Looking through the changes: an analysis of the buried watercourses of Como

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Abstract

Studying territorial evolutions and investigating their underlying processes is essential to ensure continuity in well-done land management decisions. The case of Como City can be considered as a perfect small-scale example of how human influence acted on natural environment. Several watercourses hidden under the road network of the city represent one of the meaningful consequences. FOSS4G and geospatial data from different epochs of Como City historical development allowed to trace the evolution of the territorial setting and the original position of the watercourses. We quantified the variations in their peak flood discharges as a consequence of watersheds urbanization. A Web viewer was created for an easy access to the outcomes of the study.

Keywords

Buried rivers, FOSS4G, historical maps, watershed urbanization, water.

1 Introduction

The knowledge of the territory is a necessary requirement for any person who wants to operate within it, e.g. an urban planner or simply a dweller interested in his/her life-space. This perception cannot subsist without knowing the physical and environmental features as well as their historical and cultural value (Turri, 2002). The built environment, which constantly interferes with the natural one, can produce countless benefits for resident communities but also unpleasant consequences.

As a relevant example, we present here the temporal and spatial study of the watercourses – partially buried – of Como City. This city is placed in a valley which looks onto the southern part of the occidental branch of Lake Como. The origins of Como City date back up to the old Roman times. As a result, the valley has witnessed many transformations that have profoundly changed its natural landscape, especially regarding its watercourses. The Romans conquered the region in 196 BC. The alluvial plain they decided to settle in was a wetland crossed by many streams which probably occupied the central axis of the valley (Gianoncelli, 1975). For this reason, Romans were forced to divert the riverbeds out of their original positions and these works continued all along the Middle Ages and the Modern Age. With the beginning of the 20th century, a growing need for space for suburbs expansion led to the burial of both the major and minor watercourses within the city centre.

Historical large-scale mapping of Como City allows a detailed investigation of the territorial changes occurred. A huge amount of historical maps is actually

preserved in the State Archive of Como (http://www.ascomo.beniculturali.it). The oldest map dates back to the 17th century, while many others belong to different cadastral series from 18th and 19th centuries. Maps from the 20th century, mainly related to Master Plans of the city, are instead available in the RAPu Archive (http://www.rapu.it).
The present work can be considered as a proposal of best practice to be applied to the study of the territory. To guarantee the sustainability, the reproducibility as well as the potential customisation to other contexts, all the analyses were made by taking advantage of the maturity and flexibility of Free and Open Source Software for Geospatial (FOSS4G).

2 GIS tools and data processing

The main purpose of the study was to quantify the human influences on Como watercourses and the related watersheds. To enable GIS capabilities on the aforementioned cartographic dataset, the original paper maps (retrieved as digitally scanned images from the archives) were georeferenced through the QGIS Georeferencer GDAL plugin (see Figure 1A). To show that the original position of the main watercourse (Cosia Torrent) differs from the actual one (Gianoncelli, 1975), flow-accumulation raster from 10m cell-size TINITALY/01 DTM (Tarquini et al., 2012) was created using SAGA GIS (http://www.saga-gis.org). This allowed to extract the original flow-path of the torrent deriving from the pure terrain slope. A qualitative comparison between the original and the actual flow-path, the latter retrieved from Lombardy Region geoportal (http://www.cartografia.regione.lombardia.it/geoportale), visually highlights the large diversion work performed by the Romans (see Figure 1B).

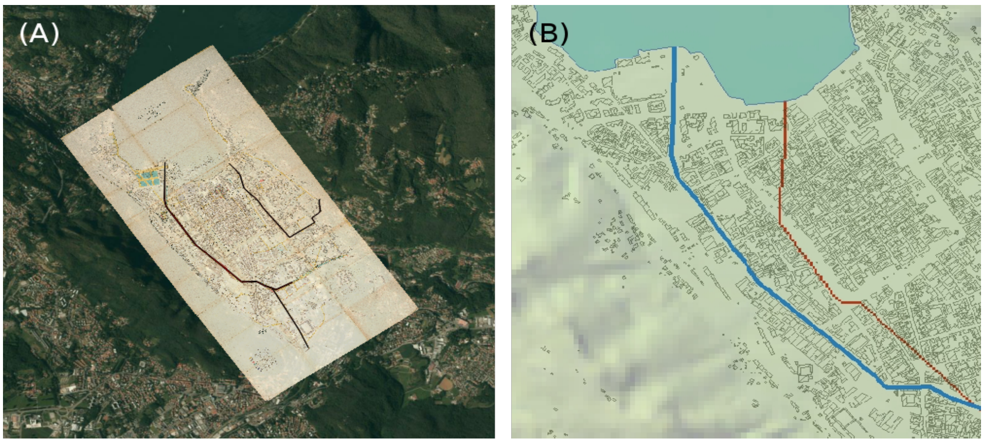

Figure 1: A) A georeferenced historical map of Como City; B) Actual Cosia flow-path (blue line) and DTM-extracted flow-path (red line).

Morphological data of both the watersheds and watercourses of interest were also extracted using SAGA GIS geoprocessing tools. A fast qualitative field-survey was then performed using the Geopaparazzi Android mobile app (http://geopaparazzi.github.io/geopaparazzi). Georeferenced pictures and measurements of several cross-sections along the watercourses (including the channel geometry and the hydraulic roughness) were collected during a number of field campaigns, thus providing a valuable set of input data for the hydraulic modelling (see Section 3).

3 Effects on surface runoff

One of the well-known issues related to urbanization is the widening of impervious areas, which results in an increased surface runoff affecting the watersheds. As a consequence, after intense rainfalls higher peak flood discharges into streams are expected to occur in shorter times.
To quantify this phenomenon on the watercourses under study, Curve Number (CN) maps (USDA, 2004) were created starting from land use D.U.S.A.F. data from different periods (1955, 1999, 2012) and the pedological map of the area. The analysis of CN maps allowed to detect the increase in imperviousness occurred in the area (see Figure 2). This can be easily related to the birth of industrial facilities, new residential areas, etc. which has historically happened within the watersheds under investigation. Moreover, an average weighted CN can be assigned to any sub-area of interest and expected peak runoff can be readily computed involving the Runoff CN method. Project storms with a return period of 2, 20 and 200 years were designed using rainfall records from A.R.P.A. Lombardia (http://arpalombardia.it). Starting from these storms, we computed the expected peak flood discharges for the three land use scenarios at the outlet of the main watercourses (Cosia, Aperto and Valduce). Using the same storms, the differences between the results can be attributed exclusively to the changes in land use brought by the urbanization process (see Figure 2).

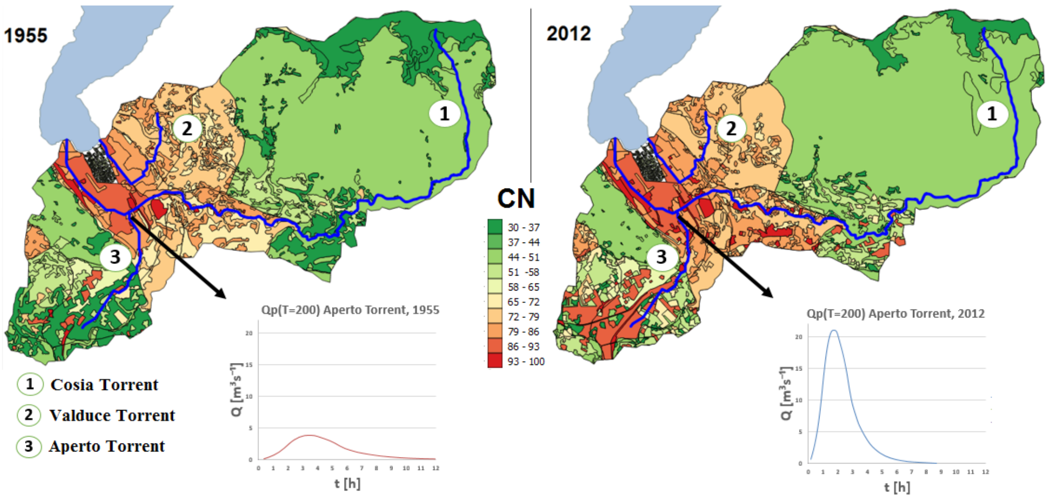

Figure 2: CN maps of Como watersheds in 1955 and 2012 and the change occurred in Aperto Torrent peak flood discharge (200 year return period).

The watercourses were buried more than 60 years ago. Therefore the outcomes of the hydrological modelling can be used to perform updated hydraulic simulations. This is advisable to check the efficiency of the buried channels in conveying the peak flood discharges, whose increase has been clearly proved.

4 Web viewer

To spread the outcomes of this study, a Web viewer based on the Leaflet JavaScript library (http://leafletjs.com) was created to let users access, navigate and compare all the geospatial data (see Figure 3). The data were published as standard WMS layers using GeoServer (http://geoserver.org). To provide users with not only a spatial but also a temporal perception, the inclusion of a time slidebar is planned which will allow to filter the visualization of layers according to the historical period they refer to.

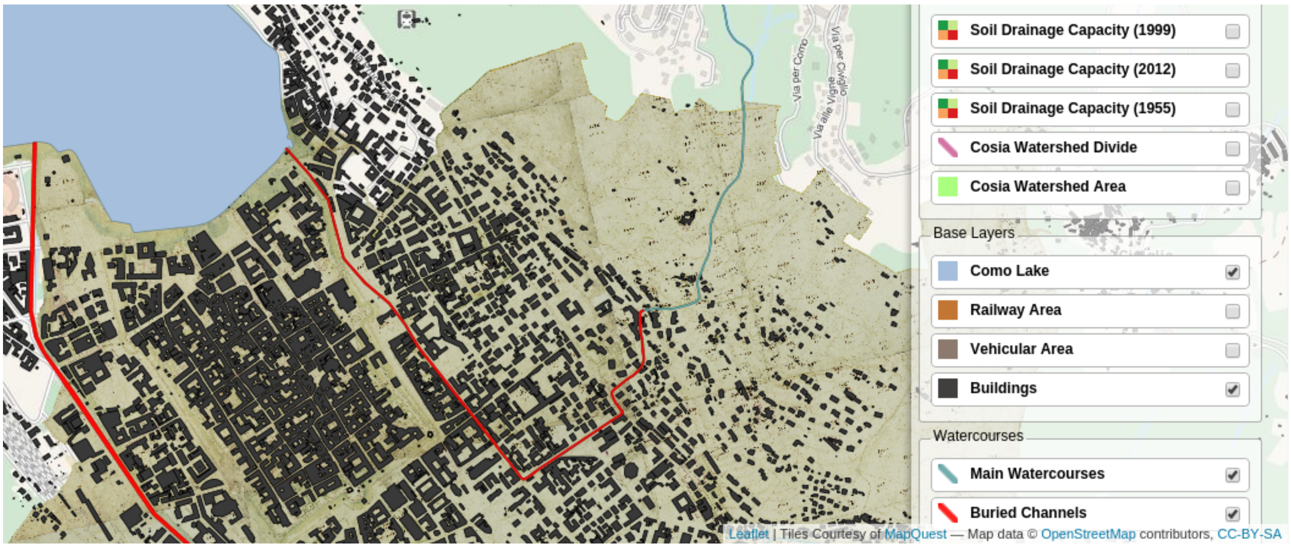

Figure 3: Web viewer showing the geospatial data used in the study.

5 Results and conclusions

The available FOSS4G technologies appeared to be adequate for this analysis. The possibility to retrieve both visual and numerical results makes them suitable for a broad target of users. The achieved outcomes can be considered as a starting point for more rigorous investigations. Besides its simplicity, the presented peak flood discharges estimation proved to be powerful enough to point out the magnitude of changes. Actually, hydraulic simulations based on field-data collected with Geopaparazzi were performed with HEC-RAS software. This choice was due to its simplicity and completeness. Implementation of FOSS4G solutions with equal capabilities is strongly advisable to boost their application in river analysis. Finally, the use of an interactive Web viewer may allow to spread in a very intuitive way the historical memory of changes as well as the awareness about their significant effects on the environment.

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