Delimitation of River Segment for the Assessment of Ecological Flow

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ABSTRACT

In the framework of FlowTech research project, the methodology of delimitation of representative river sections is essential for the development of hydraulic and hydrodynamic models for the assessment of ecological flow regimes. The definition of these study areas includes GIS analysis and the use of satellite and airborne imagery data. Starting our assessment with a greater potential study area, we follow a step-by-step methodology, in order to exclude areas that are not meeting specific criteria. Specifically, an updated National Road and Hydrographic network database is analyzed in order to detect riparian sections, located less than 500m (walkable distance with heavy equipment) away from the nearest road network. On the sections selected, a slope map is created from a Digital Elevation Model of 2m spatial resolution, so the pixels which represent high steepness can be avoided as riparian areas with intense relief where is difficult to cross and install equipment. The experts' knowledge and remote sensing imagery data are combined to identify the indicators (presence of water, type and density of vegetation, the width of the riverbed, and the main characteristics of the shores (vegetation and soil cover, slope etc.) that characterize the remained segments of riparian habitats. The methodology mentioned leads to the study area. The selected representative sections can then be safely visited for the collection of further in-situ data and flow measurements for the final definition of the hydraulic parameters (e.g. depth, velocity, substrate) and the development of hydraulic / hydrodynamic models. In contrast to the traditional approaches which have high labor requirements, this approach aims to scientific methods to simulate fish habitat in an efficient and cost-effective way.

1. INTRODUCTION

A riparian ecosystem operates through various mechanisms, so the distinction of the river into different habitats simplifies the analysis and study of the parameters that affect it. To determine the study area, a representative river reach must be located within it. The representative river reach has similar hydromorphological conditions which are defined as hydromorphological units characterized mainly by hydraulic parameters. The methodology presented can be followed after the preliminary selection of a wider area. This selection is based on thorough previous research, historical and present data of existence of the targeted habitats in the area and the knowledge derived from the judgment of experts. Within that area, a smaller representative reach (approximately 1km long) must be selected, where almost all types of the river habitat can be found at a smaller representative proportion.

Goal of the Study

The purpose of this study is the deployment of a low-labor and cost-effective methodology for the definition of delimited segments along a river, for the safe collection of in-situ data and flow measurements for the proper assessment of the ecological flow.

Study Area

The study area selection method is the actual subject of this study. Our primary research led us to a part of Aoos river water basin in the region of Epirus in Northwestern Greece which is considered one of Europe's last free-flowing and intact network of rivers and streams, with records of rich fish fauna activity still today (Fig. 1 and 2).

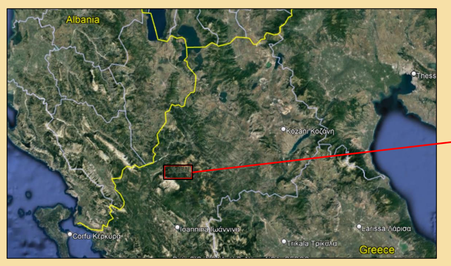

Fig. 1. *Position of Aoos river basin. Epirus region, NW Greece (Google Earth imagery)*

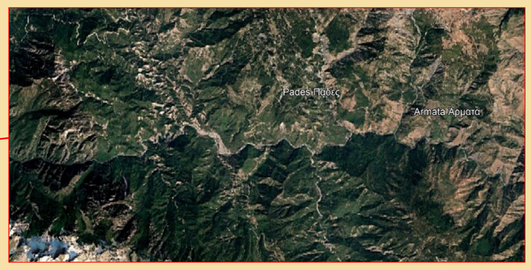

Fig. 2. *Part of Aoos river basin close to village Pades (Google Earth Imagery)*

2. METHODOLOGY

A wide area was selected studying the bibliography and the historic data of various areas of Greece, as well as the reports of the local people regarding the target fish existence in the rivers. In this way we determined a part of Aoos river water basin with a 144Km network of waterways.

Data

In order to proceed, the following relative raster and vector Geo-data were gathered:

✓ Vector data of the local road network (taken by the updated Geo-database of OpenStreetMap portal).

✓ Vector data of the region's waterlines (taken by the updated Geo-database of OpenStreetMap portal).

✓ Raster data of Digital Elevation Model (DEM) covering an area of 7,200Ha, (provided by the National Cadastre of Greece) (Fig.3).

✓ Satellite RGB imagery of the region (provided by Google Earth portal)

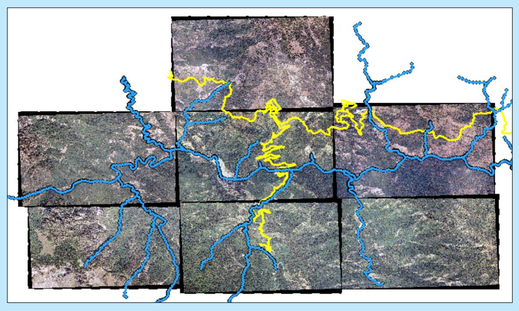

Fig. 3. *Part of Aoos river network (blue) and the local road network (yellow) overlayed on Greek Cadastre aerial imagery.*

waterway	name	width
stream		
stream	Βρυσοχώρι	4
stream	Σκαρβένας	5
river	Ρασενίτης	10
stream	Σκαρβένας	6
stream	Σκαρβένας	6

Fig. 4. *Attribute table of river network: waterway type and width. (ArcGIS)*

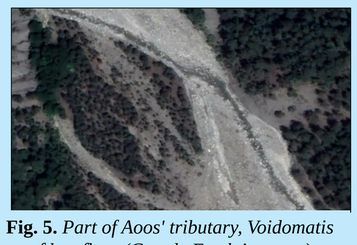

Fig. 5. *Part of Aoos' tributary, Voidomatis of low flow. (Google Earth imagery)*

The following analysis was caried out on the defined wider river network using the relevant collected data:

- In the first step, the waterlines database provided a field with the type and width of every river and stream (Fig.4) and all the streams and small rivers were selected (about the half of the total length of rivers).
- In addition, recent Google imagery of recent years was used in order to confirm the water existence within the river network, as well as the presence of dense vegetation in the areas of interest (Fig.5).
- In this step the linear vector data of the rivers were converted into vertices. With GIS Analysis we selected all river vertices that are less than 500m from the closest road network vector lines (Fig. 6a, b). We consider this distance as the maximum convenient distance for our team to carry heavy equipment from our vehicle to the river site of study.
- The DEM data were used to create a slope map of a 2-meter-pixel dimension. In this map the pixels of no more than 10^o of slope were distinguished, so it could be possible to detect steep parts within the riparian area that could impede our field work. With this method, we excluded more river vertices that were presented in these parts.

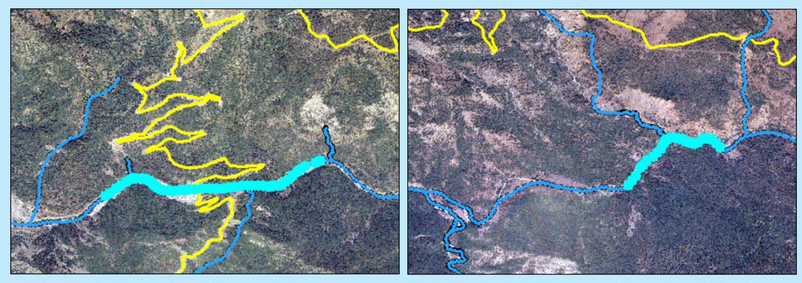

Fig. 6a, b. *Examples of detected river segments (light blue) with distance of less than 500m from the road network (Total river length detected = 2,480m)*

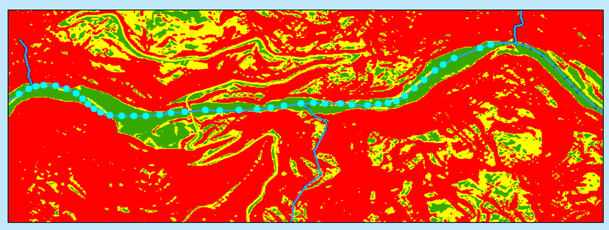

Fig. 7. Slope Mapping from DEM raster. The green pixels indicate an average slope less than 10^o. (River length = 1,410 m)

3. RESULTS

Our analysis started with a total length of rivers and streams of 144 Km and was concluded with a delimitated river segment of 1.5Km. In Table 1 are shown the methods used for the river segment delimitation and the resulted decrease of the waterline length for each method. The typology of the rivers contributed to a 50% decrease of the initial waterline length, while the inspection via satellite imagery helped to exclude another 5km of low flow rivers.

In addition, the selection of river vertices with a distance of less than 500m from the nearest road network pointed to 2.5 Km long river segments, from which a continuous river site of 1,410m length with almost no slopes of more than 10^o was extracted. This will be the river segment where all representative hydromorphological units must be identified in order to proceed to in situ measurements.

Fig. . The resulted defined segment of the Aoos River.

Table 1. River segment methods of delimitation and the resulted decrease of the waterline length

	Study Area	Waterlines Length (m)	Method of Delimitation
1	Aoos water basin (part): Main rivers and tributaries	144,195	Bibliography, Historic data, Expert's knowledge
2	Aoos water basin (part): Main rivers. Exclusion of stream waterway types.	73,055	GIS Analysis of national hydrographic network data
3	Aoos River: Exclusion of low flow rivers	68,052	Google Satellite imagery inspection
4	Aoos River: River segments with distance < 500m from road network	2,480	GIS Analysis of national hydrographic and road network data
5	Aoos River: River segments with distance < 500m from road network and slope <10^o	1,410	GIS and raster (DEM) data analysis

4. CONCLUSIONS - DISCUSSION

The methodology presented:

- comprises a simple and fast process that can be completed in 1-2 days, with no labor time wasted in travelling.
- is easy to be learnt and carried out step-by-step by any user, without previous experience.
- is cost efficient; all data used are part of open-source databases which can be easily found on-line, such as OpenStreetMaps and Google Earth. Moreover, it does not require costs of travelling to various remote areas of potential interest.
- consists of the safest possible way to inspect remote areas of interest that could encompass threats (steep cliffs, rough terrains etc.) to the research team members.
  - has the risk of not resulting to an adequate river segment that covers all of researcher's criteria, thus the parameters may have to be flexible regarding, for example, the minimum distance from road network or the slope's angle and presence.

Further opportunities:

- Open-source infra-red satellite imagery data, such as Sentinel or LandSat could offer more opportunities for further analysis with no additional cost. The processing of multispectral imagery can facilitate to the detection of water surface or the estimation of vegetation density, however, a more experienced remote sensing analyst is demanded.

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