34. Quantitative and modelling evaluation of the hydrologic function in the Greaca landscape

ŞTEFAN Ionuţ, BODESCU Florian, IORDACHE Virgil

University of Bucharest, Dept. Of Systems Ecology and Sustainable Development, 91-95 Splaiul Independentei street, Bucharest 76201 sector 5, Romania

Address of author responsible for correspondence: Ionuţ Ştefan - University of Bucharest, Dept. Of Systems Ecology and Sustainable Development, 91-95 Splaiul Independentei street, Bucharest 76201 sector 5, Romania; e-mail: stefanionutdoru@yahoo.com

ABSTRACT. The hydrologic function has been evaluated for the Greaca area, component of the Lower Danube Wetlands System. The evaluation was comparative for two periods of time (before and after the Danube dam was build). The antropic impact on this area is discussed analyzing the total volume of water retained by this area, for the two periods of time. We used SWAT to evaluate the degree of basin fragmentation and, based on the results obtained, it is discussed the human role in the fragmentation of hydrologic basins.

KEY WORDS: hidrology, GIS, Danube, SWAT

INTRODUCTION

Natural resources and services ensured by the components of the natural capital represent essential factors in the production of goods and services for the economic system or it conditiones directly the structure, functions and quality/health of the human populations [6].

In the last century, because of the economic growth and the low level of scientific information necessary for the understanding and evaluation of the multifunctional role of the wetlands, most of them were treated as "unusable surfaces, areas with no economic importance, and were transformed (drained and diked) in agricultural areas, forested areas, industrial complexes, urban areas [7].

The hidrologic function is a very important one in maintaining the ecosystem's growth and development and in maintaining the production of goods and the offer of services for the other ecosystems in the ecologic hierarchy, especially for the socio- economic systems.

In this context, we have analyzed the structure of the Greaca hydrologic basin to observe the structural differences caused by the anthropic intervention in this area to transform it in a agricultural area, controlling the hydrology of this area to obtain maximum productivity for the socio- economic system.

MATERIALS AND METHODS

In this paper we have tried to modelate the hidrologic function of the Greaca area, comparatively for two periodes of time. In this way we attempted to characterise the structural and functional differences caused by the modiffication of the hydrologic function in this area because of the different ways of land use. In the reference state, the Greaca area was complete flooding regime, and in actual state, this area is diked and drained because of the Danube dam.

For achieving the main objective we have used two GIS software: GRASS and SWAT GRASS.

GRASS (**G**eographic **R**esources **A**nalysis **S**upport **S**ystem) is an Geographic Information System used for the management and analyses of the georeferenced data. With GRASS you could also process images, produce maps and graphics, spatial modelling and view of a wide range of data types. This software is free of charge [e.g.1]. With GRASS one can analyze raster and vector images and produce maps and graphics.

This software containes over 350 programs and tools for the creation of maps and images on the screen and for printing on paper, for processing of multiband spectral images and for the creation, use and save of satial data.

GRASS also represents a data base in witch one can save many data bases. The general structure of a GRASS Data Base is: (1) a general data base in witch we can save many (2) locations, and for each location we can save many (3) maps. One advantage of this software is that if it is opened on a server, many people can work on the same location and the results are optained faster and are more efficient.

We have used GRASS to modify the DEM (Digital Elevation Model) of the Greaca area, to obtain a DEM for the reference hydrologic structure and another DEM for the present hydrologic structure. After we have obtained the two modified Dem's, we have done a quantitative evaluation of the hydrologic function (the quantity of water detained by the two models) and after that we have applied the SWAT analyses to obtain the hydrologic basins and subbasins for the two models.

We have modified the DEM after we have extracted the hydrologic networks for the two different periods by digitizing hydrologic and soil maps with were georeferenced in **Stereo 70/ S-42 Romania** system. After that we used the **r.mapcalculator** tool to combine the hydrologic networks with the Digital Elevation Model. Before that the hydrologic networkswere modified so that they were transformed in binary system (0 and 1; 0 for no data, and 1 forthe hydrologic network) like in **Fig. 3**.

After the transformation, the hydrologic networks were combined with the DEM using the following formula:

$$A-(B*2)$$

where A=Digital Elevation Model; B=hydrologic networks and 2=a value with which the DEM was modiffied. The modified DEM's obtained are shown in **Fig. 4**.

After we have modiffied the digital elevation models for the two periods of time we can apply the SWAT analyses for both of them. For the SWAT analyses we need as input: the DEM's for the two periods of time, Land Use maps, Soil maps, Precipitation informations, and at the end of the analyses we can obtain the hydrologic balance.

SWAT (**S**oil and **W**ater **A**ssessement **T**ool) is a model which can be applied at the scale of a hydrologic basin. It has been developed to forecast the damage caused by the different types of land use on water, sediment and agricultural products from big and complex hydrologic basins with different soils, land use methods and management, for long periods of time. [e.g. 3, 4, 5].

RESULTS

After we have obtained the Digital Elevation Models for the two periodes of time, analyzing them, we have observed some structural differences after we have made longitudinal and transversal profiles (figure 6).

As you can see in the pictures above, the Greaca landscape was stronglly modiffied, and the old fen can't maintain as much water as it could in the period of reference. The bottom of the old fen is heigher now because of the use of agricultural machines. As you can see in the reference state (1960) the height of the water was about 3 meters and in the actual conditions, water only exist in the drainage channels built by humans so that the land could be used for agricultural purposes.

After that we have done some quantitative analyses, analyzing the total volume of water detained by the reference state, the actual state, and in case of restoration. The results are shown in the following graphics.

Analyzing the data in the two graphics, we can observe that the area in the reference state could retain much more water than the same area in the actual conditions. Olso we can observe that in case of restoration, the volume of water is not so big because of the modiffications brought by the agricultural practices from this area. At the 12 meters water level, the difference in the volume of water retained is very big between the two time moments because of the reduction in surface of the areas that could retain water (in 2005, water can be retained only in the drainage channels). In conclusion, the debt of the Socio-economic system for the Greaca landscape, can be deleted only if the area is restoredin very big proportion, by geomorphologic modifications so that the actual structure can resemble the reference structure.

After we have modified and analysed the DEM's, we will present the results of the SWAT analyses: hidrografic basins, subbasins and the hydrologic network, for the two periods of time.

If we analyse the basins and subbasins for the two periods of time we can observe a bigger degree of fragmentation in the actual state because of the human impact. The most fragmentated area is the area of the old fen where, in present, agriculture is applied. Also we can see that the number of subbasins is very big in the actual state (31 subbasins) comparative with the reference state (5 subbasins). In the following table (**Table 1**), are presented the subbasins with their surfaces.

Table 1

Number of subbasins and their surfaces

Subbasins/ Reference state (1965)	**Surface**	**Subbasins/ Actual state (2005)**	**Surface**
1	97.5 km^2	1	95.8 km^2
2	58 km^2	2	0.105 km^2
3	157.8 km^2	3	7.14 km^2
4	42 km^2	4	1.32 km^2
5	40.4 km^2	5	0.631 km^2
Hidrografic basin	**395.7 km^2**	6	0.0109 km^2
		7	0.00363 km^2
		8	5.18 km^2
		9	15.5 km^2
		10	8.22 km^2
		11	27.5 km^2
		12	0.00263 km^2
		13	13.3 km^2
		14	21.5 km^2
		15	9.81 km^2
		16	4.72 km^2
		17	2.92 km^2
		18	2.7 km^2
		19	6.49 km^2
		20	16.6 km^2
		21	9.75 km^2
		22	0.754 km^2
		23	11.8 km^2
		24	12.2 km^2
		25	9.12 km^2
		26	18 km^2
		27	8.57 km^2
		28	9.64 km^2
		29	8.75 km^2
		30	8.78 km^2
		31	23.2 km^2
		Hidrografic basin	**360.00263 km^2**

Analysing the data in **Table 1** we can see that with the high degree of fragmentation of the hidrografic basins, between the two periods of time, the surface of the basin has been reduced with 35.7 km^2 due to the human activities in this area.

Fig. 9 shows the maps representing slopes for the Greaca hidrografic basin comparative for the two periods of time:

Analysing the maps above one can see that in the map representing the reference state, the Greaca area was deeper, with a bigger slope (7^0, 8^0, 9^0), we can see the line of the old fen that could retain a bigger volume of water, comparative with the actual state when bigger slopes can be found only in the drainage channes and in the rest the slopes are very small (< 3^0), almost horizontal, because of the ploughing of the earth for transforming this area into a agricultural area.

Conclusions

- ✓ The hidrografic network is highly modified compared with the one in the state of reference, so, the actual hidrografic basin is much more fragmentated than the one in the state of reference; the actual basin is divided in 31 subbasins and the hidrologic basin from the state reference was divided in 5 subbasins;
- ✓ By simulating a flooding scenario, we could estimate that the actual structure can retain in case of floods comparable with the ones in 2006, 0.031 km^3 of water, comparable with 1.245 km^3 of water, that it would retain in the reference state;
- ✓ In case of restoration, the function „Retention the water from floods", will be with 10% smaller than in the reference state, because of partial filling with soil of the old lake Greaca;
- ✓ We have created a data base with the structural characteristics of the landscape Greaca for the future more detailed hydrologic modelling of the landscape;
- ✓ We couldn't run the hydrologic model at this point because we don't have detailed data base with the structural characteristics of every soil type in the studied area.

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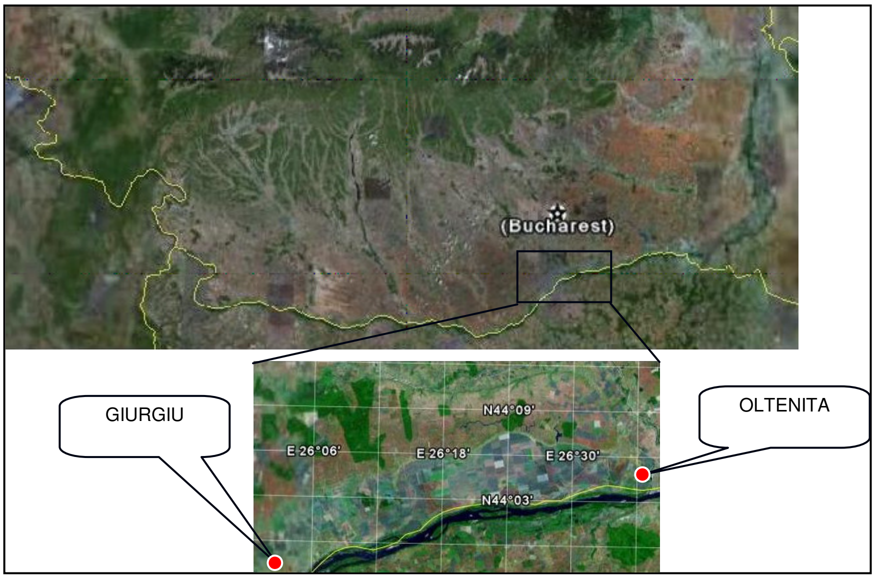

Figure 1. The location of the study area
(pictures taken with Google Earth)

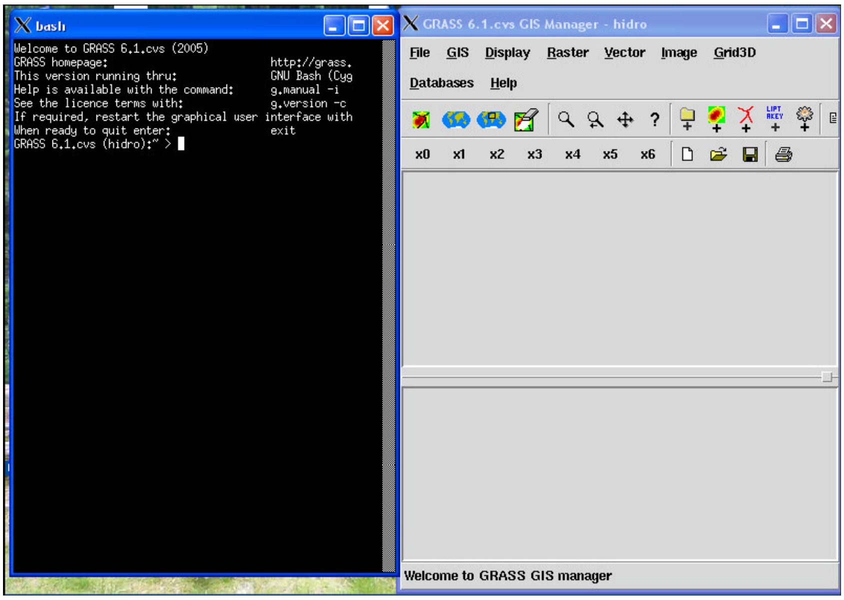

Fig. 2. Grafic interface of the GRASS software

Fig. 3. Hydrologic network in binary system (0 and 1)

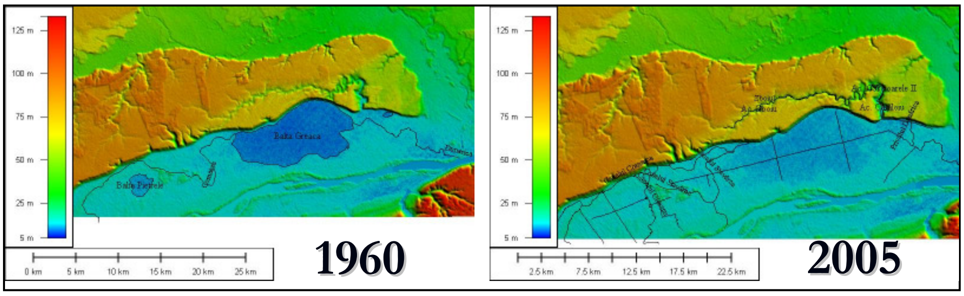

Fig. 4. The Digital Elevation Models modified for the two periods of time

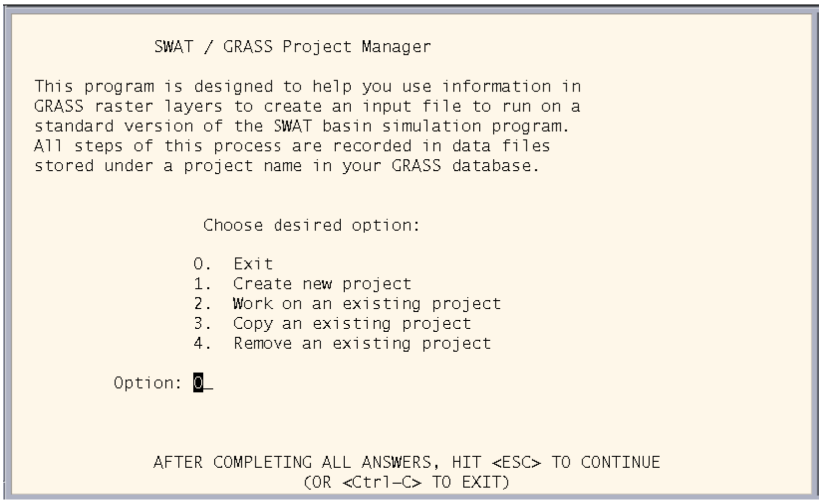

Fig. 5. Start window of SWAT GRASS

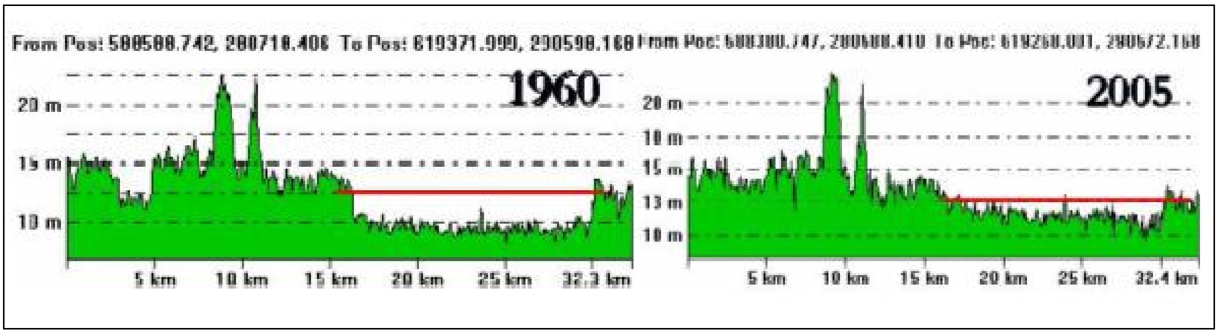

Fig. 6. Difference in the height of the land for the two periods of time
(1960-left; 2005-right)

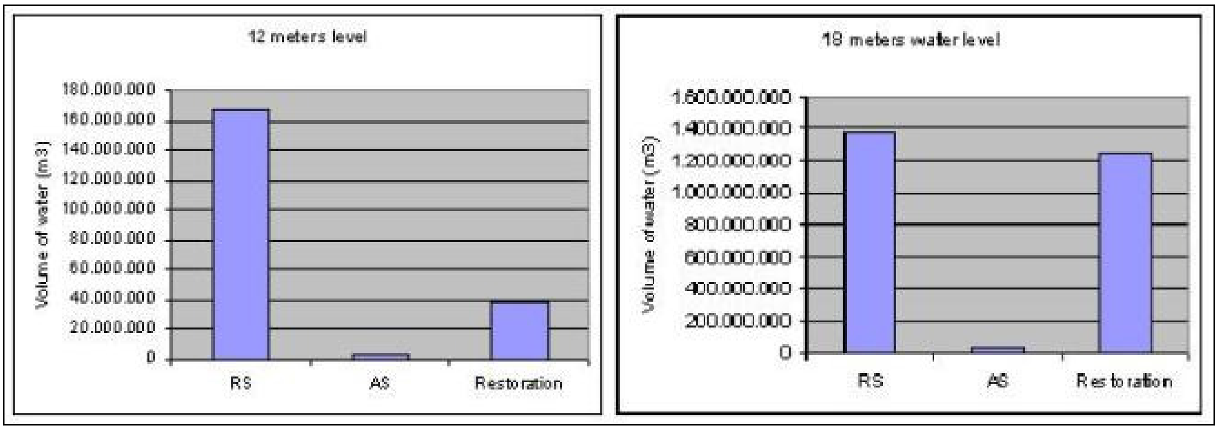

Fig. 7. The quantity of water retained at 12 meters and 18 meters water level in 3 situations: RS=Reference state; AS=Actual state; In case of restoration

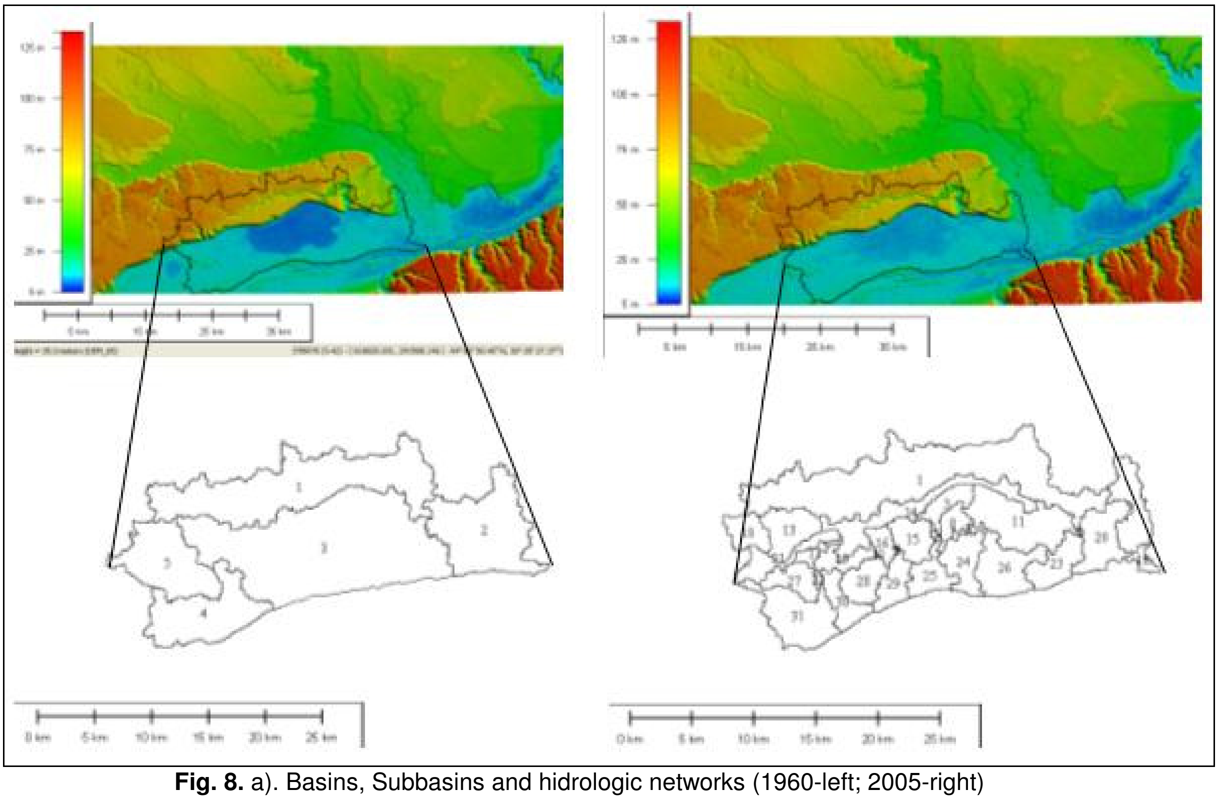

Fig. 8. a). Basins, Subbasins and hidrologic networks (1960-left; 2005-right)

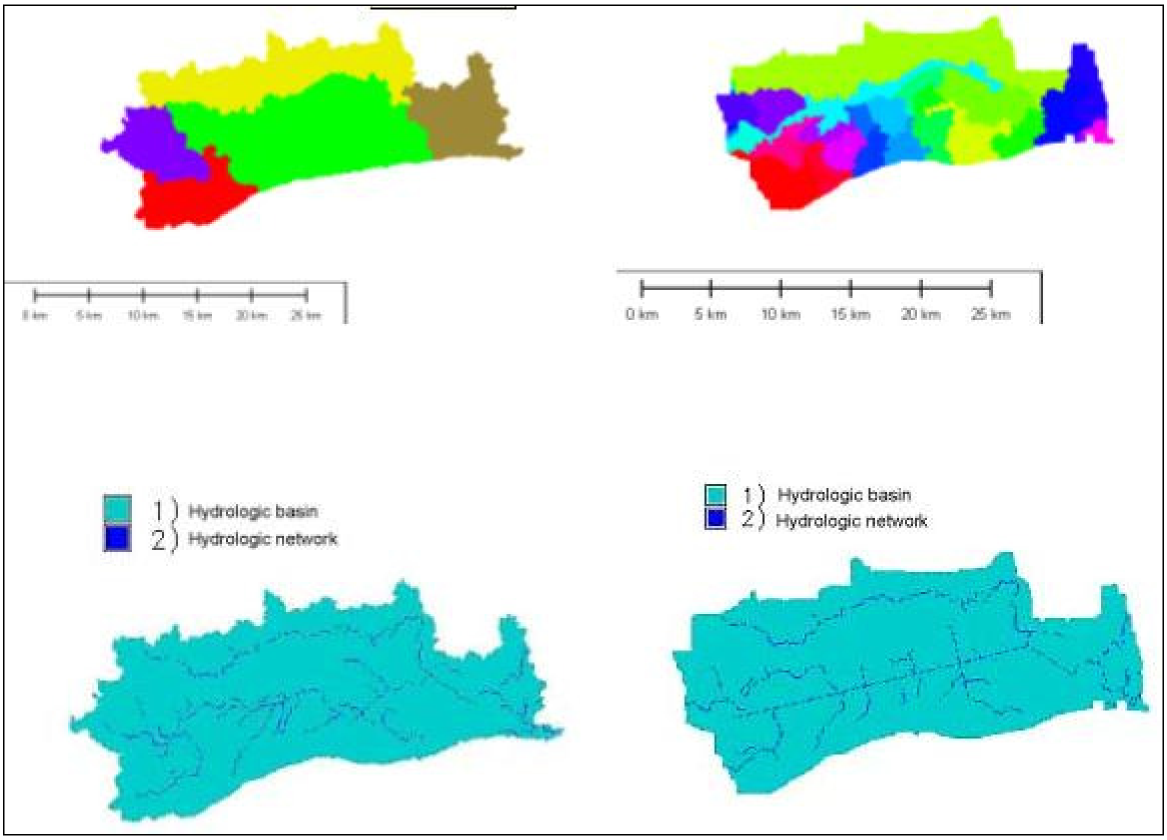

Fig. 8. b). Basins, Subbasins and hidrologic networks (1960-left; 2005-right)

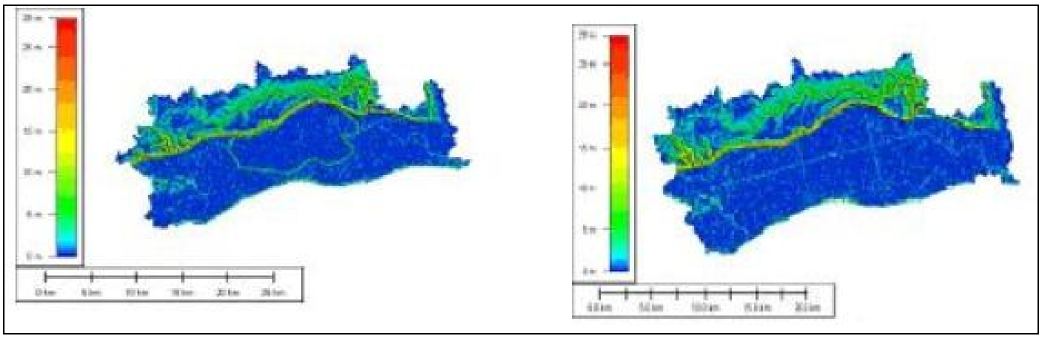

Fig. 9. Slope maps generated with SWATGRASS (1960-left; 2005-right)