SHORT - TERM LAND USE CHANGES AND HYDRODYNAMICS IN THE MUSON RIVER WATERSHED (TV) IN RELATION TO CLIMATE CHANGE

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Abstract

Land development is the result of the economic and social organization of a community, and is connected to the adaption of resident population to changing environment. The assessment of land use changes can help controlling and understanding these transformations. This study illustrates the land use modifications of the Muson river basin (Treviso province, Northern Italy), occurred in the last twenty years, and that contribute to conditioning the river hydrodynamics, in relation to climate change.

Key words: *land use; climate change; Muson river watershed; soil*

Introduction

Data concerning land use are the most frequently requested information for the formulation of strategies for sustainable use, and to evaluate the efficiency of environmental policies. In this concern, a major theme is the transformation from natural conditions to an artificial (anthropogenic) use (YAALON, 2007; RITTER ET AL., 2003). The transformation determines often the loss of best soils and causes negative impacts to the environment, such as changes in the hydrodynamic level of rivers and microclimate. Moreover, climate change can cause negative effects on the environment, such as increased natural hazards (e.g. flooding, landslides). Yet, the quantity of rainfall that flows along the slopes and arrives at the river bed depends on the soil cover: moving from forest, grazing and meadows to arable land and urban areas, the overland flow and the flooding risk increase. The aim of this study was to ascertain the effects of land use changes and the hydrometric level variations in the Muson river watershed (Northern Italy), in connection with the current climate change.

Materials and methods

Study Area

The Muson river watershed is extended approx 15.000 ha from the pre – Alpine area (maximum altitude is 1.775 m a.s.l at Mount Grappa) to the alluvial plain (minimum altitude is 42 m a.s.l at Castelfranco Veneto). Its area is totally included within the Treviso province, and it is part of the larger Brenta river watershed (Fig. 1). The Muson river takes origin from the hilly area of the municipality of

DOI: 10.6092/issn.2281-4485/4543

Monfumo (NW Treviso province) and flows into the valley at the foot of the northern slope of the Asolo hills in south – west direction up to Pagnano, where it turns in south direction and leads into the high alluvial plain between the Brenta and the Piave rivers. Near to Spineda (Riese Pio X municipality, NW Treviso province) it receives, in the right, the contribution of the Lastego river, which flows down from the Monte Grappa slopes. At Castello di Godego it receives the Brentone stream and, in this area, the mountain basin of the Muson dei Sassi river ends downline of Castelfranco Veneto, after the confluence with the Avenale ditch. Proceeding to south, the canal of Muson river is, at first, dammed and then it becomes hanging not receiving contributions from other streams. Finally, it joins the Brenta river, north of Padua, near Pontevigodarzere. (ARPAV, 2008).

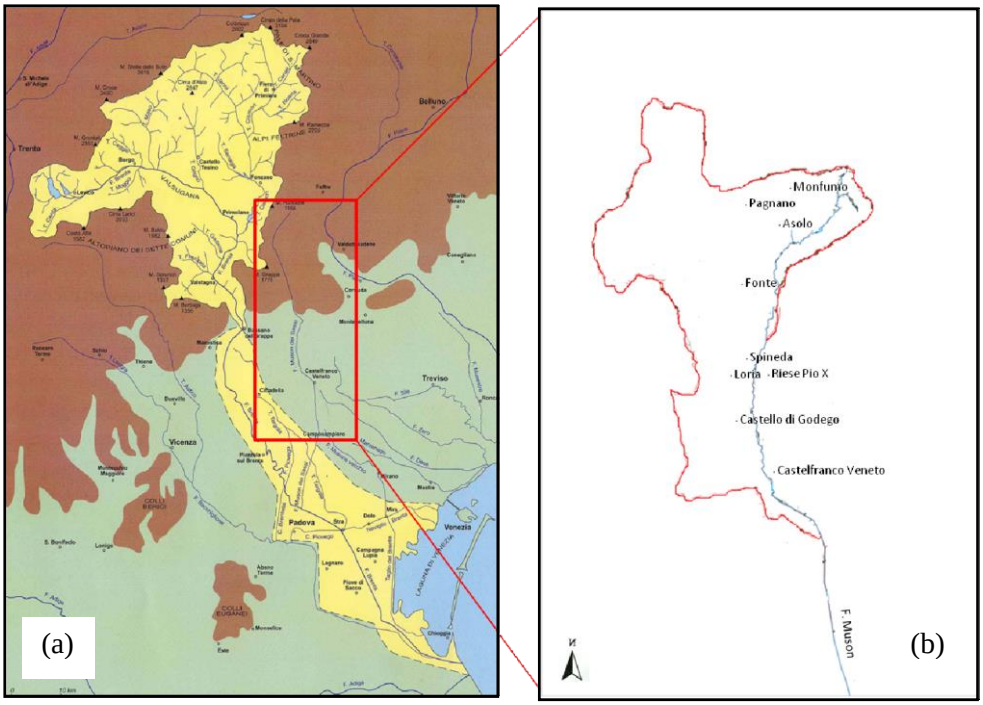

Figure 1. *Schematic map of the investigated area. (a): The Brenta river watershed is depicted in yellow, the pre – Alpine area in brown, the plain area in green, (b) the Muson river watershed (red line) and the Muson river (blue line) (ARPAV, 2008).*

Geology and geomorphology

The morphology of the Muson watershed can be divided in three different sectors: the pre – Alpine, the hilly and the high plain. The pre – Alpine area includes the southern slopes of the Mount Grappa; the hilly area is composed, to the east, of Asolo and Monfumo hills and of the Costalunga ridge and, to the west, of the Fonte and St. Zeno mountains and of the Paderno, Crespano and Borso del Grappa alluvial fans. The plain area belongs to the Venetian high plain. The Mount Grappa is composed of limestone and calcareous marl (grey limestone, *biancone* and

scaglia rossa of Jurassic and Cretaceous age) (DAL PIAZ, 1964; ISPRA, 2004). The piedmont area is occupied by alluvial fans located at the foot of Mount Grappa, and by hills. The fans are mostly formed by sandy and gravelly sediments, while the hills are composed of marly limestones, marls, claystones, siltstones, sandstones and conglomerates of the Tertiary (ISPRA, 2004). During the Pleistocene, the deposition of gravelly sediments by the Brenta and Piave rivers, in the alluvial fans, led to the creation of the high plain. Subsequently, in the Holocene, the Muson river has deposited a layer of clayey sediments at the confluence of the two coalescent fans (ISPRA, 2004).

Climate

The climate of the study area is divided into three districts, that correspond to the previously described morphological sectors: "*outer alpine district*", "*fore alpine district*" and "*alluvial plain district*" (ARPAV, 2011). In the "*outer alpine district*" the climate is characterized by average annual temperature of 7° C and rainfall of about 1.500 mm per year, which are distributed mainly in autumn and spring seasons. The climate of the hills ("*fore alpine district*") is distinguished by a lower amount of rainfall and higher temperature. In the plain ("*alluvial plain district*") the average annual temperature is around 13 – 14° C and the annual precipitation is around 1.000 mm (ARPAV, 2011).

Soils

The soils, in the pre – Alpine sector, are mostly Mollisols (Lithic Hapludolls) on slopes, and Alfisols (Ultic Hapludalfs) at bottom slopes (PROVINCIA DI TREVISO, 2008). They are fine – textured, moderately deep and with moderate permeability; the main land use is permanent pasture and forest. In the hilly area, soils are mostly Inceptisols (Rendollic, Typic or Oxyaquic Eutrudepts) and Entisols (Lithic or Typic Udorthents) (PROVINCIA DI TREVISO, 2008). Inceptisols are coarse – textured, while Entisols are fine – textured. In both soils the infiltration capacity and permeability are high and, the main land use is generally agricultural. The most common soils in the plain area are Alfisols (Typic Hapludalfs) and Inceptisols (Rendollic, Typic or Dystric Etrudepts) (PROVINCIA DI TREVISO, 2008). The Alfisols are fine – textured with a moderate permeability, while the Inceptisols are medium – textured with a good infiltration capacity and a high permeability. In the plain area, the main land use is agricultural.

Map processing

Aerial photographs of land use in the period 1990 – 1992 were compared with satellite photographs taken in the 2009, in order to ascertain land use changes occurred over a period of 20 years. The aerial photographs, of the 1990 – 1992, are available in the Department of Environmental Sciences (Ca' Foscari University of Venice, Italy), while the 2009 series were downloaded from the Veneto Region database, as vectorial data, and they belong to the flights operated by the Veneto Region. The two series of images were analyzed with two different methods: interpretation of aerial photographs (1990 – 92) with a mirror stereoscope, and GIS

DOI: 10.6092/issn.2281-4485/4543

elaboration of soil cover data (2009 vectorial data). This has led to the creation of two land use maps. Photographs taken in 1990 cover the plain sector of the Muson watershed, ending at the hilly sector. The flight altitude and the scale of the aerial photographs are respectively 3.000 m and 1:20.000 (REGIONE DEL VENETO, 1990). The hilly and pre – Alpine areas, instead, are included in the aerial photographs take in 1991 – 1992. The average flight altitude is 2.700 m and, consequently, the images scale is variable around 1:18.000 (REGIONE DEL VENETO, 1992). The frames used to interpreter the land use of the whole watershed are 81 for the plain and 57 for the hill and the pre – Alpine zones (138 in total). Before the interpretation of the frames, is important to choose the land use legend. Concerning the frames 1990 – 1992, the scale used has allowed the recognition of the following uses: urban areas (U), arable land (S), forest (B), permanent crop systems (IS), meadows and permanent pasture (P), afforestation (r), riparian vegetation (R) and quarrying (E). After photo – interpretation, thanks to the software Esri ArcGis 10, it was possible to create the actual land use map at the scale of 1:50.000. The vectorial data was used for the creation of the land use map related to 2009; this was elaborated with the same software Esri ArcGis 10. The legend of the two maps was uniformed in order to make a comparison of the actual land use. From the 2009 general land use map, four thematic maps (scale 1:50.000) representing single land uses (forest, afforestation and riparian vegetation; arable land; urban area; meadows, permanent pasture and permanent crop systems) were derived.

Climate aspects

In this study we have used climate data obtained from studies carried out by the ARPAV (Regional Meteorological Center, Teolo, Padua). These studies analyzed meteorological data of the period 1956 – 2004 and allowed identification of the last significant climatic change in the period 1987 – 1988, when the average annual temperature was increased from 14.7 to 16.2° C (CHIAUDANI, 2010). The Meteorological Center of Teolo provided also the rainfall data relating to two pluviometers at Pove del Grappa and Castelfranco Veneto. The first station is located outside the Muson basin, but it is representative of the meteorological conditions in the hilly area; the second one is indicative of precipitation in the plain sector. The available data are related to the hydrological series from 1992 to 2011.

Hydrometric levels

Concerning the hydrometrics levels, we used data recorded from 1998 to 2009 at the hydrometer installed at the Borgo Vicenza bridge (Castelfranco Veneto), and provided by ARPAV and Treviso Civil Engineering Service.

Results

Aerial photographs taken in 1990 – 92 and 2009 show that, in the last decades, urbanization has increased up to 13% (Tab. 1) in the alluvial plain, and significant

land use modification has affected also the mountain and hilly areas, with serious consequences on river hydrodynamics.

Land use change	Values (%)
Urban areas	13
Forest stands	28
Meadows and permanent pasture	23
Arable land	36

Table 1
Land use of the Muson river watershed (2009)

Thanks to the comparative analysis of the land use maps, it was possible to ascertain the land use changes in the study area. The pre – Alpine area has not undergone significant changes (the major land use is permanent pasture). In this area, the maximum annual average rainfall (up to 1.771 mm) was recorded (ARPAV, 2011); more than half of the rain (1.099,55 mm) infiltrates feeding the karst aquifer (ARPAV, 2011), without conditioning the hydrodynamics of the Muson river. In the piedmont area, there was an increase of urban areas, afforestation and permanent crop systems in spite of meadow. In the plain the principal land use is the arable land and there are not important changes in regard to this use, even if there is an increase of urban areas.
The analysis of rainfall data evidenced different trends (MANIERO ET AL., 2009), in particular:
- a decrease in winter rains amount: from 135 – 200 mm to 80 – 150 mm (ARPAV, 2011);
- an increase of rainfall during spring and autumn: from 80 – 100 to 120 – 160 mm (ARPAV, 2011);
- a decreased persistence of snow cover: reduced by 12% (ARPAV, 2011);
- a dramatic reduction of small glaciers and snow line elevation: the average is decreased by 35% and the maximum by 16% (ARPAV, 2011).
Our results showed that the hydrometric levels increased in the rainy seasons (i.e. spring and autumn). Moreover, the hydrometric levels are significantly ($P < 0,05$) associated with the rainfall amount (Fig.2).
From Fig. 2 it emerges that hydrometric levels present a decreasing trend in the period 2000 – 2009, consistently with rainfall distribution. Precipitation at Pove del Grappa (red line, Fig. 2) resulted to increase in 2009 in comparison to 2000 (+300 mm on yearly basis), with minor peaks in spring and autumn. Conversely, at Castelfranco (green line, Fig. 2) a decreasing trend (-56 mm on yearly basis) is recorded for the same period (2000 – 2009), with minor peaks corresponding to those of Pove rainfall and the hydrometric levels. The more uniform rainfall distribution in the region is likely due to changing climate conditions recorded in the last decade in the mountain and hilly areas.

DOI: 10.6092/issn.2281-4485/4543

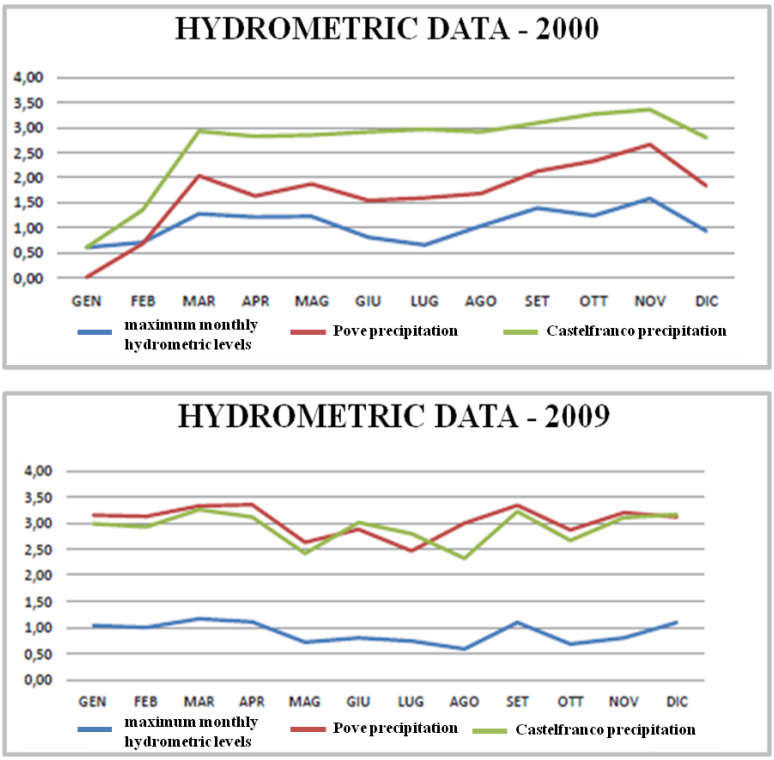

Figure 2
Hydrometric levels (in blue) associated with the rainfall amount (in red and green). Original data are transformed by the logarithmic function ($log_{10}(x_i)+1$).

In this study we found out that the most important land use changes involved the urban areas, with an increase of 13%. This impact might cause a negative effect on the hydrodynamics of the area, due to the decrease of soil absorption capacity and increase of the superficial flow, leading to a major flooding hazard. The increase of forested areas, instead, has a positive effect on hydrodynamics, counteracting the effect of rainfall, and regulating the overland flow. Moreover, our data showed that there is a strong correlation between the rainfall and hydrometric levels of the studied area.
The applied methodology proved useful for improving the monitoring actions and for a sustainable land management.

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DOI: 10.6092/issn.2281-4485/4543

CHANGEMENTS D'UTILISATION DES TERRES A COURT TERME ET HYDRODYNAMIQUE DANS LA RIVIERE MUSON BASSINS (TV) EN RELATION AVEC LE CHANGEMENT CLIMATIQUE

Résumé

L'aménagement du territoire est le résultat de l'organisation économique et sociale d'une communauté, et est relié à l'adaptation de la population résidente à l'environnement changeant. L'évaluation de l'utilisation des sols peut aider le contrôle et la compréhension de ces transformations. Cette étude illustre les modifications d'utilisation des terres du bassin de la rivière Muson (province de Trévise, Italie du Nord), qui ont lieu au cours des vingt dernières années, et qui conditionnent l'hydrodynamique de la rivière, par rapport au changement climatique.
Mots clés: *utilisation des terres; changement climatique; bassin versant de la rivière Muson; sol.*

I CAMBIAMENTI A BREVE TERMINE DELL'USO DEL SUOLO E L'IDRODINAMICA DEL BACINO IDROGRAFICO DEL FIUME MUSON (TV) IN RELAZIONE AI CAMBIAMENTI CLIMATICI

Riassunto

L'evoluzione del suolo è il risultato dell'organizzazione economica e sociale di una comunità ed è connessa all'adattamento della popolazione ai cambiamenti ambientali. La valutazione dei cambiamenti climatici può aiutare a controllare e capire tali trasformazioni. Questo studio illustra le modifiche nell'uso del suolo del bacino del fiume Muson (provincia di Treviso, Italia settentrionale), avvenute negli ultimi 20 anni, che possono influenzare l'idrodinamica del fiume, in relazione ai cambiamenti climatici.
Parole chiave: *uso del suolo; cambiamenti climatici; bacino idrografico del fiume Muson; suolo.*