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CHAPTER 4

Recording of environmental data and study of the procedures for monitoring and management of emergencies arising from marine flooding (SFINX project)

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Introduction

This paper looks at the experience gained during the SFINX Project (Interreg III Italy-Greece) relating to the monitoring and management of coastal emergencies caused by marine flooding.

Specifically, it describes the analysis of a highly degraded area of the Salento, where seasonal construction, often unauthorised, has unfortunately upset the fragile environmental equilibrium and its defences. This has resulted in the collapse of some buildings and serious risks to the buildings that remain and to the local population.

The City Council of Lecce was entrusted with the task of surveying the risk factors, recording environmental data and studying the system of management and intervention in case of flooding.

The project was conducted in collaboration with the Department of Arts and Heritage (of the University of the Salento).

1. Demarcation of the area

Casalabate is a marine coastal area situated about 15 Km North of Lecce. It has been heavily affected by human activities since the 1950s and practically all the buildings present were built without authorisation.

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The whole of the urbanised area of Casalabate lies on land that slopes very gently down to the sea, from the highest inland areas (about 15-20 metres above sea level) to the lowest areas near the sea shore (parts of which are less than a metre above sea level).

The mainly carbonatic composition of the rock has certainly favoured the development of karst phenomena (in the calcareous Mesozoic bedrock) and para-karst phenomena (in the outcropping quaternary calcarenite).

Added to this is the fact that the built-up area of Casalabate has no channels for collecting and carrying away rain water, which often drains directly into the subsoil through ground-level wells (such as the one in Piazza San Pio).

These point sources of rain water flowing directly into the subsoil can only increase the local erosive power of the subterranean waters, especially in those areas where the calcarenitic rock is particularly crumbly (as when composed of dune deposits).

2. Preliminary Studies

The Municipal administration of Lecce cooperated actively with the University of the Salento to meet the project's objectives by creating some of the GIS and WebGis information layers but mainly by conducting the following geological surveys:

A) GEOGNOSTIC SURVEYS AND MONITORING OF THE WATER TABLE

1. Geognostic surveys

- Vertical drilling of 101 mm diameter cores in terrain characterised by coarse grain-size such as sandy gravel, gravel and pebbles, and in rock of various kinds (18 surveys);
- Insertion of PVC piping into the above-mentioned holes in order to enable the measurement of the water table. The pipes were 100 mm in diameter and were placed in the last stretch of the hole between the water table and the bottom of the shaft (18 surveys);

2. Water table monitoring surveys

- Vertical drilling of 200 mm diameter cores in terrain characterised by coarse grain-size such as sandy gravel, gravel and pebbles (see AGI classification), and in rock of various kinds (5 surveys);
- Insertion of PVC piping into the above mentioned holes (180 mm in diameter) in order to enable hydrogeological monitoring of the water table (5 surveys);

B) GEOPHYSICAL PROSPECTION

1. Ground Penetrating Radar survey

The GPR profiles were carried out using a "Pulse-Ekko" system or equivalent, with 225 MHZ antennae and sampling intervals of up to 200 nanoseconds (3,000 ml);

C) HYDROGEOLOGICAL PROSPECTION

1. Measurement of the filtration velocity of the groundwater

Measurements to determine the filtration velocity of the groundwater. The best method for measuring filtration velocity (FV) is that of "point dilution". This widely tested method measures the VF by monitoring, from the point of injection, the dilution of a tracer at intervals of time. The rate of dilution of the tracer indicates the filtration velocity of the groundwater (5 tests);

2. Measurement of the water table

- At one of the points used for monitoring the water table a hydrometrograph was installed in order to continuously record all variations in the water table.
- Periodic measurements of the water table were taken at all the geognostic survey points (23 locations);

3. Thermo-salinometric bores

In all the survey bores, thermo-salinometric surveys were conducted in order to assess salinity and temperature patterns along the whole water column being surveyed (23 locations).

3. System for recording environmental data

In addition to the information gathered in the above-mentioned surveys, two significant environmental parameters were also monitored (tide levels and rainfall). These are closely linked to the movement of surface and subterranean waters and cause frequent flooding, damage to buildings and, in some cases collapses.

For these reasons, the following equipment was installed in the Casalabate branch of the Lega Navale nautical association:

1 **Tide gauge** with a range of -30 +30 m and a resolution of 1 mm; this included a sensor with an encoder attached to a pulley, a wire float, counterweight, and an SDI-2 electrical output connected to an external data logger. The data logger has an LCD display for taking direct readings, an infrared interface with RS-232 port, a circular memory EEprom with a recording capacity of at least 500,000 readings and a programmable data-recording interval of between 1 minute and 24 hours, a GSM modem for the transmission of data and alarm signals when the threshold is exceeded, a photovoltaic panel for recharging the battery, a rechargeable battery of suitable dimensions so as to power the tide gauge for a period of at least 60 days without recharging, a sealed container with IP65 protection to house the data logger and equipment pertaining to the power source and data transmitter, stilling tube and metal mounting.

1 **Rain gauge** of the tipping-bucket type with a 324 cm^2 funnel and electrical impulse sensor (0.2 mm/impulse) connected to an external data logger. The data logger has an LCD display for taking direct readings, an infrared interface with RS-232 port, a circular memory EEprom with a recording capacity of at least 500,000 readings and a programmable data-recording interval, a GSM modem for the transmission of data and alarm signals when the threshold is exceeded, a photovoltaic panel for recharging the battery, a rechargeable battery of suitable dimensions so as to power the rain gauge for a period of at least 60 days without recharging, a sealed container with IP65 protection to house the data logger and equipment pertaining to the power source and data transmitter, and a steel pole 50 mm in diameter and 2 m in height on which to mount the gauge.

Figure 1 - *Tide gauge in the Casalabate branch of the Lega Navale nautical association*

Figure 2 - *Rain gauge of the tipping-bucket type in the Casalabate ranch of the Lega Navale nautical association*

The recorded data can be downloaded in situ using a cable connected to a laptop computer, or remotely by using the modem present in the Data Gathering Centre.

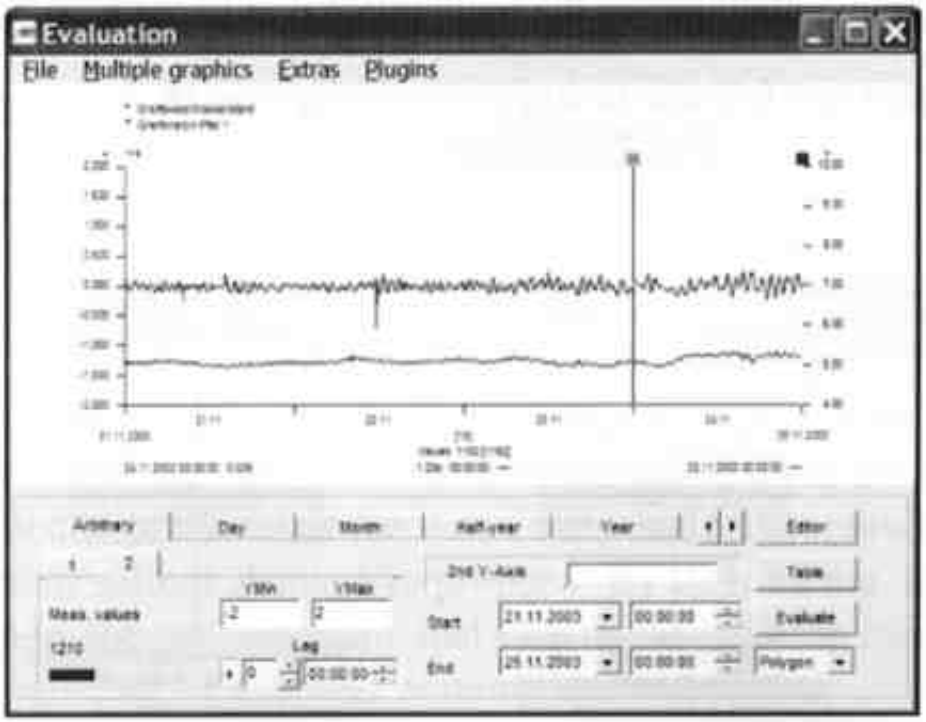
The data are currently recorded in a database on the server of the DPC (Data Processing Centre) and managed by HYDRAS 3 software; the figure below shows the software's main functions.

Figure 3 - *The software's main functions*

The following figures show functions of the software, such as:

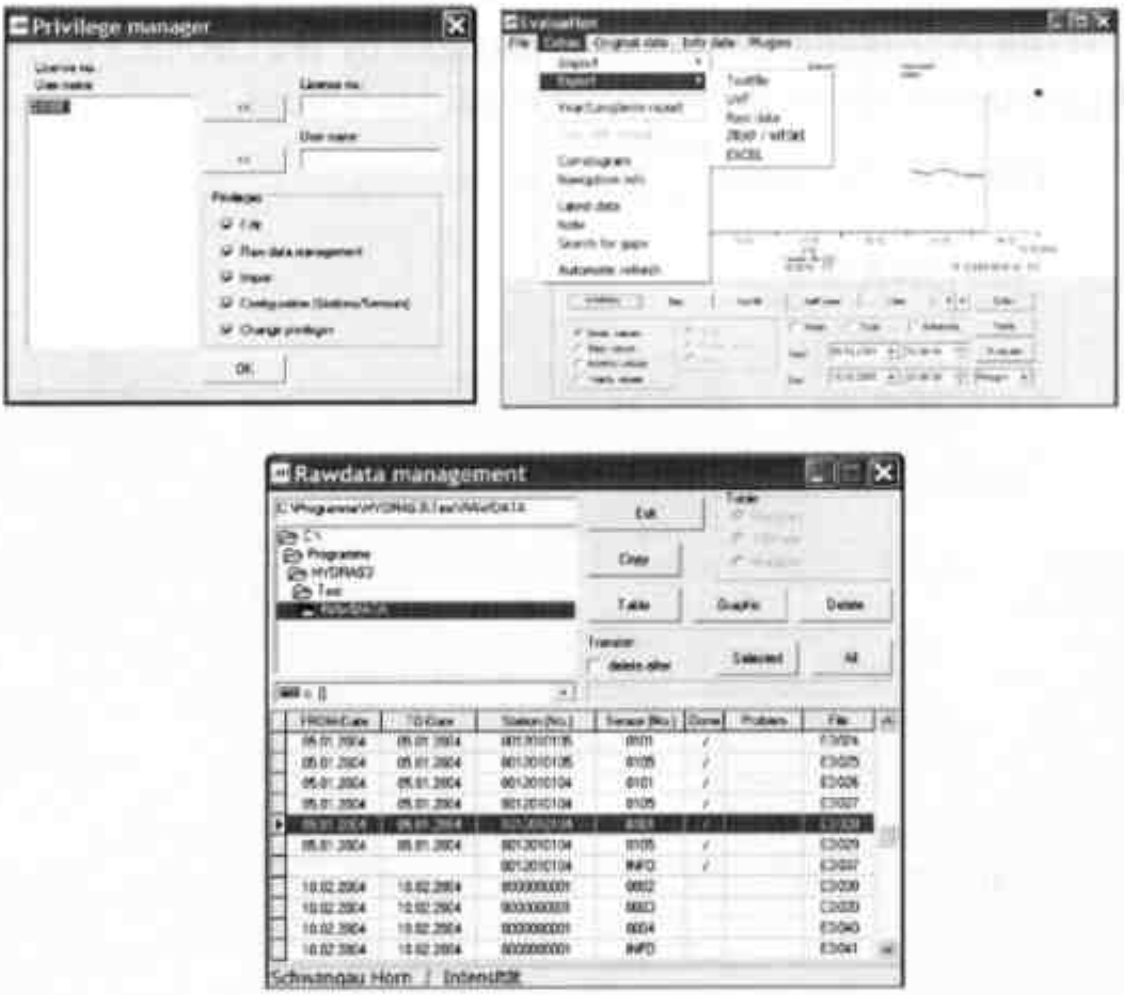
- the possibility of generating graphs with superimposition and/or comparison of a number of data layers.

Figure 4 - *Functions of the software*



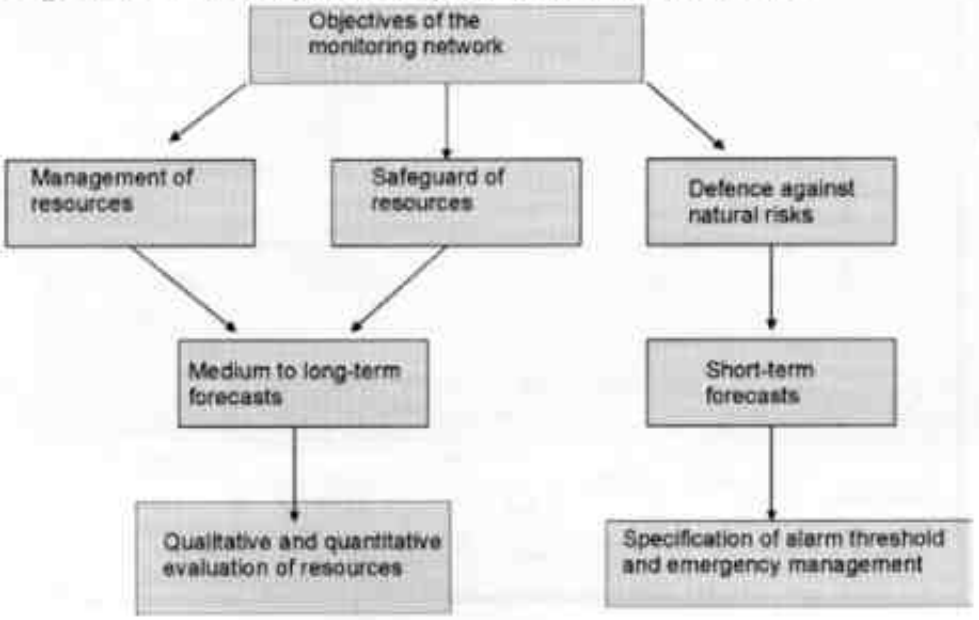
- the possibility of selecting graphs and groups of data and exporting them in the most commonly used formats:

Figure 5 - *Management of data*



The diagram below shows the main objectives of the monitoring network:

Figure 6 - *Main objectives of the monitoring network*



4. General operational procedures in the case of an alarm being given under Italian Legislation

Whenever a risk event occurs in an area, the office charged with dealing with the situation is the Municipal Civil Protection Centre, which is usually part of the technical and administrative structures of the municipal authorities and has the following responsibilities:

- Forecasting and prevention of natural or man-made disasters;
- Implementation, revision and management of the Municipal Civil Protection Plan;
- Drawing a map of the risks to the territory and other related thematic maps;
- Adoption of measures designed to tackle natural events linked to human activities that the municipal department can normally deal with act on its own;
- Adoption of direct and immediate measures in the case of "natural disasters or other events which, due to their intensity and size, need to be tackled with extraordinary means and powers" (article 2 of Law 225/92 comma C.) in order to remove the causes of the disaster and bring help to the affected population;
- Promotion among the citizens of a culture of Civil Protection;
- Training and education of personnel charged with Civil Protection and management of the relative municipal register.

Whenever an alarm signal is received or a risk event occurs within the territory of the municipality, the response of the Civil Protection Centre is divided into various phases.

1) Attention

The attention phase is activated in order to tackle small-scale phenomena and events, either natural or man-made, which are geographically limited or of modest dimensions and which do not involve danger to persons or serious damage to property. By their nature, they can be dealt with by the relevant municipal structures following regular procedures (article 2 of Law 225/92 comma A).

If the state of Attention occurs, the relevant structure or department must perform the following:

1. Establish contact with all other relevant boards or organisations, exchanging information on the measures to adopt;
2. Guarantee communication between the affected boards and organisations and the managers and operators of civil protection;
3. Send to the scene or possible trouble spots one or more teams, informing the authorities of the event and the measures adopted;
4. Inform higher organisations, should the size of the event make it necessary.

2) PRE-ALERT

This phase occurs when the relevant municipal structure or department believes that the nature and size of the event pose a risk to the population and/or property. In this case the Civil Protection Operational Centre (COM) will inform the local government leadership and will activate a series of initiatives including:

1. Immediately send a pre-alert message to Civil Protection personnel and the organisations and associations that will implement the measures;
2. Prepare initiatives to tackle the event and activate the Municipal Civil Protection Centre (COM);
3. Enhance monitoring activities;
4. Inform the municipal authorities about the event and the measures adopted;
5. Inform higher organisations on the progress of the event.

Civil Protection Associations are involved in this pre-alert phase via the pre-alerting of the contactable operators, the activation of vehicles and equipment and the verification of relevant supplies, and remain involved until a declaration is issued to say that the pre-alert is terminated. The relevant municipal structure or department will be informed of the available organisational system.

3) Alert

This phase is activated when the event that triggered the pre-alert worsens irreversibly and there is a high probability of an alarm situation arising.

The head of the COM, in agreement with the relevant municipal leaders, coordinates and activates the relevant personnel at the COM and all those who will provide the necessary support for the procedures. He or she also summons the Permanent Coordination Committee and the Technical-Operational Committee at the municipal level.

The municipal departments alert the responsible officials in the boards and private companies operating in the municipality and inform the National Civil Protection Department and the Regional administration.

The population are informed as to what they should do if the event occurs.

In this phase the heads of the Associations prepare their teams and vehicles, including material appropriate to the type of intervention to be carried out. In addition they meet with the COM and make themselves available to the head of the Centre, indicating the personnel and vehicles they intend to use to tackle the event.

4) Alarm

The alarm phase occurs when natural disasters or other events take place in the municipal territory which, due to their intensity and size, must be tackled with extraordinary means and powers. The alarm is also declared if an event which had already given rise to an alert situation subsequently becomes so large as that it can no longer be dealt with using normal means and powers.

If an alarm situation occurs, even without warning, the COM informs the municipal authorities (the mayor and/or a councillor with specific responsibility for such situations) who, if they accept the assessment of the officials, arrange for the state of alarm to be declared.

The municipal authorities send the message of alarm to the relevant department, summon the Civil Protection Committee and arrange for the population to be informed.

The heads of the Civil Protection voluntary associations are also informed, who in turn put in place the measures required by the Civil Protection Operational Centre.

5) Relief operations

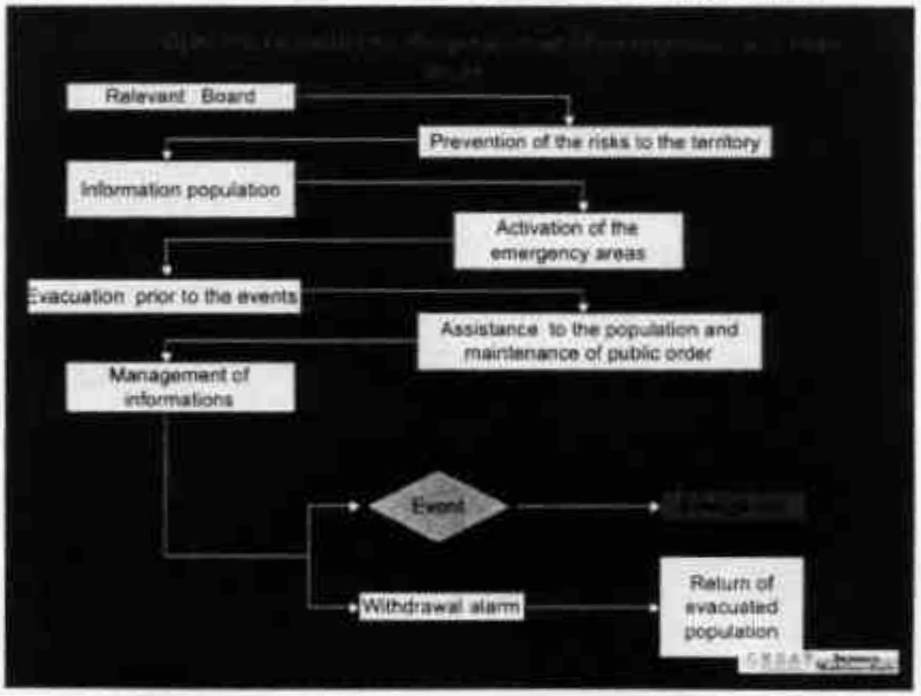
The final phase, to be implemented rapidly, consists of relief operations, which will be directly coordinated by the mayor in his/her capacity as "Municipal Civil Protection Authority".

When an emergency occurs within the territory of the municipality, the mayor becomes responsible for leading and coordinating relief services and assistance to the affected population and provides for the necessary measures to be taken, immediately informing the relevant departments and organisations on the regional and provincial level, including the Prefect. The voluntary associations are directly coordinated and mobilised by the mayor via the Civil Protection Operational Centre (Law DLgs 112 comma C).

The procedures for intervention are already set out in the Municipal Emergency Plans, drawn up in accordance with national directives.

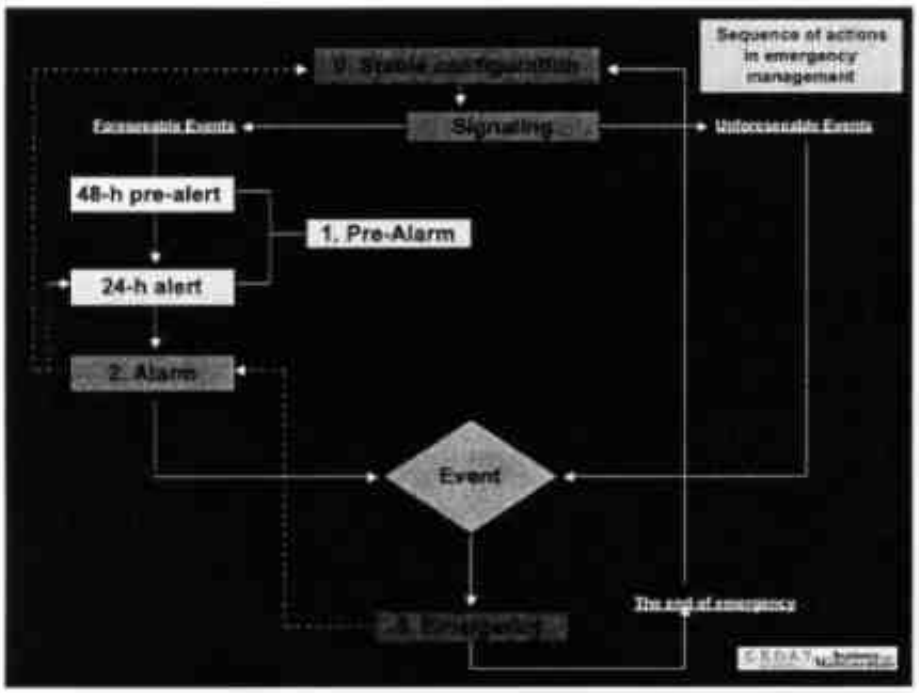
The first diagram below shoes the sequence of actions in the management of emergencies.

Figure 7 - *Sequence of actions in the management of emergencies*



The second shows the operational phases to be implemented, focusing on prevention:

Figure 8 - *The operational phases in the management of emergencies*



5. Activities linked to relief operations

The relief phase must be adequately planned in accordance with procedures which must be clearly set out before a disaster event strikes. These procedures must be rigorously codified and applied by every element in the emergency system, in order to allow an adequate management of the activities.

Indeed, it is necessary to follow a sequence of activities such as:

- Forecasting the degree to which the functioning of the transport infrastructure will be affected, identifying alternative solutions. It is also necessary to identify what is needed for the rapid restoration of the transport system
- Forecasting possible interruptions to essential services such as energy, water and gas supplies and the adoption of measures to cope with any prolonged suspension of supply
- Forecasting the number of homeless and the provisional structures for housing them

- Identify sanitary and health needs including specific situations and specialist assistance
- Carrying out a census of the public resources available in the municipal territory including those belonging to voluntary associations
- Establishing what equipment and vehicles are necessary for dealing with the emergency and draw up records for identifying critical situations and damage to the various sectors of social life.

In general the prefect and the mayor coordinate the relief activities by activating the Relief Coordination Centre (CCS) or Mixed Operational Centres (COM).

In concert with the Prefecture, the mayor assigns the initial tasks to perform and plays a logistical support role, carrying out a systematic survey of the damage using the municipality's technical offices. The management of relief on the municipal level is oriented towards optimising the intervention and liaising with bodies providing relief from outside the municipality.

It is thus fundamental to have a good knowledge of how to access the affected locations and an analysis of the usable routes. The authorities must also be prepared to rapidly mobilise technical experts should their contribution be required.

Further analyses will need to be carried out in order to identify the most suitable type of equipment for dealing with the emergency, considering the environmental context of the affected areas.

Depending on the relief scenario drawn up in advance, it is a good idea to prepare forms which enable a survey of the damage in order to have a proper assessment.

Finally it is necessary to note in detail the equipment and materials available in the municipal territory, identifying the personnel (municipal, police, local voluntary organisations) that can be used.

Once all people involved in various capacities and at various levels in the monitoring and alarm procedures have been identified, software routines are established in order to make the system automatic, with particular reference to the management of the system via the internet.

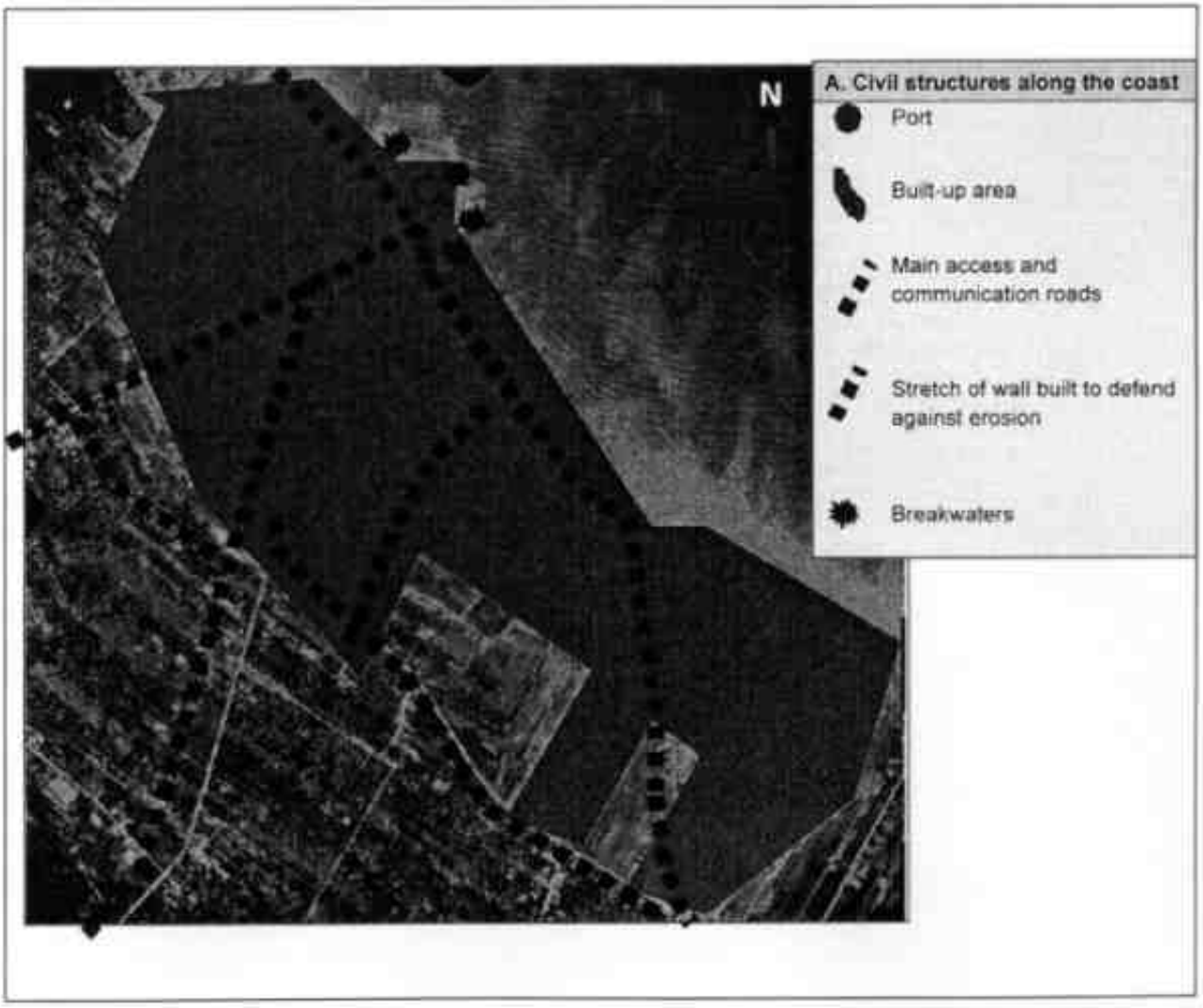
6. Analysis of the current situation and risk factors in the district of Casalabate

The Municipality of Lecce charged the CEDAT Europa Srl company with carrying out a detailed study of the phenomena taking place and the risk factors in the district of Casalabate (Lecce). After performing the necessary surveys in the area, CEDAT Srl identified the following:

1 – Civil structures along the coast

- The port;
- The built-up area;
- The main access and communication roads;
- The stretch of wall built to defend against erosion;
- The breakwaters

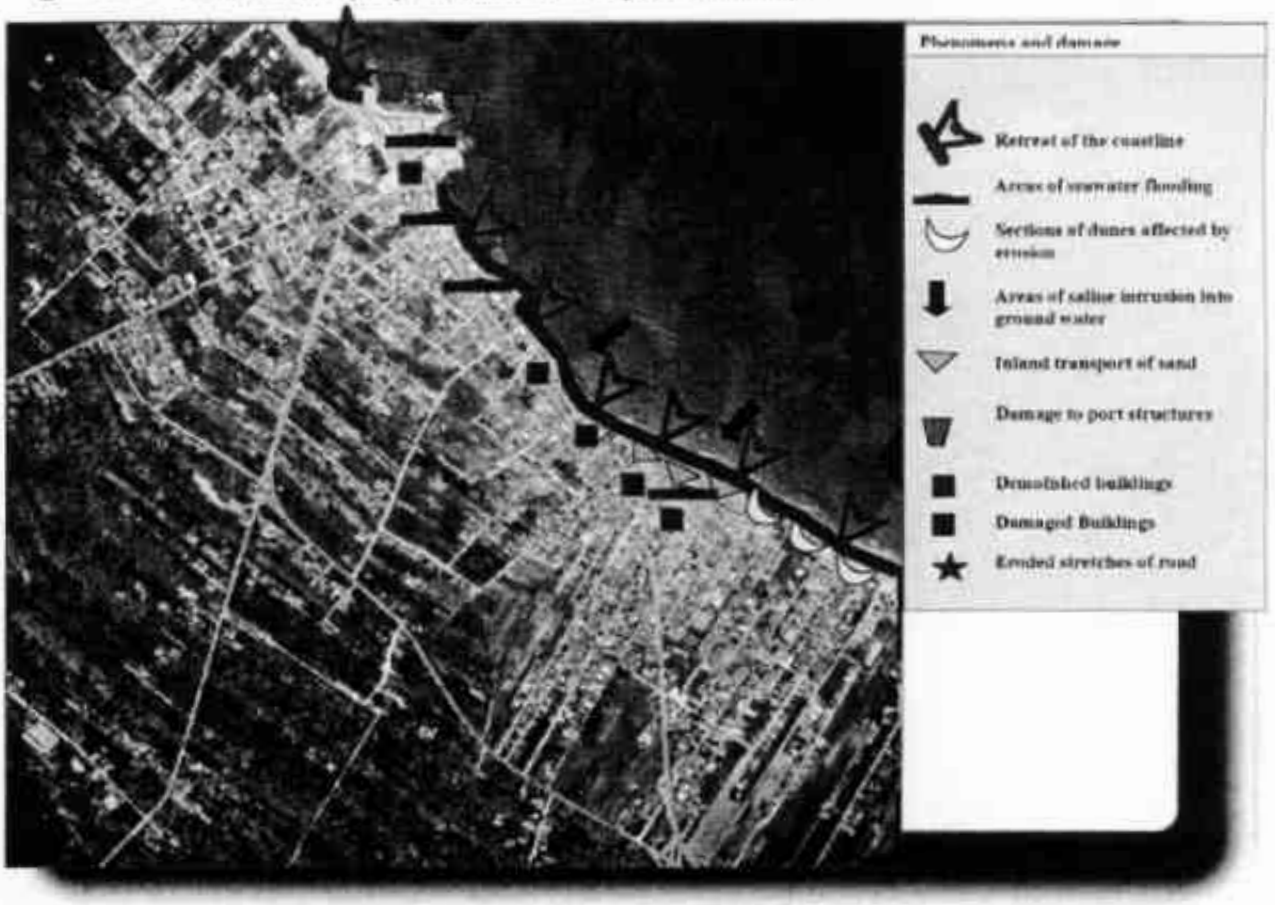
Figure 9 - *Map of civil structures along the coast of Casalabate*



- Evident retreat of the coastline;
- Areas affected by marine flooding;
- Erosion of the dunes;
- Areas where salt water is entering the groundwater;
- Transport of sand inland;
- Damage to port infrastructure;
- Fallen buildings;
- Damaged buildings;
- Erosion of a stretch of the coast road

The location of these phenomena is shown in the following figure:

Figure 10 - *Hazard map of coastal area of Casalabate*

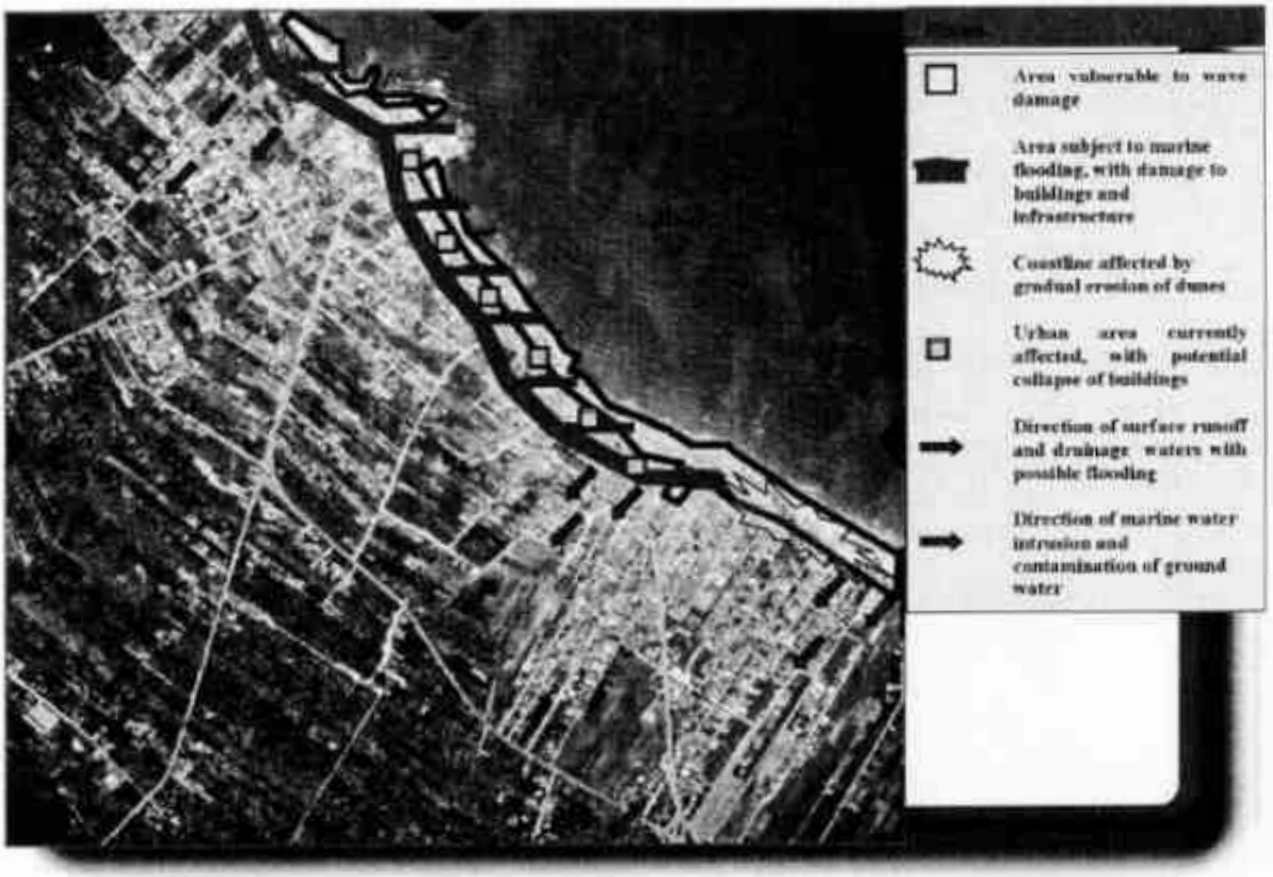


CEDAT Srl also evaluated

- The strip of land vulnerable to the impact of wave motion;
- The areas subject to marine flooding, with further possible damage to buildings and infrastructure;
- The coastal strip affected by the progressive erosion of the residual dunes;
- The urban area with where problems are already under way, with potential collapse of buildings;
- The channels which collect and drain surface waters, with possible flooding;
- The channels by which sea water enters and contaminates the groundwater

according to the following risk map:

Figure 11 - *Risks at Casalabate*



Lastly, three alarm conditions have been identified that correspond to three ranges of values recorded by the tide gauge, indicating possible immediate damage, the structures responsible for relief operations and the equipment and vehicles to mobilise, as shown in the following table.

Table 1 - *Alarm conditions, structures and vehicles to mobilise*

Alarm thresholds (tide gauge)	**Phases of Civil Protection**	**Structures charged with responding**	**Vehicle and equipment to be mobilised**
1 – 1.5	Possible marine invasion of the first rows of houses and roads (attention and alert)	Municipal Department Mayor or mayoral nominee Prefecture Provincial administration	Municipal Technical Offices Mobile equipment
1.5 - 2	Marine invasion with damage to buildings, roads and defence structures (alarm)	Municipal Department Mayor or mayoral nominee Prefecture Provincial administration Regional administration Voluntary organisations Coordination Committees	Municipal Technical Offices Health and technological services Municipal Civil Protection Plans
> 2	Marine invasion, accumulation of sand, damage including collapsed buildings, damaged roads and suspension of public services, dead or injured (relief)	Municipal Department Mayor or mayoral nominee Prefecture Provincial administration Regional administration National Civil Protection Service Police Voluntary organisations Coordination Committees	Municipal Technical Offices Health services Rapid technological intervention services Specialised companies (construction, evacuation and hospitalisation of people affected)