Jouniaux Marie
Laboratory of geomorphology and remote sensing
Liege University (Belgium)

Evolution of the west shorelines of Genoa

and specially the beaches around Vesima.

Jouniaux Marie, laboratory of geomorphology and remote sensing, Liege University

This article follows point by point the PowerPoint presentation realised at the Coastal Governance, Planning and Design and GI congress in Genoa (Italy), 16-20 November 2004. The purpose of this paper is to give a complete explanation of the presentation realised at this congress.

1. Subject of the search

The subject of our search realised in collaboration with the department of geomorphology and remote sensing of Liege University (Belgium) and the department DIPTERIS of Prof. Fierro of Genova University is the study of the evolution of the west shorelines of Genoa and specially beaches around Vesima. *(slide 1)*

This paper will follow the contents presented at the conference. In a first time, we will localise the area of the search and then we will analyse the contribution of remote sensing in the study of the beach evolution. *(slide 2).*

2. The purposes of the study *(slide 3)*

The main goal of this study is to have a better view about the littoral dynamic to manage beaches in the future. To have access to this main goal, we first made an evaluation of affectation changes on the west shoreline of Genoa (with the help of satellite imageries) and in a second part; we studied the evolution of the Vesima shoreline (by diachronical analyses of aerial photographs). *(slide 4)*

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3. Introduction *(slide 5)*

Today, 80% of the beaches around the world show erosion tendencies. The two principal factors responsible for this are:

- The sea level rise (Bruun law)
- The human action on the coast (walls, breakwater, sea wall, …)

In this context, Italy decided not to wait anymore and to act to limit the disappearing of its beaches (which are very important for the Italian economy). So, Italy organised a coastal plan (Piano territoriale della costa, P.T.C). This plan allows the use of artificial nourishment techniques to save the beaches. *(slide 6)*

4. Localisation of the area *(slide 7)*

The search area is located in the north of Italy and especially on the west shoreline of the city of Genoa. To be more precise, we can localise it between Arenzano and Genoa. *(slide 8)*

5. First contribution of remote sensing: analysis of anthropic pressures on shorelines. *(slide 9)*

To realise this analyse, we used satellite imageries.

- The first image is a Corona picture of the year 1973. The department of geomorphology and remote sensing of Liege University has obtained this image. This Corona image is a declassified imagery.

- The second image is a SPOT 5 imagery. This image has a very high spatial resolution (2,5 meter on the ground). The department of geomorphology and remote sensing of Liege University has also obtained this image. To receive this image, we realised an ISIS ask to the CNES (Centre National d'Études Spatiales) of France. The ISIS demand gives the possibility to European laboratories of search to obtain very good pictures at a low cost. In our case, our demand was accepted and we have received the image. *(slide 10)*

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With those two imageries, we realised a coloured composition. To create this coloured composition, we first georeferenced (to give the same reference system to the two images) the 2 images. To realise this we used a topographic map of the area.

On this map and on the SPOT 5 imagery, we selected ground control points (G.C.P). Ground control points are homologous points identified on both the topographic map and the SPOT 5 imagery (in our case) to be rectified. The GCPs are located in each area using file reference systems specific to each image. For the final rectification to be as accurate as possible, a large number of GCPs had to be selected for the entire processed image. Once this action realised, we obtained an image in the same reference system as the topographic map. Afterwards, we realised exactly the same process with the Corona image but not with the topographic map as a reference but with the SPOT 5 image as a reference. At the end, the result of all this process gives two images that can be superimposed.

Because of that, we had the possibility to realise a coloured composition with the two imageries. For the coloured composition we attributed the green canal to the SPOT 5 imagery and the red canal to the Corona imagery. The results of this composition are visible on the *slide number 11*.

This *slide 11* shows the important changes that were done in the part of Voltri (west Genova) between 1973 and 2002. In this image, the green sectors are the elements present in 2002, which weren't present in 1973. The red elements are those present in 1973 and which disappeared in 2002. In yellow are the elements similar between 1973 and 2002.

Knowing that, we can analyse the image. We can see that this area has changed a lot. The Voltri terminal (container's harbour) has appeared and some new roads and buildings have appeared too. At this scale, many important changes are visible on this part of the shore. *(slide 11).* The second part of the shore *(slide 12)* doesn't show any important changes at this scale. Nothing can be precisely noticed. So, to be able to go further in our search, we used another application of remote sensing.

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6. Second contribution of remote sensing: diachronical study of the shorelines evolution. *(slide 13)*

The area used for the second application of remote sensing is the shoreline between Arenzano and Voltri. To be more precise, we can say: the shoreline between Carbo del Pizzo and Scoglio Nave. *(slide 14).* This shore has the particularity not to be homogenous. It is a mixture of cliffs (red square) and pocket-beaches (yellow).

To imagine how the shore is in this region, the followings slides *(slides 15,16,17)* show the different beaches present on the analysed area. Those beaches are the following:

- Lupara *(slide 15)*
- Vesima *(slide 16)*
- Agugia *(slide 17)*

All of those beaches show important human pressures. In those pictures, we can see campings, railways, coastal roads, seaside resorts, protection walls, houses built on piles, … Each beach has its particularity.

- For Lupara, we can see the camping, the railway, the costal road and a protection wall just behind the seaside resort.
- For Vesima, the particularity is that there is a railway station, which is open each summer. So, many tourists from Genoa can easily go to this beach. Because of that, human pressures on this beach are very important. A piece of evidence of it is the presence of houses built on piles on the tempest berm. Those elements limit the natural movement of the beach and so increase the erosive action of the sea.
- For Agugia, observations are similar; an important vertical wall was built to protect the coastal road of the sea action. The problem is that the impact of the presence of this wall on the beach is very bad. The waves are more reflected and so their erosive action is increased.

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7. Evolution of Vesima and around beaches. (Second contribution of remote sensing) *(slide 18)*

To realise this second analysis, we used aerial photographs. The department DIPTERIS of Prof. Fierro of Genova University obtained those photographs. We had 4 different years of views (1944, 1973, 1983, 1993). For each year, we had 2 or 3 photographs. Our first purpose was to create one picture of the shoreline with the 2 or 3 initial pictures. The new picture we obtained is called mosaic.

To realise those mosaics (one per year), we proceeded like in the first part with the satellite imageries. We fixed the central picture as a reference. Then, we selected ground control points (homologous points identified in both pictures) on the covering part between the picture of reference and the other pictures. Once the mosaic was created, we georeferenced it. For that, we used a topographic map of the area. On this map (1992) and on the mosaic (1993), we selected a large number of ground control points (GCP) for the entire processed image. Once this action realised, the mosaic was in the same reference system as the topographic map. After that; we realised exactly the same process with the other mosaics but with the mosaic 1993 as a reference picture. At the end, the result of all this process gives super imposable mosaics. Because of this particularity, we had the possibility to realise coloured compositions with two different mosaics.

The first coloured composition created is between the mosaic 1944 and 1973. The green canal was attributed to the mosaic 1944 and the red canal to the mosaic 1973. The result of this composition is visible on the *slide number 18*. This coloured composition shows that the beaches grew during the period 1944-1973 (red beaches). This growth of the beaches is the result of the human action. In fact, in the years '70 the motorway was built in the inland. The result of this work was the throw of a lot of sediment coming from the digging of the tunnels on the beaches. It's for this reason that the beaches have increased so much.

A second coloured composition was created with the mosaics 1973 and 1993. The red canal was attributed to the mosaic 1993 and the green canal to the mosaic 1973. The results of this application are the following: the picture shows that the beaches show erosion (green beaches are beaches present in 1973 and disappeared in 1993). The situation on this picture is almost equal to the extension of the beaches in the year 1944!! But today the erosive action is still present! So, those beaches are disappearing. This come back of erosive action is due to the fact that as the motorway is finished, there aren't anymore throws of sediment on the beaches and as the natural deposits by torrent aren't important, those beaches are more and more eroded day after day. *(slide 18)*

8. Problems we met during the work *(slide 19)*

We met different problems during our work. The most important ones are the following *(slide 20)* :

- Impact of picture quality and the presence of a large proportion of sea on which no GCPs could be identified. Those elements gave difficulties for the resample and the creation of the mosaic and the coloured compositions.
- Impact of the breaking *(battigia)*: this one appeared on several pictures (mosaic of1983 and SPOT 5 imagery of 2002) as a large white area, which gave the impossibility to use them in the realisation of the coloured composition.

9. Comparison between 1993 and 1983 photographs *(slide 21)*

These pictures show the impossibility to determinate correctly the shoreline of the beach in the picture of the year 1983. This picture wasn't used in the creation of the coloured composition.

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10. Some examples *(slide 22)*

The following pictures show the strong, power that the sea can have in tempest periods. In those pictures, we can see the problems met with the breaking *(battigia)*. Here the beaches have disappeared under the sea action and power. Pictures took in those conditions cannot be useful in the analysis of the shoreline evolution.

11. Analysis of pixel intensity *(slide 23)*

This picture shows the pixel intensity value. Each mosaic is represented in the graphic. We can easily notice that for the year 1983 (blue line) the pixel intensity value is very high in the distance of 18-30 meter in the transversal cut in the beach. These values are the result of the breaking effect on the picture. So this picture of the year 1983 is not usable in the construction of coloured compositions.

12. Action against erosion: artificial nourishment *(slide 24-25)*

To act against erosion, the actual process is to use artificial nourishment. This process consists in nourishing beaches with sediments of similar lithology coming from back-beach rivers. The purposes are:

- Maintain the beaches as they are today
- Maintain the economical activities such as tourism, which is important for the country

13. Conclusions *(slide 26-27)*

This work gives us the possibility to show the generalised erosion of the area. This is because those beaches don't receive any natural sediments. It gives us the possibility to affirm that at the present time, without artificial deposits, those beaches wouldn't exist anymore! So, in the context, we can understand the important role of the artificial nourishment action whether it is organised or not.

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14. Prospective *(slide 28-29)*

After this work, some new ways are open in front of us. It could be interesting to go further with a socio-economical study about the impact and the future of artificial nourishment actions. It could also be interesting to know who benefits from those amenagments? what is the durability of those interventions? Is this technique "a well without end"? What are the social impacts those operations lead to?

Many other ways could be analysed in future work and collaboration between European research groups.