WATER RESOURCES MANAGEMENT FLOWCHART IN REGIONAL UNIT OF KASTORIA

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ABSTRACT

The continuously increasing rate of freshwater demand, along with the limited availability of water resources which is further deteriorated due to climate change, have exacerbated the conflicts among competing water users in shared water systems in Greece. The current study investigates the water resources availability of the Regional Unit of Kastoria in Western Macedonia aiming at equitable use of surface water resources. Water systems are usually complex systems since they include all means of water supply, water demand and water regulation. The efficient investigation of the water resources of the Regional Unit of Kastoria, was based on an integrated hydrological model that was developed in the framework of the current study for the main land – surface water cycle components simulation of the whole study area. At first, the study area was divided into six catchments which were further divided into eleven sub-catchments. The inputs of the hydrological model are the household, agricultural and industrial water volumes as well as the precipitation while the output of the model is the runoff of each catchment. The hydrological model was visualized by a comprehensive flowchart representing all the water system's components. The quantitative estimation of the main hydrological cycle components and the simulation of the precipitation – water demand – water conflicts interrelation form the basis of sustainable water management strategies development. The hydrological model provides a range of water allocation solutions among users for each water demand and supply condition. The hydrological simulation model that was developed in the current study could approach and resolve any water allocation problem with water budget thresholds and non-linear relationship among the model components. The methodological framework presented in the current study could be transferred to any complex or not water system.

KEYWORDS

Flowchart; Regional Unit of Kastoria; Water allocation; Water conflicts; Water resources management

1. INTRODUCTION

Sustainable water resources management and regulation is fragmented at most times between various functions and sectors of water governance [1,2] causing conflicts among water users [3,4,5,6]. Agriculture, industry, energy supply, household and tourism are examples of such different functions and sectors that influence or being influenced in various ways by the quantitative and ecological water status and by the inter-related water systems [7,8]. Monitoring and regulation responsibilities regarding the integrated water resources management are commonly divided among a wide range of authorities in contrast to the directions of the European Union Water Framework Directive of non- fragmentation in water management field [9].

The current study proposes a conceptual flowchart for achieving an efficient integrated water management in the Regional Unit of Kastoria. The conceptual framework focuses on water resources by clarifying and integrating a number of different water components.

2. METHODOLOGY

2.1 Study area

The study area is the River Aliakmon catchment within the administrative boundaries of the Regional Unit of Kastoria (Figure 1). River Aliakmon constitutes the longest river of Greece having a length of about 297 km. The sources of the river are located in the Regional Unit of Kastoria. River Aliakmon constitutes the main hydrographic element of the Regional Unit of Kastoria, draining the whole area. The study area is located in the Water District of Western Macedonia [10] covering an area of approximately 1,368 km^2.

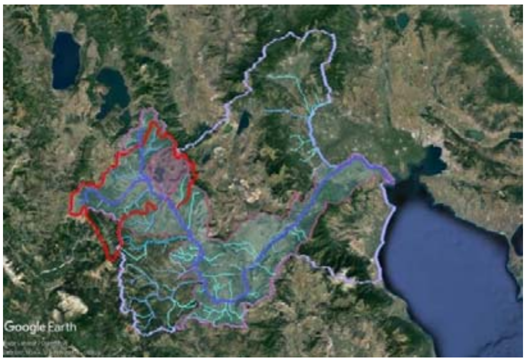

Figure 1. River Aliakmon (blue colour) catchment (light blue colour) along with the Regional Unit of Kastoria (red colour).

The high water supply needs of the Thessaloniki urban area and the high irrigation needs of the Thessaloniki plain at the downstream part of the River Aliakmon along with the requirement for ecological flow maintenance increase the water stress of upstream catchments [11,12,13]. Therefore, the estimation of water supply and needs of upstream catchments constitutes a core issue within the framework of the sustainable water management of the River Aliakmon catchment.

2.2 Development of the flowchart simulation model

The model was developed in its simplest form for the simulation of the surface water balance components in the study area. The main purpose of the model refers to the examination of the water potential of the study area to fulfil the water needs of local users in order the water surplus; if any, to be directed to water users outside the study area.

The first step of flowchart development constitutes the division of the whole study area into catchments and sub-catchments having similar hydrological and geomorphological characteristics. Afterwards, the model components nodes were defined representing the catchments and sub-catchments, the lakes and artificial reservoirs, the structural water management works, and the water supply and demand locations. Each different hydrological feature is representing in the flowchart with a different symbol aiming to the water balance estimation of each sub-catchment and catchment. The output of each catchment represents the runoff which occurs at the catchment outlet. It should be noted that the runoff component constitutes the main output of the hydrological simulation model acting, in parallel, as the control measure variable for the model calibration.

The conceptual framework of the model aims at both environmental and socio- economic sustainability through the incorporation of a number of different water management approaches.

3. RESULTS AND DISCUSSION

3.1 Catchments and sub-catchments delineation

The study area was divided into six catchments which were further divided into eleven sub-catchments. ArcGIS software was used during this procedure along with the exploitation of the Digital Elevation Model of the Hellenic Cadastre with a spatial resolution of 5 m. In particular, the catchments (C) and sub-catchments (sC) of the study area are:

- C1: River Aliakmon – Grammos
  - sC1.1: River Aliakmon right bank – Downstream of Nestorio dam
  - sC1.2: River Aliakmon left bank – Downstream of Nestorio dam
- C2: River Aliakmon – Koresteia
  - sC2.1: River Ladopotamos
  - sC2.2: River Vraxopotamos
- C3: River Stravopotamos
  - sC3.1: River Stravopotamos partially
  - sC3.2: River Mpougazi – Downstream of dam
  - sC3.3: River Mpougazi – Upstream of dam
- C4: River Velos
- C5: Lake Kastoria
  - sS5.1: Lake Kastoria partially
  - sC5.2: River Gkiole
- C6: River Poros
  - sC6.1: River Poros – Downstream of Germas dam
  - sC6.2: River Ksiropotamos – Upstream of Germas dam.

3.2 Flowchart model

The hydrological simulation model components are represented as shown in Table 1.

Table 1. Main hydrological model components.

Symbol	***Description***
	Artificial reservoir
	Lake
	Planned artificial reservoir
	River Inlet – Outlet
	Stream Inlet – Outlet
	1st order river
	2nd, 3rd etc. orders river
	Stream
	Rivers or streams confluence
	River catchment
	Irrigated river catchment
	Planned irrigated river catchment
	River Aliakmon catchment remainings
	Hydroelectric station
	Planned hydroelectric station
	Dam
	Planned dam
	Planned linear hydraulic structure
	Spillway
	Diversion channel
	Water abstraction structural work
	Outlet of linear water body
	Planned outlet of linear water body

The water resources management flowchart of the Regional Unit of Kastoria as developed using the above model components is presented in Figure 2.

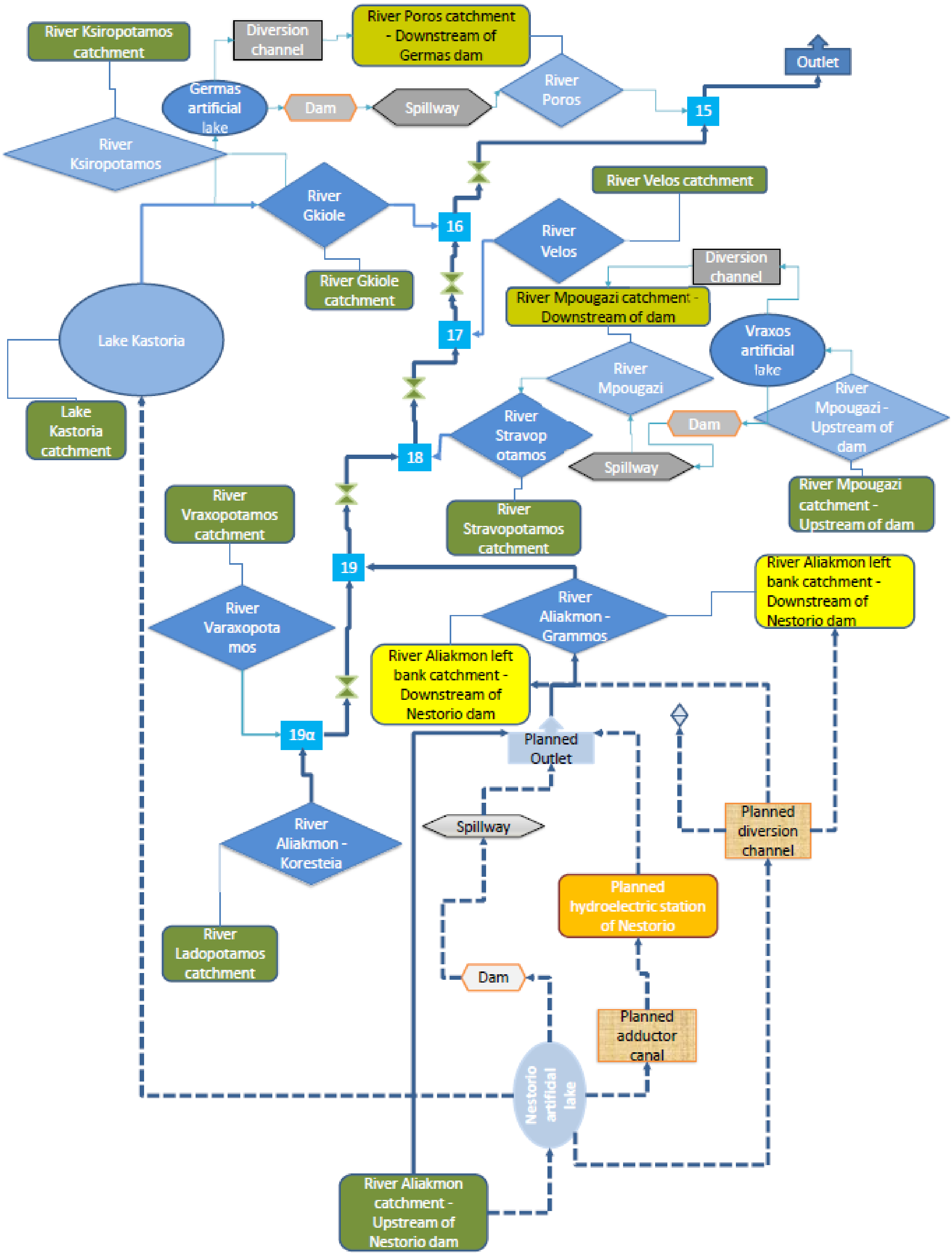

Figure 2. Water Resources Management Flowchart in Regional Unit of Kastoria.

4. CONCLUSIONS

Integrated water resources management through the development of a flowchart aims at confronting the non-organized exploitation of water resources in the spatial scale of an administrative district. The flowchart constitutes a core tool for the necessary questions formulation whose answers will assist local authorities to achieve a sustainable water allocation among water users. Long-term water management scenarios will be developed in the following step of the current research with the contribution of the competent authorities and stakeholders on the basis of the water management flowchart.

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