in the same village of the backcountry. This population rents fully equipped accommodation with kitchen.

● We model the up-country's agro-tourism business economic players using 4 archetypes:

1. The E_Farmer agents describe the local peasants; they sell their products to the visitors, maintain the landscape, and keep the village alive during the low tourist season. These agents are essential to preserve the upcountry public image and authenticity necessary to appeal to visitors.

2. The E_Merchant agents describe the trading actors: general stores, bakeries, souvenir and handicraft retailers.

3. The E_Lodger agents describe the economic players providing accommodations to visitors: camping resorts, hotels, guest houses and other privately-rented properties. In our model we take into account their rates, class, capability, and their ability to provide catering.

4. The E_RestoBar agents describe the agents providing only catering to visitors.

● We model the up-country's touristic spots and entertainment players taking into account: appeal value, the cost and the time to visit. We develop 3 archetypes:

1. The NSpot agents enable to take into account the natural sites attracting visitors like view sites, strands, lakes, waterfalls, and excursions.

2. The HSpot agents enable to take into account the heritage, cultural, and historical monuments attracting visitors like castles, churches, palaces, monasteries, and ruins.

3. The ESpot agents describe the leisure and entertainment players: museums, aquariums, zoos, festivals, golf, and via ferrate.

● We model the up-country's public managers. These stakeholders influence the system editing rules, providing grants, and attracting the attention of tourists towards the backcountry. These actors can be described using two archetypes:

1. The VCouncil agents enable to take into account the influence of the village's councils: creating and promoting attractive spots for sightseeing, issuing licenses to economic players.

2. The CCouncil agents describe the influence of the counties' councils on the global number of visitors and on the aids to the traditional farming. These councils are in charge of the promotion campaign of large areas toward the European market, thus they control the annual evolution of the coastal visitors number and consequently the up-country's.

● We use a Guide pattern agent to model the elements informing the sightseers about the region, the sightseeing, the lodgers... These agents representing elements like road signs, notice boards, booklets, travel guides feed the tourist agents' representation of the world. During their trip, tourist agents meet Guide agents and update their knowledge.

3.3 Environment Modeling

The ground environmental model must take into account the farmers' influences on the landscapes. Cultivated farmlands, byroads, orchards, meadows, and livestock landscapes are a powerful way to attract urban visitors looking for authenticity.

The multi-agents formalization of the ground environmental system is concretized by the GroundParcel pattern. A GroundParcel agent represents a homogenous ground area taking

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into account its land cover and its dynamic. This pattern also takes into account the farmer's works on the area's vegetation and its natural evolution in case of abandon.

GroundParcel is refined from a generic agent pattern provided by the CORMGIS platform to model the space that can either represents a grid parcel or an irregular area.

3.4 IMPLEMENTING THE MODEL

At the beginning of the simulations, the system is initialized creating one instance for each element constituting the up-country system. They are instances of the classes modeling each category of agent's patterns. The pattern classes (GroundParcel, E_Farmer, E_Merchant, etc) are derived from CORMGIS generic agents' classes that include all the attributes and methods essential to run and drive simulations.

Our up-country model includes agents with very different rhythms. The visitors' time step is near the 15 minutes, while the rhythm of the other agents is rather annual. Thus we use a variable time step:

1. During the sightseeing season (15 April to 15 October), between 07H and 23H, we use a 15 min diurnal time step to take into account the sightseers' various rhythms.

2. During the sightseeing season (15 April to 15 October), between 23H and 07H, we use a 60 min nocturne time step to take into account the visitors' rhythm.

3. Considering there is no visitors out of the tourism season (15 October to 15 April), we use a one month time step to take into account the farmers' activities and the evolution of the nature.

CORMGIS is a native hybrid MAS GIS platform thought to use géodatabase and to store the results of experimentations. This platform provides a complete framework to model stakeholders of systems with a strong spatial component and run simulations.

3.5 TOURISTS' INTERACTIONS MODEL

Buying the main part of their productions, the visitors influence the players of the backcountry traditional economy. Our model uses the numbers of visitors' buying acts to the economic players dealing the local production.

The number of sales for a shop is a function of the number of people viewing it, the number of buyers in the shop, and the landscape. Indeed, more people view the shop, more people will enter and. Moreover more people are seen in the shop, more the shop seems interesting and more people will be attracted, enter and finally buy something.

The landscapes have a major influence on these buying acts, indeed people visiting Corsica are looking for deeply rooted products and landscapes suggesting traditions increase sales.

Our model of tourist buying behavior takes into account the both the influences of landscapes and presence of others people in the shop.

Our models of economic players and farmers are based on the number of buying acts. If the number of sales is too low some economic players abandon their activities, stopping to take care of the landscapes, and finely reducing the interest for the up-country. On the other hand, good sales preserve or increase the number of players of the traditional economy and maintain the landscapes.

People visiting the Sia's backcountry are looking for famous local productions: "marron glacés", chestnut flour, delicatessen, Corsican cheeses, and honey.

3.6 COUNCILS' INFLUENCES

Modeling the backcountry system, we take into account the major influence of villages and county councils.

3.6.1 Council's influence on economic players

The county council (CCouncil agent) influences the economic players sustaining directly the activities:

- The council provides technical and financial assistance, helping the weakest players to survive, sparking off new companies.
- From November to March, out of the sightseeing season, the council can deals subsidies to keep alive some economic players.
- The county council has a major influence on landscape: delivering building licenses, granting farms.

We model the county council influence on the backcountry's economic players enabling the economic agents to ask for help to the county council agent. According to the council's rules, the weakest economic players can receive a financial subvention to survive.

Our model takes into account the number of selling acts and the amount of the subvention to decide to keep alive the weakest economic players. The value of the assistance accorded to the each economic player depends on the nature of its activity.

Our model takes into account the influence of the county council on the founding of new company. A new company of retails or catering (E_Merchant and E_RestoBar agents) can start only if the others same type companies' sales reaches a threshold during the previous year. The value of the council help for business foundation reduces this threshold.

We use the same rules to model the behaviors of farmers and lodgers (E_Farmer and E_Lodgers agents), but due to the agreements and the importance of capital money required to start such enterprises, our model uses the sales of the last three years in the same activities.

The life of economic players is ruled by a yearly cycle, weakest businesses die in October, at the ending of the sightseeing season; while new players start their activities in March, beginning of the sightseeing season.

3.6.2 Councils' influence on landscapes

The county council influences the landscapes delivering building licenses and sustaining the famers. Landscapes have a major influence through its attracting power of tourists.

We model the influence of the county council on landscape through the rules governing the farmers' behaviors (E_Farmer) we exposed previously. Moreover the CCouncil agents decide to subsidize cultures: cultivated farmlands, byroads, orchards. The E_Farmer agents exploit many parcels represented by the GroundParcel agents. Abandoned parcels, following their own dynamics, return to wild lands

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The influence of farmers on the Sia's landscapes results in chestnut and olive groves, orchards and meadows. Abandoned zones become scrubland near the shores and pine forests in high lands.

3.6.3 Councils' influence on visitors

The county and villages councils influence the visitors' behavior through their promotion campaigns and their actions of information toward travelers. Indeed, to plan their trip, visitors need to known what are the interesting attractions, where are the main sightseeing, how is important the local heritage.

To inform potential visitors, the councils promote their territories launching advertising campaigns, inviting the media and the travel agencies managers, participating to fair trades. Thus, once arrived, previously informed, tourists move to visit the promised attractions.

Besides their outward campaigns, the councils spare no efforts to inform visitors and retain them. These efforts are materialized in many tourist information offices, road signs, road map, notice boards, and numerous booklets.

To model the councils' influences on visitors we create the Guide agent pattern. These agents inform visitors about the territories: the sightseeing, hotels, bars, and restaurant. The tourist agents use them to update their representation of the world and plan their trip. The Guide agent pattern takes into account the media intrinsic credibility, the interest and the location of each referenced entities. This pattern is used to instance tourist information offices, road signs, notice boards, booklets, road map and travel guides.

The Sia area is referenced in all the travel guides, visitors can found information and booklets in the tourist information office located in the village of Porto. All economics players deal free booklets edited by the councils. Moreover councils have installed numerous road signs and notice boards along the roads.

Our model provides to each agent Tourist agent a guide to initialize its representation of the area and plan its trip. Moreover they use the Guide agents they meet during their trip to update their representation of the region and re-plan their journey.

4. Spatiotemporal data processing

Due to its architecture and genericity, our multi-agent model implies an important work to prepare the spatiotemporal data required by the simulator to study the targeted areas. This importance is strengthened by the fact that the backcountry's tourism economic systems are naturally highly dependent from factors varying in space and time: weather, sightseeing geography, and landscape.

Thus it's necessary to complete the system's behavioral agent based module with a kitted up toolbox dedicated to the definition and preparation of raw data about the targeted sites. The ArcGIS GIS based unit of the CORMGIS modular platform provides a complete tools suite to manage spatiotemporal data.

Spatiotemporal data processing must occur before and after the simulation runs:

- Before experimentation, the spatiotemporal data pre-processing consists in collecting and getting into shape information about the territories. These geodata are necessary when launching simulations to create instances of agents from the behavioral models as shown figure 5. In addition, the events supposed to occur during simulations must be inventoried and compiled to build scenarios. These scenarios must take into account the systems' temporal and spatial modifications: weather, land covers, farming, players of tourism industry, administrative and environmental councils' rules, interactions between stakeholders. During simulations, these events are triggers to spark off instantiations of new agents and force the systems' inputs.

-After experimentation, the spatiotemporal data post-processing consists in analyzing the spatiotemporal data generated during the simulations. This work is necessary to highlight the key factors of the countryside's dynamics, and to provide explicit documents about future to the systems' stakeholders and decision makers. Furthermore the data generated during previous simulations can be reused to define scenarios for next simulations.

The CORMGIS GIS module enables to use sharply exact data to describe the target sites: economic players' localization and attributes, sightseeing spots, administrative and legal rules governing precisely each area, landscape evolution, environmental conditions. The native layered data organization in GIS allows taking into account the different levels in the backcountry management we identified when we built the archetypes' models. Thus the systems can easily be considered at different levels of abstraction for both management and modeling.

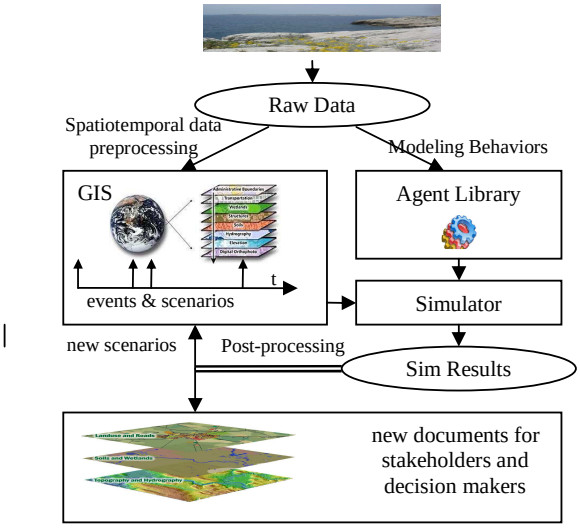

Figure 5. Spatiotemporal data pre & post processing.

5. RUNNING SIMULATIONS

Experimenters and decision maker can exploit our SIA multi-agents model using CORMGIS under two modes: "Analysis" and "Role Play Game".

Used in the first mode CORMGIS core simulator explores predefined scenarios and follows the experiences planned by the users. They define a domain for system's each key attributes

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(fixing the limits min max step) at the initialization. A simulation is run for each combination of attributes' values. During computations, experimenters cannot modify scenarios or models. For any simulations, any time step, the results and data relevant for users are stored in a dedicated database for further analysis.

The second mode of CORMGIS provides to its users a complete control on models, on behaviors and on current simulation. We develop dedicated graphic interfaces to interact during experimentations like in a role play game. Developed using Smalltalk, the simulator and the Sia's model enable hot modifications during experimentations and don't require a new compilation or a re-initialization. As in the first mode, all the results obtained during the simulations are stored in the database.

In the two modes, the events occurring during the simulations are stored and can be used to define new scenarios. Thus the events registered during a role play game session can be used for systematic experimentations using the first "Analysis" mode.

Our first experimentations using our Sia's multi-agents model are focused on the study of the flow of visitors in the village of Evisa, 17 km far from the sea by road, altitude 800 meters, about 100 inhabitants in winter, 900 residents during the touristic season. In august, during the peak season more than 4000 people can cross the village.

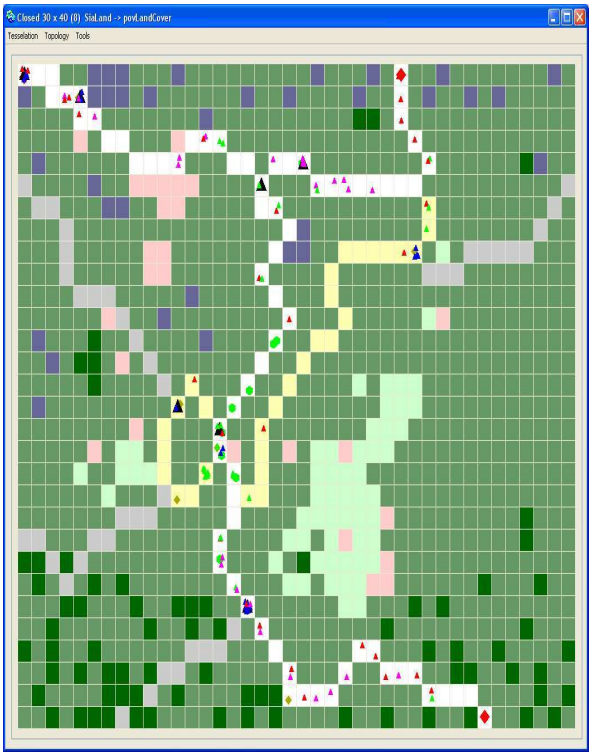

Figure 6.Multi-agents point of view of Evisa area

Figure 6 shows the CORMGIS window dedicated to the observation of the agents during simulations in an area (4x3 km) centered on Evisa. This window shows nine E_RestoBar agents (green points), eight NSpot sightseeing spot (brown points), seven Guide agents (big black triangles), and 125 OD_Tourist agents (small colored triangles). The cells are GroundParcell agents represented using a land covert point of view

We calibrate and refined our visitor's model behavior comparing the results obtained by simulations about moves, number of visits, buying acts of people passing by Evisa with the results of our observations campaign from July to August 2008.

Fitted up of a trustable model we explore how, installing road signs, notice boards and editing booklets, the village council could increase the number of visits and buying acts with the same flow of visitor. We run simulations to test the various hypotheses using the "Analysis" mode of CORMGIS.

6. CONCLUSION & PERSPECTIVES

The study and simulation of interactions in the Mediterranean backcountry systems imply to take into account the constraints and spatiotemporal data. A generic multi-agent based behavioral modeling approach must be conducted jointly to spatiotemporal data processing works to fit to each territory [14]. The use of the CORMGIS platform enables taking into account different levels of abstraction and to fit to data or systems' knowledge lacks.

The countryside problematic is bordering the traditional agricultural community and the new leisure industry, at the confluence of the coastal and land worlds, meeting point of the nature dependent and independent activities, is emblematic of both the complex interactions between new and ancient economic systems, and the tools' expectancies to find a way toward a sustainable and harmonious development. Following our methodology we build a model fitted to answer to the local authorities' expectancies. The first simulations dedicated to the study of the visitors flow in the Corsican village of Evisa confirm the relevance of our hybrid MAS GIS approach to model the backcountry systems and help decision makers.

Our future works will first focus on collecting data of the whole 2008 touristic season to complete our model of visitor's behavior. We will extend our operational model to the accommodations and next to the interactions between the Sia's coastal zone and the backcountry.

Following our methodology we will meet the county council and the farmers to calibrate and validate our model of their interactions. Once our model validated we plan to collect new data to study other regions of Corsica having a similar economic system with a backcountry.

Furthermore, using our system, we will explore the impact of granting policies dedicated to support permanent and traditional backcountry's activities. Thus decision makers could choose the more efficient economical measures to reach their aims and limit the waste of money.

Moreover we can use our methodology and system to explore others fields with a strong spatial component and numerous stakeholders such as the fresh and wasted waters problems, conflicts about fixing the rules to protect nature between the rich urban coastal populations and backcountry's inhabitants, epidemics and diseases.

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Digital Object Identifier: 10.4108/ICST.SIMUTOOLS2009.5607
http://dx.doi.org/10.4108/ICST.SIMUTOOLS2009.5607