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STATE OF THE ART OF HYDROLOGICAL MODELS AND SUITABILITY IN BASINS WITH LIMITED INFORMATION

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In order to better understand and interpret the hydrologic cycle for a watershed, it is pertinent to first comprehend its spatial and temporal basin response. A hydrologic model aims to simulate the various rainfall-runoff processes and its production of flows. Presently, there is a wide variety of models based on the different hypothesis that include, among others, the physical and morphometric characteristics of the basin, as well as the availability of hydrologic information.

This work reviews and evaluates the state of the art of grouped and semi-distributed hydrologic models suitable for the Guadalquivir River Basin, in Tarija, Bolivia. An important challenge of this region that could condition the applicability of the models is the limited availability of hydro-meteorological and physical information. Among the 'grouped' models are the Témez and HBV, and among the semi-distributed models are the SACRAMENTO, WEAP, and HEC-HMS. The analysis of the bases of each model will be useful to determine in which situations it is convenient to use one or the other.

Keywords: *Models; grouped; semi-distributed; Basin; hydro-meteorological; morphometric*

ESTADO DEL ARTE DE MODELOS HIDROLÓGICOS E IDONEIDAD EN CUENCAS CON ESCASA INFORMACION

Para lograr una mejor comprensión e interpretación del ciclo hidrológico en una cuenca, es necesario entender la respuesta de la misma en tiempo y espacio. Un modelo hidrológico, busca representar los diferentes procesos involucrados en la distribución de la lluvia y la generación de caudales de la cuenca. En la actualidad, se dispone de una amplia variedad de modelos basados en diferentes hipótesis que consideran, entre otros, las características físicas y morfométrica de la cuenca, así como la disponibilidad de información hídrica.

En el presente trabajo se revisa y analiza el estado del arte de modelos hidrológicos agrupados y semidistribuidos idóneos para la Cuenca del río Guadalquivir, ubicada en Tarija, Bolivia. Entre las principales características de la región que condicionan la aplicabilidad de los modelos destaca la baja disponibilidad de información hidrometeorológica y física de la cuenca. Entre los modelos denominados 'agrupados' se encuentra el Témez y HBV y entre los semidistribuidos, SACRAMENTO, WEAP y HEC-HMS. El análisis de las bases de cada modelo será de utilidad para determinar en qué situaciones resulta conveniente utilizar uno u otro.

Palabras clave: *Modelo; Agrupados; Semidistribuidos; Cuenca; Hidrometeorológica: Morfométrica*

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1. Introduction

Hydrology is the study of the circulation and distribution of water. It provides the methods to solve the problems presented in the design, planning and operation of hydraulic works. It requires an adequate interpretation and measurement of the variables involved in hydrologic cycle and their interrelation between the different processes. However, there are hydrologic variables that are complex to measure and interpret. An example are the hydrological abstractions that depend on the process of measurement, and collection of physical and geomorphological data of the basin. Regardless of the inherent complexities, hydrological models represent the most efficient tools to analyze.

A hydrological model represents the different processes involved in the distribution of rainfall and the generation of runoff of a basin. There is a wide variety of models which have been created using clearly understood assumptions that guarantees correct results (Jorquera et al., 2012).

The Guadalquivir River is one of the principal sources in the region for irrigation and drinking water. It is the recipient of substandard wastewater treatment and in many cases, clandestine, untreated sewage. The Guadalquivir River is a source of exploitation of riverbed aggregates and, in some areas, serves as a solid waste landfill (Programa Estratégico de Acción-PEA, 1999). Figure 1 shows the location of the Guadalquivir Basin in the Department of Tarija.

Figure 1: Location of the Guadalquivir Basin in the Department of Tarija

Bolivia's information source for hydrometeorological data is the National Meteorology and Hydrology Service (SENAMHI). SENHAMI has offices in the Department of Tarija and maintains the hydrometeorological stations located in the of department and the study area.

1.1 Guadalquivir River Basin

The upper Guadalquivir River Basin is located in the Department of Tarija in southern Bolivia. The basin has an area of about 1.700 km² and a length of 70 km. It includes four sub-departments (counties): San Lorenzo, Padcaya, Uriondo and Cercado. Currently, the Central Valley of the Guadalquivir River Basin located within Cercado encompasses the largest population of the department. This concentration of people generates significant demands on water availability for various uses and environmental problems such as water quality impacts. The result is that the Guadalquivir River has become a source of ever-increasing contamination that threatens the health of the people (Copa et al., 2016).

Hydrometric information in the study area is scarce. According to Espejo (2016) in the report of the surface water balance of the Guadalquivir Basin, many of the monitoring stations have been abandoned since the mid-1990s. This has aggravated information deficit for the region.

Information on land use and plant cover is also very scarce. The classification of soils for hydrological purposes comes from several sources. A study for the agricultural-ecological and socioeconomic zoning of the Department of Tarija (ZONISIG) dates from the year 2000 (Ministerio de Desarrollo Sostenible y Planificación, 2000). However, the technical information is only limited to general data.

The methodological guide for the studying of surface water balances of Bolivia, Soria (2016) indicates that for the use of factors such as vegetation coverage, land use, use and type of soils it is a very common practice to consider several sources of information for the same factor due to the possible existence of gaps or incomplete data.

1.2 Conceptual analysis of hydrological modeling of watersheds

With consideration of spatial representation, hydrologic models can be classified as distributed, semi-distributed, and grouped. These models use computer platforms for development and simulation of their analysis process and require hydrometeorological and physical data of the watershed as inputs. In many cases, watersheds do not have all of the required information or the information they do have is unreliable or incomplete. Therefore, the use of one or another of the available models must not only accordance with the intended scopes and basis of the study but the available information as well.

The general equation of the water balance that represents the basis of hydrological modeling is usually defined by two fundamental conditions influencing the precision of the model, the spatial boundary and the temporal scale. However, the availability of data and the objective of the study that influences the selection of the models are also factors that affect the quality of the results and the degrees of uncertainty (Stolpa, 2017).

La caracterización de los modelos en función a su representación espacial permite disponer de algunos modelos que tienen una mayor utilización y aplicación a nivel global. Estos modelos pueden ser clasificados en modelos distribuidos, semidistribuidos o agregados, también denominados “agrupados”.

The characterization of the models according to their spatial scale also allows for some approaches to have a greater use and application at a small sub basin or global level. These models can be classified into semi-distributed, distributed or aggregated models, also called “grouped”.

1.2.1. Semi-distributed Models

Semi-distributed models are used for the case when watersheds cannot be considered small and many of the parameters cannot be assumed as homogeneous. The basic approach of the grouped process can thus be modified to independently analyze regions of similar hydrological behavior and then combining the individual responses.

Semi-distributed models were also developed to avoid the problems of the distributed models. In this type of model, the basin is divided into sub-basins larger than the grids of the distributed models. The sub-basins are analyzed as a single unit when combined. This allows for a better physical base than the aggregated models and requires less input data than the distributed approach (Tellez et al., 2016). Examples of these models are: WEAP (Centro de Cambio Global Universidad de Chile, 2009) y SACRAMENTO (Lujano et al., 2016).

1.2.2. Distributed Models

Distributed models allow for a greater and detailed representation of a basin through discretization of a large number of small regular and irregular elements. These grids or meshes simulate the development of localized runoff within the grid and the passage of runoff from one grid or node to the sequential downstream grids. The process continues until the entire basin is drained. The models also account for the spatial variability of the various parameters and interaction of the variables thus accounting for the different processes in each of the generated cells. This type of model can best represent the heterogeneity of the basin through the specific conditions in each cell.

However, these models require a considerable amount of detailed information that is not always available or is very expensive to generate. For example, Francés y Vélez, (2003) point out that these models can also require complex routines in addition to the numerous parameters, because of their heterogeneous nature. The necessary mathematical equations do not always account for these heterogeneities, so these types of models are costly in time, storage and management of information. The most widely used distributed models include: TETIS, MIKE-SHE y TOPMODEL.

1.2.2. Grouped Models

One of the main limitations in watershed modeling is the lack of, or limited knowledge regarding the depth and infiltration properties of the basin soils. This can be aggravated by the subsurface conditions such as the presence of rock that can influences percolation and underground flows. This limitation is usually over simplified by assuming that the basin is homogeneous in both its superficial, and subsurface processes. Although this assumption can be reasonable for small watersheds, aggregated models consider the watershed as a whole, where parameters and variables are constant in space. The advantage of these models is that they do not need to calibrate many parameters and have simple mathematical expressions. However, they do not show the internal variability of the system. Therefore, their results are the representation of their average situation. Example of this type of models are: Témez, HBV and HEC-HMS.

A guide describing study methods for determining surface water balances of Bolivia has been developed by Ministerio de Medio Ambiente y Agua (2017). The guide indicates that although the grouped models consider the basin or the system as a single unit, it is important to point out that these types of models are applicable only when the modeler can reasonably assume that a watershed has homogeneous properties at the scale of analysis. Likewise, Soria et al., (2008) argue that the low availability of information encourages the engineer to apply clustered models. This practice can introduce considerable uncertainty that can be difficult to evaluate. Therefore, an intermediate method such as semi-distributed models are better suited to properly analyze model the response of a watershed than grouped systems connected with each other to form a global system (Collick et al., 2009).

2. Goals

The objective of this study is to identify the hydrological models that could be more suitable in the Guadalquivir River Basin. A selection of models based on its application in regions with similar characteristics to Guadalquivir River Basin is deeply analyzed.

3. Review of the State of the Art Models

A broad variety of models have been developed by state and academic institutions for the simulation and investigation of the hydric balance in watersheds. These models were also in accordance with the needs and physical conditions of their watersheds. However, many of these models have been adopted and are currently used in different countries of the world as basic tools of analysis and research. Table 1 to 3 summarizes the characteristics of the projects carried out. Below, each model is described.

Table 1: Hydrological projects with semidistributed models (source: author)

Model	Proyect/application	Reference	Principal characterístics
Sacramento	“Regional variation of flow duration curves in the eastern United States”	(Chouaib, Caldwell, & Alila, 2018)	Semi-distributed model for the analysis of the interaction processes between climate and land use properties in precipitation-runoff modeling
	“Application of multi-step parameter estimation method based on optimization algorithm in sacramento model (Dongyang y Tantou)”	(Zhang et al., 2017)	Method of optimizing the model in three steps and performs the optimization with the description of each step
	“Applying the SAC-SMA hydrologic model to a tropical watershed (Brazil)”	(Da Silva et, al. 2016)	Model applied to the Piracicaba River basin to determine daily runoff, evaluate its performance and use as a water resources management tool
	“Cuenca del río Ramis (Titicaca-Perú)”	(Lujano et al., 2016)	Model semi-distributed rainfall-daily pass runoff for hydrological forecasting, using for modeling the software RS-Minerve
	“Obtención de series hidrológicas (Gipuzkoa)”	(Ocio & Zabala, 2012)	Semi-distributed model of continuous analysis for the superficial analysis of the hydrologic cycle, with a daily temporal step in obtaining ecological flows
	“Modeling the Hellenic karst catchments”	(Katsanou & Lambrekis, 2017)	Semi-distributed model applied to mountainous areas of the study basin
WEAP	“Cuencas de suministro de agua (El Alto – La Paz)	(Escobar et al., 2013)	Semi-distributed/quasi-physical one-dimensional model with use of different temporal scales, modeling of the hydric balance and the planning of the water resources relative to climatic change
	“Subcuenca del trópico húmedo (México)”	(Esquivel et al., 2013)	Continuous analysis model to determine the flow balance sequentially under a fluvial system, the predictive efficiency of the model and the calculation of runoff of the study basin
	“Balance hídrico de la Cuenca del Guadalquivir (Bolivia)”	(Espejo, 2016)	Planning model with GIS interface for to linking with other models, this project analyzed in a simple way the complexity of the basin that covers several municipalities
	“Cuenca andina del río Teno”	(Mena & Vargas, 2009)	Model to analyze the impact of climate change in the study basin, calibrated and validated from monthly data
	“Cuencas Criosféricas y Revisión de Aplicaciones en Los Andes”	(Ramirez, 2015)	Integrated water resource planning system with scenario management
	“Water resources in the Huai Sai Bat sub-basin (Thailand)”	(Polpanich et al., 2017)	Model used for water-use planning involving major stakeholders and beneficiaries
	“Langat River Basin (Malasia)	(Leong & Lai, 2017)	Integrated model, applied in water planning with the incorporation of several scenarios

Table 2: Hydrological projects with distributed models (source: author)

Model	Proyect/application	Reference	Principal characterístics
Tetis	"Black soil region, (northeastern China)	(Li &Fang, 2017)	The purpose of this paper is to assess the potential impacts of climate change on water discharge and sediment yield for the Yi'an watershed of the black soil region
	"Sierra de las Minas (Guatemala)"	(Morales-De La Cruz & Fránces, 2008)	Model used to study the hydrology of the Teculutn Basin in a daily time step
MikeShe	"Yanqi basin (China)"	(Li et al., 2015)	In this case study, is used to derive later parameter parameters from open and forecast models for a distributed hydrological model of the Yanqi basin. China, using the MikeShe model
	"Guishui river basin (Beijing)"	(Zheng et al., 2014)	Distributed hydrological model used to simulate surface runoff in the Guishui river basin
TopModel	"Nysa Kłodzka river basin (SW Poland)"	(Jeziorska & Niedzielski, 2018)	The model was used to model the dynamics of the flow in four mountain basins
	"Yang River Basin, (Thailand)"	(Shrestha & Lohpaisankrit, 2017)	This study aims to assess the flood hazard potential under climate change scenarios

Table 3: Hydrological projects with grouped models (source: author)

Model	Proyect/application	Reference	Principal characterístics
Témez	"Cornisa-Vega (Granada)"	(Murillo & Navarro, 2011)	Grouped monthly step model, integrated with the SIMGES code to determine surface and subterranean contributions
	"Parcelas forestales y pastizales"	(Virt & Currie, 2014)	Grouped model of few parameters using Excel spreadsheets
	"Cuencas de Chile central"	(Pizarro et al., 2005)	Grouped model, calibrated and validated at monthly level
	"Cuenca del río Bérchules, Sierra Nevada (Granada)"	(Cabrera, 2014)	Grouped model, using Excel spreadsheets and the inclusion of a model to quantify the contribution of snow melt
	"Comarcas de la marina alta y la marina baja (Alicante)"	(Francés & Sáchez, 2011)	Grouped monthly step model for peak flow determination
	"Balance Hídrico Superficial de Bolivia"	(Ministerio de Medio Ambiente y Agua, 2016)	Grouped model of continuous and monthly step simulation, integrated to the software CHAC
	"The case of the Bérchules River in Sierra Nevada (Southern Spain)"	(Jodar et al., 2017)	Grouped model, considers the contribution of groundwater and snow melt
	"Assessment of Ecological Risk Based (Oporto)"	(Ramos et al., 2016)	Grouped model, used to evaluate the ecological risk associated with the alteration of the projected flow in the Guadiana River Basin
HBV	"Cuenca del Río Agua Caliente (Cartago-Costa Rica)"	(Méndez, 2016)	Semi-distributed model, used for the continuous calculation of runoff,
	"Cuenca del río Júcar (España)"	(Paredez & Merino, 2015)	Semi-distributed model for rainfall runoff modeling, using the EVALHID module

Table 3 (cont.): Hydrological projects with grouped models (source: author)

Model	Proyect/application	Reference	Principal characterístics
HBV (cont.)	Gállego-Cinca (Confederación Hidrográfica del Ebro)	(Tellez et al., 2016)	Conceptual semi-distributed model of monthly scale, using RS-Minerve
	"Cuenca del río Bérchules, Sierra Nevada (Granada)"	(Cabrera, 2014)	Semi-distributed model to obtain daily flow rates, programmed in Visual Basic
	"Omo-Ghibe River Basin (Ethiopia)"	(Jillo et al., 2017)	Semi-distributed model for rainfall-monthly pass runoff, used for the determination of water balances of unfiltered watersheds
	"Richmond River Basin (Australia)"	(Al-Safi & Ranjan, 2018)	Model used to assess the impacts of future climate change in the watershed
	"Kilombero Valley (Tanzania)"	(Koutsouris et al., 2017)	Model used for the simulation of the flow of the Kilombero Valley study basins
	"Evaluation of three semi-distributed hydrological models (Hungría)	(Kása et al., 2017)	Semi-distributed model applied to a process of comparison of three models precipitation-runoff
HEC-HMS	"Modelación hidrológica de un área experimental en la cuenca del río Guayas"	(Tapia & Gaspari, 2012)	Aggregate model, used for flow determination or runoff in the study basin
	"The upper Dong Nai river basin (Vietnam)	(Nhi et al., 2018)	Aggregate model, applied in the evaluation of impacts in four terrestrial rainfall products and one satellite-based in flow modeling
	"Nyazvidzi catchment (Zimbabwe)	(Gumindoga et al., 2018)	Model applied in water availability modeling in the watershed when soil use change occurs
	"Cuenca del río Toyogres"	(Umaña, 2014)	Grouped or aggregated model to simulate precipitation-runoff process requiring fewer parameters and requests in data entry
	"Cuenca del río de La Suela (Cordoba)"	(Weber et al., 2010)	Mixed simulation model (events and continuous)
	"Potencial de inundaciones del río Guadalquivir (Bolivia)	(Stolpa, 2017)	Continuous simulation and event model used for flow determination and flood potential

As described in the introduction, one of the main problems of working at Guadalquivir Basin is the lack of information. The state of the art shows that semi-distributed and grouped models are the most adequate for regions with little and / or low quality information. Most representative Semi-distributed and grouped models are described as follow.

3.1. Témez Model

The Témez (1977) model is an aggregate model for the continuous simulation of runoff. It requires few parameters and uses monthly steps (Ministerio de Medio Ambiente y Agua, 2016). It operates by performing moisture balances between the different processes that take place in a hydrological system from the moment it begins to rain until the time that runoff is generated as discharge to the aquifers and rivers. The model performs a global valuation. The spatial distribution of the variables and parameters are replaced by an average value.

Its application is limited to small or intermediate-sized basins with a certain climatic, soil and geological homogeneity. Its application to large basins requires a subdivision to smaller ones. The theoretical development of the Témez model is general in nature, so that in principle any interval of time can be applied (timetable, daily, weekly, monthly, yearly). However, it must be verified that the temporary periods that are used provide a response consistent with the physical reality of the hydrological system in study. The most frequently used temporal interval is the monthly (Murillo y Navarro, 2011).

The advantage of this model is that it has integrated computer platforms allowing for free access and simulation. An example system is the "Hydrometeorological Calculation of Contributions and Floods" (CHAC) (Ministerio de Medio Ambiente y Agua, 2016). It is easy to implement in Excel spreadsheets. The Témez model is widely used in Spain and several countries in South America.

In Bolivia, the Témez model has been used for the determination of the hydric balance of with total and homogeneous coverage throughout the country during the period from 1998 to 2011 (Ministerio de Medio Ambiente y Agua, 2016).

The Témez model has been used with (CHAC), which was developed by the Center of Hydrographic Studies of Spain (CEDEX) to model the different hydrographic units of levels 3 and 4 as classified by the Pfafstetter method for Bolivia (Ministerio de Medio Ambiente y Agua, 2016).

3.2. HBV Model

HBV is a conceptual, semi-distributed model and with three simulation routines. These are: precipitation, soil moisture, and evapotranspiration. It simulates the discharge for certain time intervals. The model concept utilizes the concept of a rain-snow process zone and three storage tanks, called the soil moisture tank, upper tank and lower tank.

The main advantage of this model is that it integrates free access computer systems such as RS-Minerve which has been jointly developed by the Centre de Recherche Sur l'Environnement Alpin (CREALP) and the engineering office HydroCosmos SA, together with the collaboration of the Universitat Politècnica de València (UPV) and the Federal Polytechnic School of Lausanne (EPFL) (Tellez et al., 2016).

On the other hand, the model HBV offers a better simulation when using longer periods of temporal calibration in the research process of water balances (Rusli et al., 2015).

3.3. The Sacramento Model

Sacramento is a continuous simulation model. It utilizes conceptual global parameters that can be used to simulate the water-head portion of the hydrologic cycle. It was developed in the 1970s. It optimizes the soil moisture characteristics distributed at different levels with rational percolation characteristics for a efficient simulation of discharges. This model calculates the total discharge of precipitation (P) and potential evapotranspiration (ETP) according to the initial parameters and conditions (Lujano et al., 2016).

Like the previous models, this model has integrated computer platforms with free access for the simulation. The calibration of hydrological models requires knowledge of many parameters. However, the Sacramento Soil Moisture Accounting Model (SAC-SMA) includes a series of physics-based parameters that allow simulations and predictions of rainfall-runoff (Katsanou y Lambrakis, 2017). The initial configuration can be made with the RS-Minerve (Lujano et al., 2016) whose information processing is carried out with the Geographic Information System (GIS).

3.4. The WEAP Model

Water Evaluation and Planning System (WEAP) is a semi-distributed model developed by the Stockholm Environment Institute (SEI). It is a quasi-physical one-dimensional model that can be used with different time steps. The WEAP platform is a water resource planning tool that includes a water balance model to represent hydrological processes within a watershed system. This algorithm allows representation of the behavior of the water balance from rainfall in the high basin with physiographic characteristics of mountain with steep slopes to very steep, V-shaped valleys. It determines how these contribute to the base flow of groundwater. This model works using the basic principle of mass balance and combines characteristics of hydrologic and planning models (Mena y Vargas, 2009; Escobar et al., 2013).

The WEAP model has been used in the development of the last hydric balance study in Bolivia with the different river basins within the country. An example is the hydric balance of the Guadalquivir Basin (Ministerio de Medio Ambiente y Agua, 2016). It utilizes integrated planning of water resources, with a graphical GIS interface. Espejo (2016) notes that the most important reason to use WEAP is that it allows to make variations in the methodology used in the modeling. This allows incorporating greater detail in areas where information is available and simplifying the case where the information is scarce. On the other hand, it allows systematic use of different exogenous and endogenous factors that can influence the hydric balance, such as soil use and climatic change.

Yates et al. (2005) describe how the WEAP model is spatially configured as a set of continuous sub-basins of a specific area, a homogeneous set of climatic data such as precipitation, climate, temperature, wind velocity. Other parameters that can be used in each sub-basin, are different soil types and land use which divide the water between runoff, surface, infiltration, evaporation, base flow and percolation. The values of each of these areas are finally added to obtain the aggregate values of each sub-basin.

3.5. The HEC-HMS Model

The Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) is designed to simulate the process of precipitation-runoff of dendritic basins. It is a grouped conceptual model since it represents the process of drainage of the basin by means of a grouped loss model combined with a unit hydrograph. In addition, and because it is a conceptual model, it has fewer parameters and requires fewer input information compared to fully distributed physical models (Umaña, 2014).

The model is easy to access and free and widely used internationally. It is a flexible model with many optional features and can be used to model single and continuous events. It is a model that allows automatic calibration of parameters with observed data. It can be used for sediment and contaminant transport and thus it has potential as a “universal” model (Stolpa, 2017).

4. Conclusions

The semi-distributed models appear to be the most suitable for the modeling of the Guadalquivir basin. They allow for an analysis based on the watershed subdivision and provide for interconnection of these achieve a reasonable interpretation of the results. They also allow for a lesser degree of uncertainty through their development. However, the uncertainty caused by the input data of these models is greater than the uncertainty that the models themselves can generate. This provides the opportunity to emphasize the need and importance of generating climatic and physical basin in a timely and continuously sustained way.

The Témez and WEAP models have been used recent studies of surface water balances of Bolivia with clear results in the simulation. They are models that are very easily accommodated in the situation of the high Guadalquivir River basin and the availability of information, giving more complexity to the areas that have more information and less complex where it is scarce.

The HBV model presents a better adjustment of the series of observes contributions because it introduces an intermediate storage with which the model Témez does not. From this new storage, the model replicates the subsurface flow that would allow a more comprehensive balance in the study basin. In addition, the model HBV can be adjusted and adapted to watersheds with limited hydrological and geomorphological data.

Although the Sacramento and HBV models have not been used in Bolivia, these are as potentially good as the Témes and WEAP models. These are easily developed with having easily accessible computer codes such as the RS Minerve for initial configuration and GIS for the processing of basin information. These models make it possible to have a clearer perception of subsurface flows.

Under these premises, the models Témez and HBV with grouped characteristics and the semi-distributed Sacramento, WEAP, and HEC-HMS can likely be adapted to the physical and hydrologic conditions of the Guadalquivir River Basin. They can simulate the superficial and continuous behavior of the water in the watersheds despite the lack of water and soils information.

The next step in the research will be the application of these models to determine if they reasonably simulate a response with estimated data and digital elevation models. elevation. The Témez, WEAP and HEC-HMS models will be incorporated into the study since their previous use in the region will allow for the comparison of certain parameters used in the previous evaluations.

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