Title of the Dissertation:	"Estudio de Pre-factibilidad del Sistema de Riego para la Comunidad de Sigsihuaico en la provincia del Cañar".
Title in English:	Pre-feasibility study of the Irrigation System for the community of Sigsihuaico at the province of Cañar
Original extent:	209 pp. (2 volumes) + many additional appendixes and cartographic and design maps.
University / Faculty:	Universidad de Cuenca / Facultad de Ingeniería, Ecuador.

Ecuador with a surface of about 283000 km^2 is considered to be one of the smallest countries of South America. Nevertheless, in such a small territory, it hosts a great biodiversity in terms of flora and fauna as well as ethnic variety (about 21 ethnic groups). The current Dissertation constitutes a multidisciplinary assessment on the feasibility of an irrigation system for a rural (indigenous) community, Sigsihuaico, located on one of the most beautiful but at the same time poorest Andean regions of the country (i.e. the province of Cañar).

The dissertation condenses in 20 chapters results from both applied engineering activities as well as research approaches. In this context, the dissertation focuses mainly in areas related to Civil Engineering, Water Resources Engineering, Agricultural Engineering (c.f. Chapters 7, 11 and 17), Applied Economics (c.f. Chapters 15, 16 and 17) as well as Social aspects (c.f. Chapters 5 and 17). The practical work (field and office) and the editing of the dissertation was carried out in a period of 20 months, during the last study year of the six-year Civil Engineering Programme of the Faculty of Engineering of the University of Cuenca as well as after the completion of this study Programme.

In this dissertation, the term "community" has a monolithic connotation referring to both the study site and the indigenous group settled down on it. The dissertation starts with a *Definition* of the problem (c.f. **Chapter 1**) followed by *Technical, Economical and Social Justifications* of the assessment (c.f. **Chapter 2**) and the definition of the *General and Specific Objectives* of the assessment (c.f. **Chapter 3**). A review of the state of the art (within a national context) as well as of the available information relevant to the study area is summarised in **Chapter 4**.

Chapter 5 deals with *Preliminary Studies* that addresses topics such as:

(i) The description of the indigenous group, its organisation, its typical familiar composition, its traditional way of distributing rights to its members on the use of land and water, the main cultural and religious aspects ruling in the study site, etc.;

(ii) a brief description of the study site, taking into account aspects such as current land use, cropping planning, production and market possibilities, crop market prices, potential land use and expected production, current water sources and inventory of water uses, etc.; and

(iii) a list of recommended agreements between the community and governmental and non-governmental organisations, aiming the optimisation of the assistance to the Community of Sigsihuaico.

Chapter 6 gives a detailed description of the *Topography and Geomorphology* of the study area (Fig. 1). The topographical surveying of the study area was based on the application of altimetry and planimetry methods using accurate optical theodolites and levels and demanded a very intensive field campaign, data processing for interpolation of the topographical surface by using a combination of both manual as well as computer based methods (i.e. through the use of Geographical Information Systems, GIS) and the drawing (by hand) of suitable cartographic and design plans. As depicted in Fig. 1, the northern and eastern limit of the study is the river Cañar. The study area has an estimated surface of about 212.16 ha from which 160.89 ha are cultivated and 51.27 are covered by forest. The chapter discusses aspects related to the limits of the area suitable for irrigation, land use in general, the agricultural use of the land in particular, the planimetry of land property, study of land slopes, inventory and location of existing communication ways, inventory and location of electricity infrastructure, location of data gathering stations, inventory and location of existing irrigation and drainage infrastructure, study of potential interferences among these existing infrastructures, and location of permanent wetland regions. The chapter includes a series of technical appendixes on the topographical and geo-morphological analyses.

The existing infrastructure includes 4 earthen reservoirs of different capacity that were built up in the past by the Ecuadorian Ministry of Civil Constructions (MOP), attending a request from the Community in an attempt to store rainfall as well as a limited irrigation discharge allocated in the past to the Community by the Ecuadorian Institute of Water Resources (INHERI) an that is conveyed by the Quinuales canal connected to one of the reservoirs (c.f. Fig. 1). The reservoirs are labelled in Fig. 1 as R1, R2, R3 and R4 respectively.

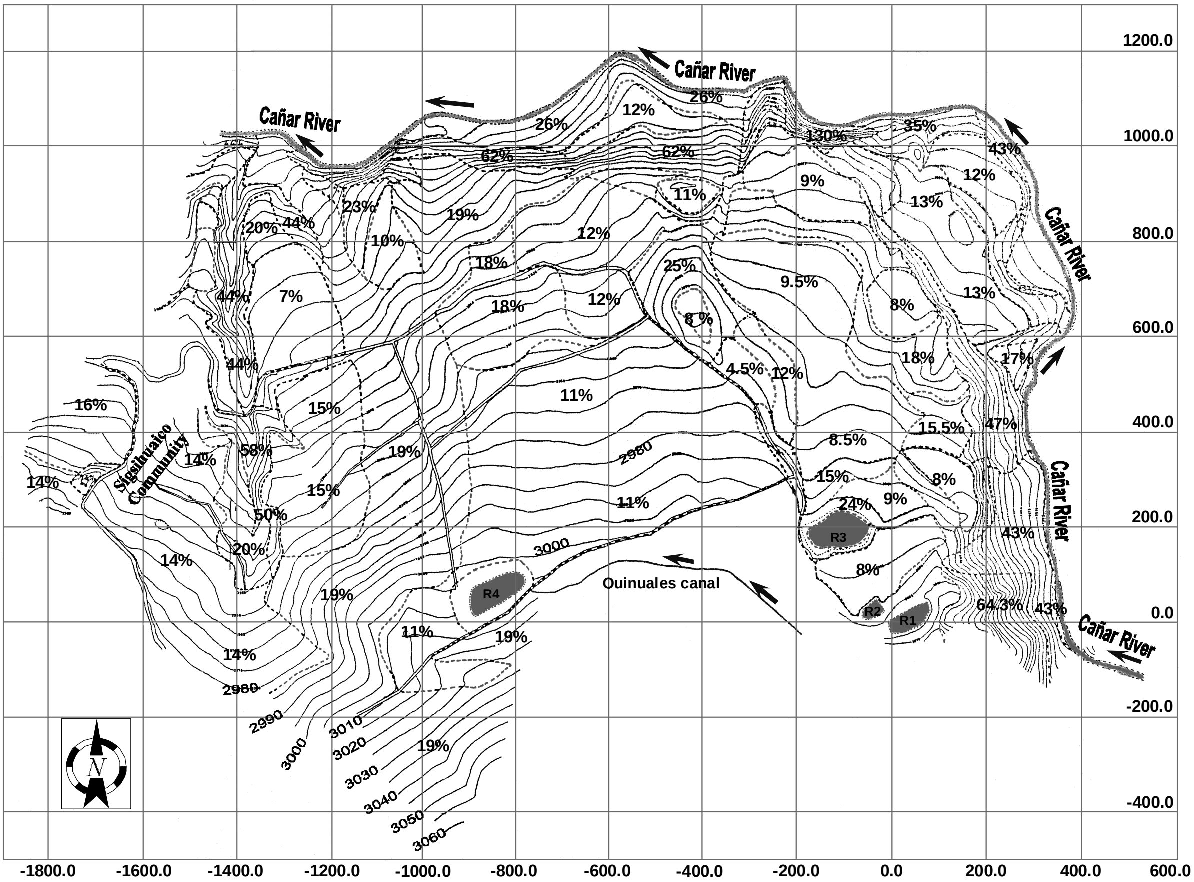

Figure 1. Map of the study area defining the topography, mean slope regions, communication infrastructure and location of the water reservoir facilities. The coordinates' system is local and referred to the topographical surveying landmark placed on reservoir R1.

Chapter 7 deals with the *Edafology-Studies*. In this context, physical, hydro-physical and chemical properties of the main soil units that exist in the study area are reported in this chapter. Furthermore, other aspects such as the critical soil saturation depth, the potential for soil salinisation and the relationship natural fertility/necessity for nutrient application are discussed. The chapter ends up with a series of appendixes on the physical tests and prospections and chemical analyses.

Chapter 8 reports the *Climatologic Studies*. Variables such as precipitation, temperature, wind intensity and direction, relative humidity and vapour pressure were included in the study, which involved several steps such as data gathering, data processing and completion of data gaps. Prior analyses were done with the intention of defining important parameters for water balance such as potential crop evapotranspiration (ET_c), which was estimated with the Food and Agriculture Organisation (FAO) Penman-method 24 (FAO-24; Doorenbos and Pruitt, 1977; Allen et al., 1998; Vázquez and Feyen, 2004). Climatologic data from neighbouring stations were used in the study. However, a local station was installed and operated in the study area to collect pan evaporation data throughout the duration of the overall studies in an attempt to cross check on the congruence of the ET_c estimates.

The main results of the *Hydro-geological Studies* are reported in **Chapter 9**. This chapter addresses aspects such as the natural regime of the water table in the study area, the chemical characteristics of the groundwater and its potential harmness on the construction materials of both the existing and the proposed infrastructures and the analysis of the feasibility of using groundwater for irrigation purposes.

In **Chapter 10** the proportion of the study site that is considered as technically *Suitable for Irrigation* is defined on the basis of topographic and geomorphologic considerations. In **Chapter 11** a *Planning of the crops* for the projected irrigation system is presented. This planning was carried out from an ecological perspective and after conducting field surveying and sounded polls about the cropping habits of the community and vicinity market requirements. In this context, the chapter includes a description of the period of development of the considered crops, average crop water requirements as a function of the different crop development periods and the recommended temperature range for a suitable crop production.

In **Chapter 12** a detailed analysis of the variables affecting the *Irrigation Planning* is depicted. With this purpose in mind, a thorough water balance was carried out to define the irrigation schedules by considering parameters such as crop evapotranspiration, precipitation and other irrigation parameters based on the hydro-physical properties of the soil units, such as Field Capacity (FC), Welting Point (WP), Total Available Water (TAW) and the Readily Available Water (RAW).

The *Hydrological Studies* are described in **Chapter 13**. These include:

(i) The definition of the hydrological network of interest for the projected irrigation system;

(ii) the determination of the general mass curve for the Cañar River that is the (potential) principal water source for the irrigation system (Fig. 1). Average daily discharges were used. This curve gives information on the percentage of days with water shortage as a function of discharge and was prepared after a frequency analysis. The design-discharge for the projected irrigation system was estimated previously as about 0.173 m^3s^{-1}, whilst the mass curve analysis revealed a 70 % confidence discharge for the Cañar River of about 1.66 m^3s^{-1}.

(iii) a frequency analysis on maximum monthly discharges for defining maximum design discharges (assuming that successive monthly data are uncorrelated). A 240-year return period was considered. The corresponding estimated discharge is 49.6 m^3s^{-1}.

(iv) analysis of the water availability for the different water conveyance alternatives considered in the study, namely, driven by gravity, by means of a combined gravity-pumping system, by means of a pumping station;

(v) determination of the characteristic discharges of the Cañar river and main tributaries;

(vi) analysis of the load and physical characteristics of the suspended sediments transported by the water sources (i.e. for designing sedimentation structures);

(vii) physical and chemical analyses of the water available for irrigation;

(viii) analysis of the range of variation of the water levels in the zone proposed for water intake in the Cañar River, for which limnimetric stations were installed and monitored throughout the duration of the studies.

The *Formulation* of water intake and distribution *Alternatives* is detailed in **Chapter 14**. The chapter starts with a preliminary definition of three potential alternatives (A) upstream water intake to 9.6 Km from the irrigation area and posterior water conveyance by gravity up to the highest reservoir; (B) upstream water intake to 6.4 Km from the irrigation area, a subsequent water conveyance by gravity up to a lower reservoir and a posterior pumping of the water until reaching the highest reservoir; and (C) water intake from the closest point in the Cañar river and subsequent pumping of the water for reaching the highest reservoir. On the basis of the technical-economic analysis reported in **Chapters 15 and 16**, option (C) was chosen and its infrastructural components, such as the water derivation infrastructure, the pumping station and the pipe line for the upwards conveyance of water, were designed as described in the rest of Chapter 14. The pumping station was designed considering irrigation water distribution by both rotation as well as demand.

Chapter 17 presents a *Study of the Agro-economic Alternatives* for the proposed irrigation system. The chapter covers key aspects such as the expected costs and benefits and the estimated period of adaptation of the community to the advised agricultural practices. The chapter includes several appendixes that illustrate the economical analyses.

The dissertation ends up with a selection of (i) the water intake and conveyance systems; (ii) the water distribution system; and (iii) the agricultural management approach that is included in **Chapter 18**. **Chapter 19** condenses some recommendations directed to the future potential users of the irrigation system (i.e. the indigenous community) and the governmental and non-governmental organisations with which the community has established contacts in the past. The recommendations are tending to achieve the education of the community in terms of soil and water conservation, suitable agricultural practices for a sustainable ecological management of the system, the maintenance of the installed meteorological station and the installation of (a) newer station(s) in the study area, etc.

Finally, all the *Cartography* that was produced throughout this study is making up **Chapter 20**. Although, GIS software such as GRASS, IDRISI and SURFER were used in the scope of the study, most of the cartography was drawn by hand owing to the lack of a suitable printing device. The cartography topics are: land ownership, topography, geomorphology, soil textures, current land use, potential land use, irrigation system layout, water distribution network, water intake infrastructure and vertical profile of the pipe line.

This assessment constitutes a pioneering approach in the southern Ecuadorian region to planning and designing irrigation systems in mountainous regions following a sounded technical and scientific multi-disciplinary background. As such, this pioneering assessment was the foundation for the latter establishment of what is now known as the Programme for Land and Water Management, an Institute annexed to the Faculty of Engineering of the University of Cuenca.

References

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