SELECTION OF HYDROLOGICAL DESIGN CRITERIA AS ANSWER TO WATER DEMAND IN ARGENTINIAN ISOLATED COMMUNITIES

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1. INTRODUCTION

The objective of this work is to propose a methodology for the identification of water resources in mountain basins, being able to contribute to the analysis and selection of small hydraulic works destined to improve the possibilities to develop sustainable projects of populations located in regions of scarce economic resources.

In Argentina there are isolated rural villages that are not properly supplied by water, which is necessary to ensure the sustainable development of these communities. Besides, the occurrence of droughts and floods are usually other problems that contribute to the previous problems.

The aspects previously exposed, concerning water resources, involve technical and social issues that must be considered from a global viewpoint. This article deals with the guidelines considered for the preliminary project of collection and distribution works for a small community located in the northwestern area of Argentina. The rural village is known as San Isidro (province of Salta), with 350 inhabitants, being located at 2,800 m above sea level.

A methodology for the identification of the adequate models for proceeding to the hydrological computation that are necessary to quantify run-off and underground water resource is proposed in this paper. Different methodologies of calculation for the estimation of extreme flow discharges (minimum and maximum) in a region with scarce hydrological and meteorological information were evaluated. At this stage, the convenience of avoiding the use of complex hydrological and hydraulic methods was specially considered because that would demand data and investments beyond the scope of a project trying to solve the problem of the access to the water of these communities.

The hydrological and hydraulic studies carried out allowed defining a basic project of a work of water collection from the sub-stream bed, able to guarantee the water supply along the whole year attending needs coming from human consumption, basic agriculture, breeding and a possible micro-hydroelectric project.

The proposed methodology has allowed defining the scope of different criteria of hydrological calculation in basins like San Isidro catchment basin, where it is very important to bring a technical answer bearing in mind the social and cultural issues of the communities.

2. OBJETIVES

The development of a methodology for the selection of hydrological and hydraulic criteria that can contribute to the definition of parameters for the project of hydraulic structures able to solve or help to satisfy the water demand in isolated rural villages of scarce economical resources states the consideration of the following aspects:

- To make a characterization of the physical context of the population that will be supplied with water, bearing especially in mind the development of the methodology for being able to bring solutions to small isolated communities with scarce economical resources.
- To define the characteristics of the water demand in relation to the uses (fresh water, irrigation, hydroelectricity) and its temporal distribution along time.
- To make an exhaustive analysis of background information, including topography, rains, flow discharges, soils). This aspect is specially important in the cases emphasized in this paper, because there would be scarce funds to carry out some field observations and measurements.
- To evaluate, taking into account the available information and hydrological models for the study of balance at a scale of one month, the temporal availability of superficial and ground water. This analysis strongly helps to the identification of water resources that would be considered for the future hydraulic works.
- To compute lowest and highest flow discharges, taking into account some basic hydrological criteria for a study to be developed until a basic definition, or considering other hydrological criteria that can result more adequate and precise for an advanced project.
- To define a minimum characteristic flow discharge, related to a high probability of excedence for the design of the hydraulic works, for instance deviation dam for irrigation and/or hydroelectricity.
- To define a maximum characteristic flow discharge for the design of protection structures, as spillway and local protection against scour.
- To define the hydrological and hydraulic parameters of the final project.

3. WORK METHODOLOGY

3.1. Conceptual aspects

Small rural villages are mostly characterized by the absence of good roads, the lack of some basic services, low salaries and the scarce availability of technical services.

From the technical point of view, the meteorological and hydrological information that is necessary to define the characteristics of the project of a small hydraulic structure is usually really scarce; in some cases, there is not information for these purposes. In fact, the information, if available, is generally constituted by temporal series that are usually short for good estimations.

On the other hand, the costs of hydraulic structures that are mostly necessary to improve the quality of life of these populations are, in many cases, similar to the funds that must be used for the basic studies of a medium size project.

This context could limit the scope of the studies of identification of water resources. Then, it is necessary to look for an equilibrium that considers the uncertainty due to the lack of information, the type, size and life of the structure, its vulnerability and its risk of failure, and the scope of the hydrological studies.

Consequently, the methodology for the evaluation of water resources related to the sustainable development of small and isolated rural villages has a global conception which is summarized in Figure 1.

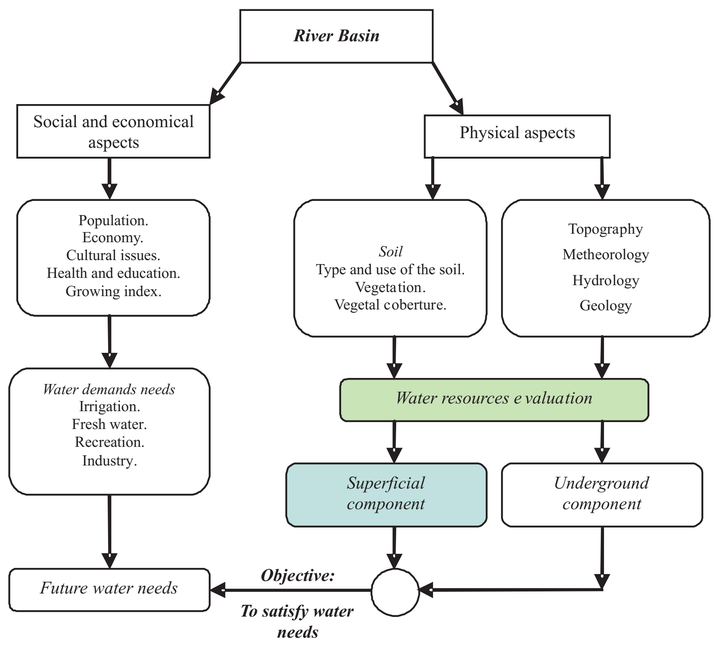

Figure 1 - General methodology

3.2. Superficial hydrology

The methodology proposed for evaluating superficial water resources presents two levels:

- *Balance*: the implementation of a hydrological model to estimate the contribution of groundwater and superficial water at different stages of the year is proposed. This result as well as the information that can be caught during field observations is highly important in order to determine, or to establish some guidelines, to finding solutions, for instance, to water supply to small rural villages.
- *Extreme values for flow discharges:*
  - *Minimum flow discharges:* this determination can be important to analyze, for instance, the firm power plant of a small hydroelectric project or the characteristics of a deviation dam.
  - *Maximum flow discharges:* these computations will be able, for instance, to define the discharge capacity of a spillway, outlet structures and local scour protections.

In order to proceed in these calculations, basic information as topography, soil parameters, precipitation and water flow measurements will be necessary. Figure 2 allows observing the general sketch stated for these evaluations, being able to see a more detailed and adjusted methodology in Figure 3.

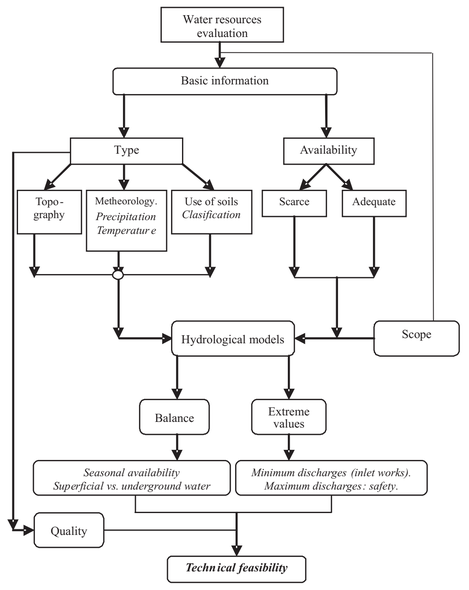

Figure 2 - Superficial flow determination

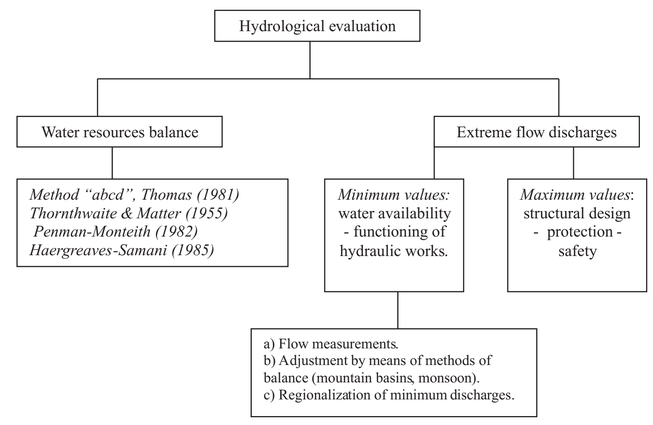

Figure 3 - Hydrological methods

Taking into account the current article and the main aspects of the projects for these isolated rural communities, where the funds for studies and works are generally scarce, two fundamental aspects that could influence on the scope of the hydrological studies are considered at this stage. These are *the cost of the works and the risk of failure of the structure.*

If there is a risk for the population located near these structures, the scope of the hydrological studies must be the most extensive. On the other hand, if environmental risk is really low, approximate hydrological methods could be considered for determining the parameters for the project of the works, except that the magnitude of the works and their costs could be really significant. Figure 4 illustrates the sketch for a scope of the basic project.

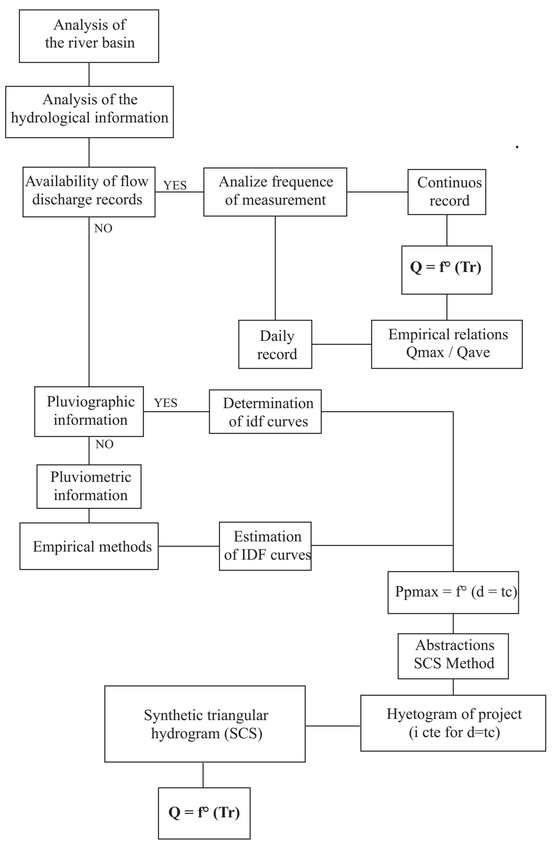

Figure 4 - Hydrological estimations for a basic project

4. APPLICATION OF THE METHODOLOGY TO SAN ISIDRO RIVER BASIN, SALTA, ARGENTINA

San Isidro river basin covers an area of approximately 98 km2, running from the headwaters of Trihuasi and Las Cuevas rivers, which leads to the river confluence San Isidro. This basin is part of Iruya river basin, which is a tributary of Bermejo river, as exposed in Figure 5. The river developes from 4,700 meters at its head until 2,600 meters above sea level, to develop the main course an average gradient of 8.5 over 25 km of length. The regime of San Isidro river basin is based on rains. Rainfall are concentrated during the summer period, a low rate regime monsoon exceeding the 570 mm annually. By falling into a basin characterized by a high slope, they generate a kind of torrential flow which develops high speeds and drag materials large.

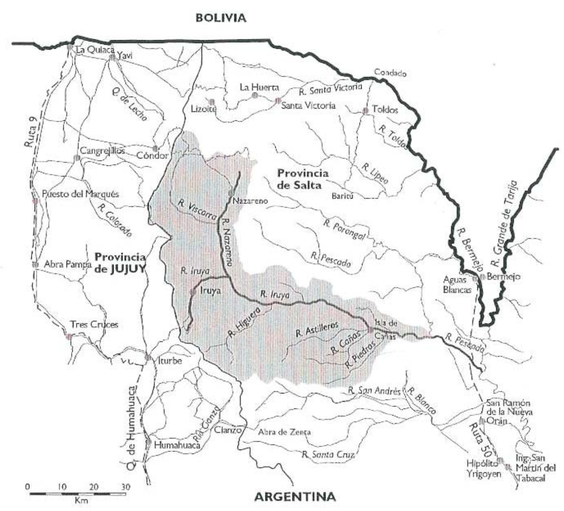

Figure 5 - Iruya river basin

The people of San Isidro is composed of about 350 inhabitants who are divided into six districts close together and linked by narrow, winding paths. In Figure 6 is a schematic layout of this rural village. From a socio-economic point of view, the economy of the population are subsistence agriculture, some crops such as potato and corn, forage such as alfalfa, and the poultry or other animals as goats and sheep.

Figure 6 - View of San Isidro, province of Salta, Argentina

The methodology previously exposed was applied for San Isidro river basin. Water resource balance was analyzed in a section of the river located downstream of San Isidro, by means of "abcd" model (Figure 7). Minimum flow discharge was estimated from two measurements, with values of 100 and 180 l/s. Maximum runoff was determined by considering different methods at the scope of a basic project.

On the other hand, hydro-geological surveys were carried out in order to analyze the potential of groundwater resources, which are avavailable during seasons without superficial run-off and have better quality conditions. Estimations of maximum flow discharge were done to determine local scour and define the location of sub-superficial horizontal drain.

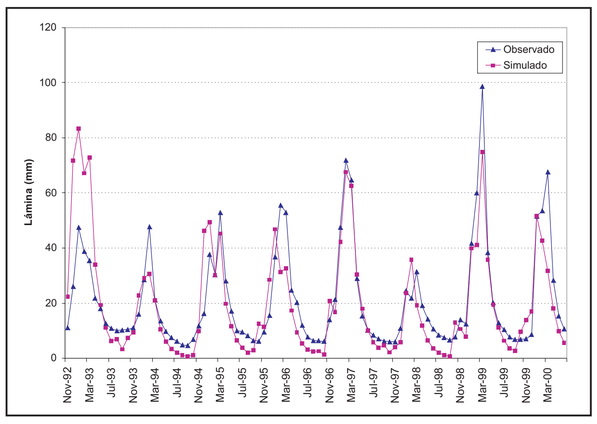

Figure 7 - Flow discharge calculated vs. Observed at San José

5. CONCLUSIONS

A general methodology for the selection of hydrological models for computing those parameters for the hydraulic design was described.

The singular focus analyzed in the current methodology is related to those cases usually associated to isolated rural villages where there are water needs, and very scarce funds for studies and works.

Two methodological guidelines were established taking especially into account, the valoration of the risk and the estimated costs of future works.

Under these circumstances, the scope of the project can be basic if there is not increase of risk due to a new structure.

The methodology, which involves some water resources balance models and minimum and maximum flow discharge, was presented and applied to San Isidro river basin in the surroundings of a small rural village with unsatisfied water needs.

These guidelines are intented to cover a wide field between conventional hydraulic and hydrological engineering and those small rural villages, where concrete solutions must be provided.

The application of this methodology to San Isidro river has finished with a basic project for water supply for this small community, whose participation have been really important during the whole extension of the studies.

6. REFERENCES

CHOW V.T & al. (1994), *Hidrología Aplicada*. Ed. Mc Graw-Hill.

CUSTODIO E. and LLAMAS M. (1996), *Hidrología subterránea,* Ed. Omega.

Instituto Nacional del Agua (2006), *Identificación de los recursos hídricos vinculada a un proyecto de desarrollo sustentable,* Proyecto PRO 1.148.