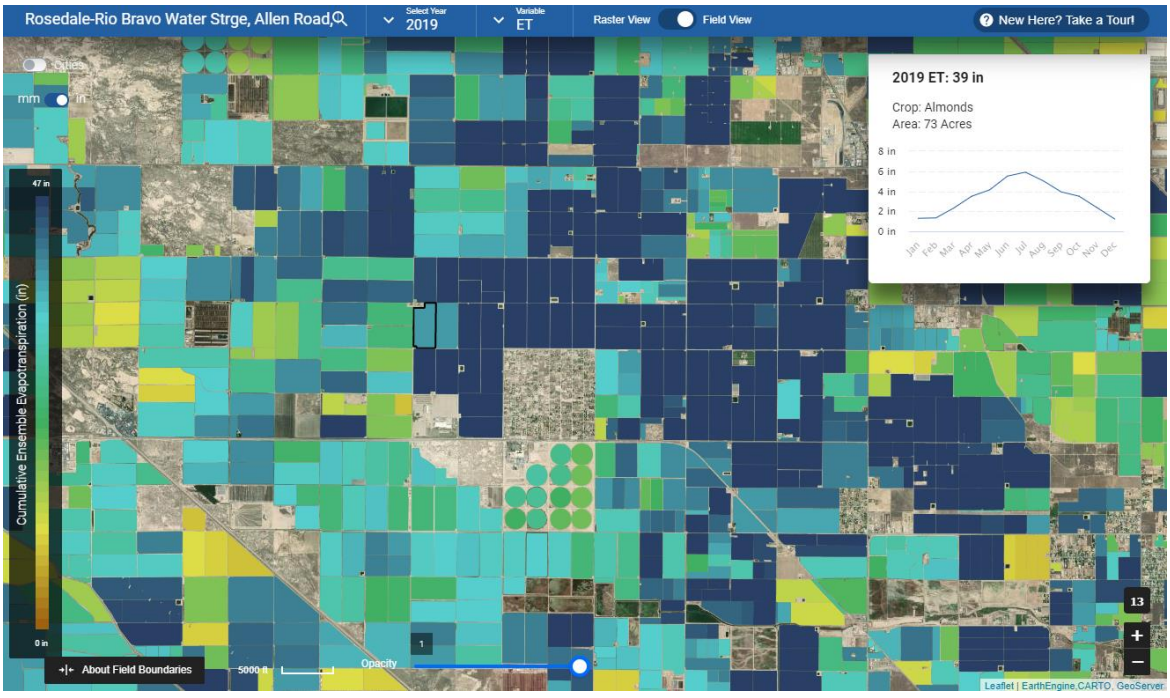
MAY 2023

OPENET

OPEN ET PLATFORM IN MEXICO

STUDY OF THE FEASIBILITY OF EXPANDING THE OPEN ET PLATFORM IN MEXICO.



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Glossary

ACU	:	Asociación Civil de Usuarios (Civil Associations of Users)
ARCMAP	:	Is the main component of Esri's ArcGIS suite of geospatial processing programs, and is used primarily to view, edit, create, and analyze geospatial data
ARCT	:	Tijuana Colorado River Aqueduct
DOF	:	Diario Oficial de la Federación (Official Gazette of the Federation)
CEA Guanajuato	:	Comisión Estatal del Agua de Guanajuato (Guanajuato State Water Commission)
CENID RASPA	:	Centro Nacional de Investigación Disciplinaria en Relación Agua, Suelo, Planta, Atmósfera (National Center for Disciplinary Research in Water, Soil, Plant, Atmosphere Relations)
CESPM	:	Comisión Estatal de Servicios Públicos de Mexicali (Mexicali State Public Services Commission)
CFS	:	Cubic Feet per Second)
CILA	:	Comisión Internacional de Límites de Aguas (International Commission on Water Limits)
CICESE	:	Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California (Center for Scientific Research and Higher Education of Ensenada, Baja California)
COLEF	:	Colegio de la Frontera Norte
CONAGUA	:	Comisión Nacional del Agua (National Water Comision)
CONAPO	:	Consejo Nacional de Población (National Population Council)
COTAS	:	Consejos Técnicos de Aguas (Technical Water Councils)
DR	:	Distrito de Riego (Irrigation District)
EC	:	Eddy Covariance method
Ec	:	Efficiency conduction performance
EDF	:	Environmental Defense Fund
ET	:	Evapotranspiration
FAO	:	FAO (Food and Agriculture Organization of the United Nations).
Ft^3	:	Cubic feet

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ha	:	Hectares
hm	:	Hectométros (Hectometers)
Hm³		Hectométros Cúbicos (Cubic Hectometers)
IBC	:	International Boundary Commission (IBC)
IDB	:	IDB Group (Inter-American Development Bank)
IMTA	:	Instituto Mexicano de Tecnología del Agua (Mexican Institute of Water Technology)
INEGI	:	Instituto Nacional de Estadística y Geografía (National Institute of Statistic and Geography)
INIFAP	:	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (National Institute of Forestry, Agriculture and Livestock Research)
IPPSON	:	Instituto Pedagógico de Posgrado en Sonora, A.C.(Postgraduate Pedagogical Institute in Sonora, A.C.)
JMAS	:	Juntas Municipales de Agua Potable y Saneamiento (Municipal Boards of Drinking Water and Sanitation)
JRAS	:	Juntas Rurales de Agua Potable en el estado (Rural Drinking Water Boards in the state)
MATRi	:	Manejo Administrativo para la Asistencia Técnica en Riego (Administrative Management for Technical Assistance in Irrigation): MATRi is a software that was designed in order to manage and systematize the information generated as a result of training and technical assistance in irrigation, as well as to facilitate its analysis and reduce times in the generation of irrigation recipes, In addition to assisting technicians and coordinators in evaluating progress, the assessment of the impacts of the project and in the generation of their work reports.
Nuup	:	Nuup (“connection” in the Mayan language) emerged in 2015 as a result of the Co-creation Agenda for Inclusive Agriculture, an initiative led by Ashoka Mexico and Central America and the Walmart de México Foundation, in close collaboration with the Aspen Network of Development Entrepreneurs (ANDE) and Accenture.
OCCN	:	Organismo de Cuencas Centrales del Norte (North Central Basin Organization)
OCPBC	:	Organismo de Cuenca Península de Baja California
OMS	:	Organización Mundial de la Salud (World Health Organization, WHO)
PTAR	:	Planta de Tratamiento de Aguas Residuales (Water Water Treatment Plant)

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REPDA	:	Registro Público de Derechos de Agua (Public Registry of Water Rights)
RH	:	Región Hidrológica (Hydrologic Región)
RHA	:	Región Hidrológico Administrativa (Hydrologic-Administrative Region)
t	:	Tons
SADERBC	:	Secretariat of Farming and Food Security
SAGARPA	:	Secretaría de Agricultura y Desarrollo Rural (Ministry of Agriculture and Rural Development)
SDA	:	Secretaria de Desarrollo Agropecuario del Estado de Guanajuato (Secretary of Agricultural Development of the State of Guanajuato)
SIAP	:	Servicio de Información Agroalimentaria y Pesquera (Food and Fisheries Information Service)
SIGMAS	:	CONAGUA's Geographic Information System for Groundwater Management
SLP	:	San Luis Potosí
SRL	:	Sociedad de Responsabilidad Limitada (Limited Liability Company)
UABC	:	Universidad Autónoma de Baja California (Autonomous University of Baja California)
UACJ	:	Universidad Autónoma de Ciudad Juárez (Autonomous University of Ciudad Juárez)
UGTO	:	Universidad de Guanajuato
Unifrut	:	Union of fruit growers that represents, protects and strengthens the apple sector, service provider and supplier of inputs that supports and promotes the development and quality of crops so that the producer is more competitive in the global environment.
UR	:	Irrigation Units (Unidades de Riego)

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1 Introduction

Improving crop water use efficiency is a key component in addressing the growing global demand for water. The determination of the water requirement of a crop at the precise time and the knowledge of its spatial variability are fundamental when carrying out a good management of the water resource of an agricultural area.

Currently there are commercial offers on the Internet for processing high volumes of images with the advantage of not having to download the images to the computer, avoiding the saturation of our computer equipment and saving time in computer processes.

In other Latin American countries these intelligent irrigation systems have been successfully applied. For example, the Argentine start-up company KILIMO, which provides advice on irrigation management and recommendation of strategies to each farmer and plot, based on periodic analysis of the soil condition to determine the water balance. Another example is located in Guatemala where IDB Lab, a laboratory that is part of the IDB Group (Inter-American Development Bank) has provided resources to implement a “climate-smart agriculture” system. This strategy includes technologies such as polymers for agricultural use, such as rain gauges and other meteorological variable sensors, to be applied to small and medium-scale agricultural systems and thus take advantage of the fertility of volcanic soils.

Sustainable water management is one of the most challenging issues of our time, especially in the arid western U.S. Maximizing the benefits of water supplies requires careful measurement of availability and use. However, one important information gap was compounding this challenge: the lack of consistent consumptive water use data. Before OpenET, access to this data was limited and expensive, keeping it out of the hands of most water users and decision-makers. OpenET fills this huge data gap in order to support sustainable water management and innovation in water conservation.

In Mexico, there is a growing need to optimize the use of water resources for irrigation through the proper use of technologies that favor productive and sustainable agriculture that meets consumption patterns modified by climate change. Faced with these needs, the OpenET team together with the Environmental Defense Fund (EDF) seek to extend the OpenET Platform, with the aim of providing

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publicly accessible satellite-based evapotranspiration data necessary for better management of water resources, especially in countries like Mexico, which faces serious problems due to water stress, prevalent in different regions of the country.

For these reasons, the objective of this work was to carry out a feasibility study for the development of the OpenET Platform in Mexico. This study allowed us to know the needs, requirements and perspectives on the use of evapotranspiration data from different actors in the water sector in Mexico. For this; field visits were made to the states of Chihuahua, Guanajuato, as well as the Valley of Mexicali and Region Lagunera, with the objective of presenting the OpenET platform, and later conducting a series of interviews with stakeholders, in order to collect data about the latent need and the potential uses of having reliable and precise data, which allow for better water management in the governmental, academic, operational and private spheres within these regions of interest.

Finally, results revealed a general enthusiasm for free access to evapotranspiration data; as well as a series of concerns regarding technical capacity, human resources, and verification of ET estimates within the country.

1.1 Objectives

The first objective was to conduct a study that gathers data and information about the need for and viability of an OpenET platform in Mexico. The outcome is a feasibility study that can help guide planning for the possible expansion of the platform in Mexico.

1.1.1 Particular objectives

- Work collaboratively with EDF's team to develop the approach and bounds for conducting a feasibility study.
- Develop and execute work plan involving both internal and external partners.
- Organize, prepare for, and facilitate interviews and focus groups with key stakeholders
- Manage relationships with stakeholders, prospective partners, and end-users, including frequent conversations and site visits as travel conditions allow.

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-Distinguish those interested in accessing evapotranspiration data, as well as possible partners.

-Identify the technical needs of those involved regarding evapotranspiration data.

-Know the potential uses, both technical and decision-making, of evapotranspiration data.

- Collect and provide information.
- Ensure that project milestones are achieved in a timely manner.
- Participate in weekly and monthly coordination meetings to discuss strategic issues and facilitate alignment and communication.
- Coordinate with the Water Manager and other designated EDF and OpenET staff as necessary.

1.1.2 Deliverables

Product 1: A work plan detailing activities, milestones, and methodology to carry out all activities.

Product 2: A memo that includes:

- A brief overview of each region describing the social, political, physical, hydrological and agricultural landscapes
- A stakeholder map identifying
  -Potential scientific and technical partners (universities / researchers / technical agency staff)
  -Potential end use partners (thought and community leaders in the agricultural, commercial, NGO, and public sectors)
  -Key policymakers and regulators that would be interested in this effort
  -Contact information for these stakeholders
- Template of stakeholder map
- Brief overview of each region

Product 3: Stakeholder interview guide and questionnaires.

Product 3.1: Conduct all interviews and provide transcript or recording of interviews. Transcripts or recordings don't have to be translated into English.

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Product 4: OpenET workshop with a few key stakeholders, that would include presentations about early findings from the consultant, as well as presentations from OpenET team on the effort and a few discussion sessions.

Product 5: Final report consolidating all of the consultancy products and including the main findings and recommendations from interviews.

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2 What is OpenET?

OpenET is a collaborative effort to develop an online platform for mapping evapotranspiration (ET) at the scale of individual fields. OpenET was built to fill an important data gap in water management across the western U.S. OpenET uses best available science and publicly available data to increase access to satellite-based ET and consumptive water use information for farmers and water managers.

ET, short for evapotranspiration, is the process by which water is transferred from the land to the atmosphere. It includes both evaporation from soil and transpiration from plant leaves. ET is a core driver of the Earth's water cycle, returning water to the atmosphere to fall again as precipitation.

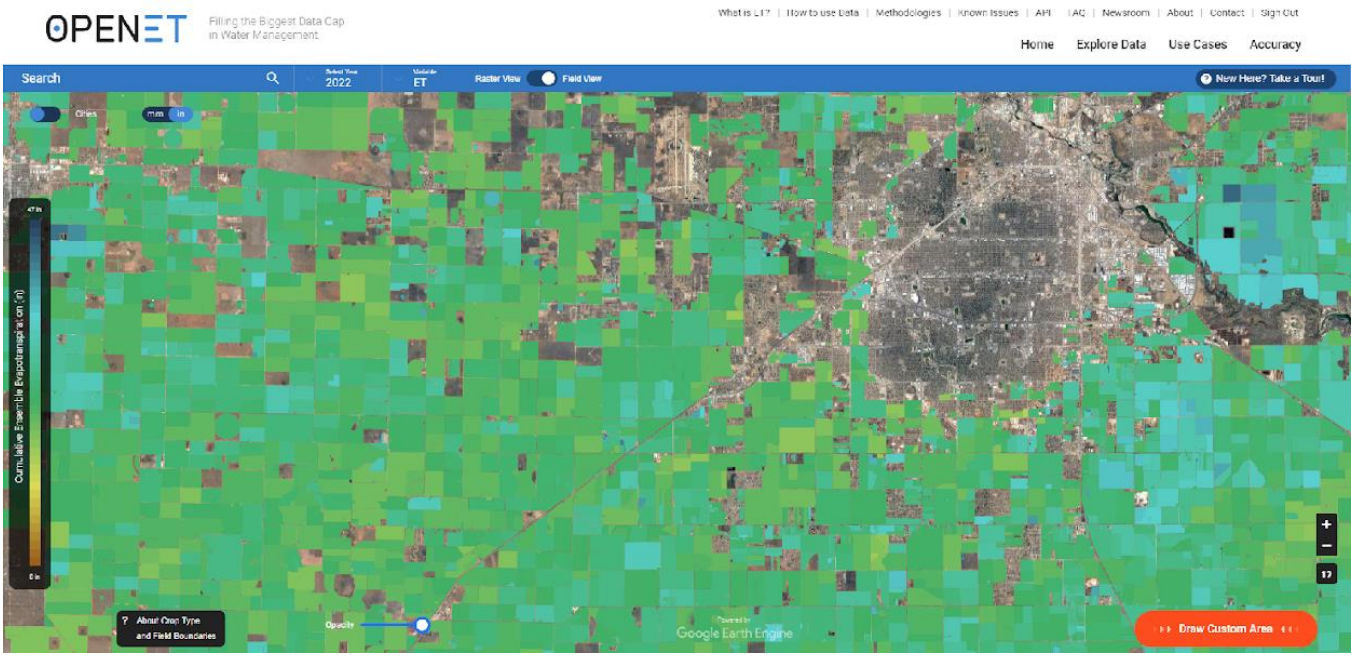

Figure 2.1 OpenET Platform: Data Explorer

For irrigated agriculture, ET is a measure of the water used to grow food and is the biggest share of water use in most arid environments around the world. In most agricultural regions, net ET (total ET less precipitation that contributes to ET) is also a measure of consumptive use of water that is diverted or pumped from surface and groundwater supplies.

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The word “open” in OpenET stands primarily for the collaborative, open, and transparent development of the platform. OpenET brings together many of the leading scientists and developers behind satellite-based estimation of ET onto one team, and is making public the models, assumptions, and inputs behind the estimates. The OpenET team aims to expand science partnerships through open collaborations with other teams and leaders in the ET community. To ensure accuracy and transparency, the OpenET team completed the largest and most comprehensive ET accuracy assessment and intercomparison study to date. High level results are available here.

It is also a core objective of OpenET to provide open access to ET data for farmers, practitioners, and water managers alike. At a minimum, any visitor to the OpenET site will be able to view field-scale estimates of monthly ET data across the western U.S. for the last five years. Users will also be able to download limited quantities of data directly from the site at no cost.

At the moment, OpenET covers 17 western U.S. states: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. Over time, the intent is to expand OpenET to include other states in the U.S. and other regions across the globe

2.1 Applications of the data

Potential applications of reliable and widely available ET data at the field scale include:

- Development of water budgets and innovative management programs that promote adequate water supplies for agriculture, people, and ecosystems.
- Support for groundwater management programs that require consistent, accurate ET data for monitoring historical and current consumptive water use.
- Support for water trading programs.
- Support for ET-based irrigation practices that maximize “crop per drop” and reduce costs for fertilizer and water.

OpenET is not intended to be a new irrigation scheduling tool. Our goal is to provide transparent, consistent, and easily accessible ET data only.

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3 Framework for the Feasibility study: Development of OpenET in Mexico

To carry out the feasibility study, first, a framework consisting of 4 stages was established, which are aligned with the deliverables of this project. The framework components are listed below:

1. Work Plan
2. Description of study areas
3. Stakeholder interview guide
   -Interviews and recordings
4. Final Report

In stage 1, a work plan was established with the schedule and breakdown of activities corresponding to each of the project stages.

In stage 2, a brainstorming session was carried out for planning the regions of interest. During the brainstorming it was decided to focus this study on the following regions: Chihuahua, Comarca Lagunera, Guanajuato and Mexicali. These regions were selected because they have large irrigated extensions and correspond to areas with high water stress.

During stage 2, in order to be prepared and schedule field visits to the regions of interest, the target areas were drafted and researched for the creation and writing of the landscapes of each region, in order to describe the social, political, physical, hydrological and agricultural aspects of the regions. The description can be consulted in chapter 4.

Subsequently, field visits to the regions of interest were carried out. The objective was to present and disseminate the OpenET Platform among different actors in the water sector in Mexico, covering the governmental, operational, academic surroundings, among others. The report of these visits is presented in chapter 6.

To finish stage 2, as a result of the field visits, the contact information of the stakeholders was collected. This information is presented as a stakeholder map in the annex.

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In stage 3, the elaboration of a questionnaire was carried out in order to know the requirements and needs of the stakeholders in terms of evapotranspiration data. The general description of the questionnaire is presented in chapter 7.1.1. Subsequently, the process of conducting the interviews was carried out, with the following activities:

- Preparation of invitation letters for follow-up interview: The purpose of sending the letter was to put the interested parties back into context and formalize this stage of the study.
- Sending the invitation letters and questionnaire to each of the stakeholders by email.
- Continuous communication with stakeholders by email and telephone to schedule the interview date.
- Conducting and recording the interviews
- Transcript of the interviews

Finally, this report corresponds to stage 4 of this framework, where all the relevant information, data collected and the results of the analysis of this feasibility study are integrated.

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4 Context of water management in Mexico and the irrigation districts

4.1 Hydrologic – Administrative Regions

The National Water Commission (CONAGUA) grouped the hydrological regions and delimited thirteen hydrological-administrative regions (RHA) in order to facilitate water administration in Mexico (Figure 4.1). On the other hand, in the Official Gazette of the Federation (DOF) with a publication date of December 12, 2007, it was reported on the agreement that determines the territorial circumscription of the basin organizations of CONAGUA, as operational units for water administration.

Figure 4.1. Hydrological-Administrative Regions of Mexico.

Source: CONAGUA, (2018)

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Subsequently and according to the RHAs, Mexico is divided into 37 hydrological regions (Figure 4.2). According to the National Water Commission (CONAGUA), hydrological regions (RH) are territorial areas formed according to their morphological, orographic and hydrological characteristics, in which the hydrological basin is considered the basic unit for the management of water resources. Its purpose is the grouping and systematization of information, analysis, diagnoses, programs and actions in relation to the occurrence of water in quantity and quality, as well as its exploitation. Normally a hydrological region is integrated by one or several hydrological basins. The limits of the hydrological region are, in general, different from the political division by states, Federal District and municipalities.

Figure 4.2 Hydrological Regions (RH) of Mexico.

Source: CONAGUA, (2018)

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4.2 Irrigation Districts

Traditionally, it has been called “irrigation district operation” or simply “operation”, the set of activities and aspects carried out directly in the hydraulic infrastructure in order to plan, schedule, distribute and deliver irrigation water to producers in an efficient and timely manner.

An irrigation district (DR) is predominantly a geographical area that can be defined as: set of irrigation canals, one or more common sources of water supply and relatively compact cultivation areas, which has a creation decree by the federal executive power, with a concession title granted to users organized in civil associations for the use of water and the administration, operation and conservation of the federal hydro-agricultural infrastructure (Pedroza González & Hinojosa Cuéllar, 2013).

It can be concluded that a DR is much more than a collection of water, infrastructure and surface, since it also implies very important and interdependent legal, administrative, socioeconomic and productive aspects.

In Mexico there are areas under irrigation outside the districts, which are known as “Irrigation Units” (UR). In essence, an irrigation district and an irrigation unit have the same objectives. The Urs are widely dispersed throughout the country. The DRs have permanent supervision by the federal government through CONAGUA and the Urs have greater autonomy and eventual supervision by the same Commission.

An irrigation district is made up of users, cultivation areas, a supply source, and irrigation infrastructure, which in turn is made up of irrigation canals, drains, regulatory structures, security structures, driving and drainage auxiliaries, and buildings that allow water administration. Additionally, there is an entire infrastructure for the management and marketing of crops. Most of the DRs have a dam as their source of supply. Sometimes the dam is very far from the irrigation zone and, in such cases, the water is conducted to the DR using the river; in other cases, the dam delivers the water directly to canals built specifically to carry it to the cultivation areas.

From the point of view of organization for the administration, there are different terms that are presented below:

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- User: rural producer owner or possessor of a surface registered in the register of users of a DR; It is the basic unit of production and organization.
- User Register: cadastral registry where farmers with the right to receive the irrigation service and who are located within the limits of a DR are registered. The basic information that it must contain is, among others: lot number, name and characteristics of the user, total area and area with the right to irrigation, type of use and the water rights that it owns.
- Civil Associations of Users (ACU): user organization, constituted under the terms of the civil code of the state in which the DR is located, which receives the title of water concession and to manage, operate and preserve the hydro-agricultural infrastructure (smaller network) located in your irrigation module. The highest authority is the general assembly of users. The president of the association is responsible for administration and the technical manager is responsible for operation and maintenance.
- Limited Liability Company (SRL): is the higher-level organization that brings together all the ACUs of a DR; It is made up of the presidents of the ACUs. It is in charge of the concession to manage, operate and maintain the main or major network of the DR.
- Transfer: administrative process, in accordance with the National Water Law (LAN), through which the users of a DR, organized in ACU, are delegated the attribution of managing, operating and maintaining the infrastructure of an irrigation module

Table 4.1 Characteristics between districts and irrigation units.

Characteristic	Irrigation District	Irrigation Unit
Surface (ha)	Greater than 2, 000	Less than 500
Property infrastructure	Federal	Private and/or ejidal
Land ownership	Private and/or ejidal	Private and/or ejidal
Quantity	88	39, 000 approximately
Organization users	Civil Association of Users	non-formal societies, organized for the concession
Concession title	water, infrastructure and machinery	water
Operation supervision	Permanent by CONAGUA	Eventual
Irrigation Planning	irrigation plan authorized by CONAGUA	undefined
Economic environment	Regional, state influence	Local influence
legal regime association	State civil code	Customs and habits

Pedroza González & Hinojosa Cuéllar, (2013)

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From the point of view of organization for the operation, there are different levels:

- Lot: area of land, property or possession of a user, registered in the user register, who receives the irrigation service provided by the ACU to which it belongs. It varies between 0.2 and 100 ha. It is the basic unit from which the DR operation is designed.
- Control point: structure in an irrigation canal through which water is delivered to a lot, irrigation section, irrigation module, irrigation unit, or irrigation district.
- Irrigation section: set of lots that irrigate through a common control point, with surfaces between 500 and 2,500 ha.
- Irrigation module: compact area with a common water delivery point, which corresponds to the lots of the users of a single ACU. The terms irrigation module (surface and infrastructure) and ACU (user organization) are used interchangeably. Usually, the area of an irrigation module varies between 3,000 and 10,000 ha, although there are exceptions at both extremes.
- Irrigation unit (from a DR): set of complete irrigation sections that are supplied by common control points. It can consist of one or several irrigation modules, normally with surfaces between 5,000 and 50,000 ha.
- Hydraulic Committee: collegiate consultation body, with the objective of proper management of water and concessioned infrastructure, made up of user representatives (presidents of ACU and SRL) and technical personnel from CONAGUA (irrigation district), where they analyze and make decisions in the administration of the DR. The Chairman of the Committee is the chief engineer of the district, and the secretary, the Chief of Operations. The presidents of the ACU and SRL participate as members, with voice and vote.

4.3 Meteorological measurement databases in Mexico

Mexico has just over 5,400 weather stations, of which approximately 2,800 report data, while the rest temporarily ceased to operate or no longer exist; however, they maintain a considerable collection of information. The main climatological variables that can be consulted are: Extreme temperatures (maximum and minimum), accumulated precipitation in 24 hours, some phenomena such as electrical storms, fog, hail, sky coverage, evaporation and normal weather conditions.

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These data can be consulted through an interactive map (from CONAGUA's National Meteorological Service, SMN). This map allows you to consult historical information from the conventional weather stations that make up the CONAGUA National Network. Said information ranges from the first data recorded to the most recent data available in the SMN databases reported by the Basin Organizations and Local Directions of CONAGUA.

Additionally, historical information can also be downloaded through the NATIONAL CLIMATOLOGICAL DATABASE, CLICOM SYSTEM (CLImate COMputing Project, http://clicom-mex.cicese.mx/), managed by CICESE (Center for Scientific Research and Higher Education of Ensenada, Baja California).

Figure 4.3 CONAGUA National Network

Source: https://smn.conagua.gob.mx/es/climatologia/informacion-climatologica/informacion-estadistica-climatologica

On the other hand, regarding the measurement of agrometeorological variables, the National Institute of Forestry, Agriculture and Livestock Research (INIFAP) has a National Network of Automated

Agrometeorological Stations (Figure 4.4). The National Network of Automated Agrometeorological Stations (RNEAA) was designed to provide the monitoring service of climate variables. With a national geographic distribution, the stations are equipped with electronic sensors that record data on: temperature, relative humidity, precipitation, solar radiation, and intensity and direction of the wind. Once subjected to quality analysis tests, the data packages are managed and stored in the National Laboratory of Modeling and Remote Sensing (https://clima.inifap.gob.mx/lnmysr/Index).

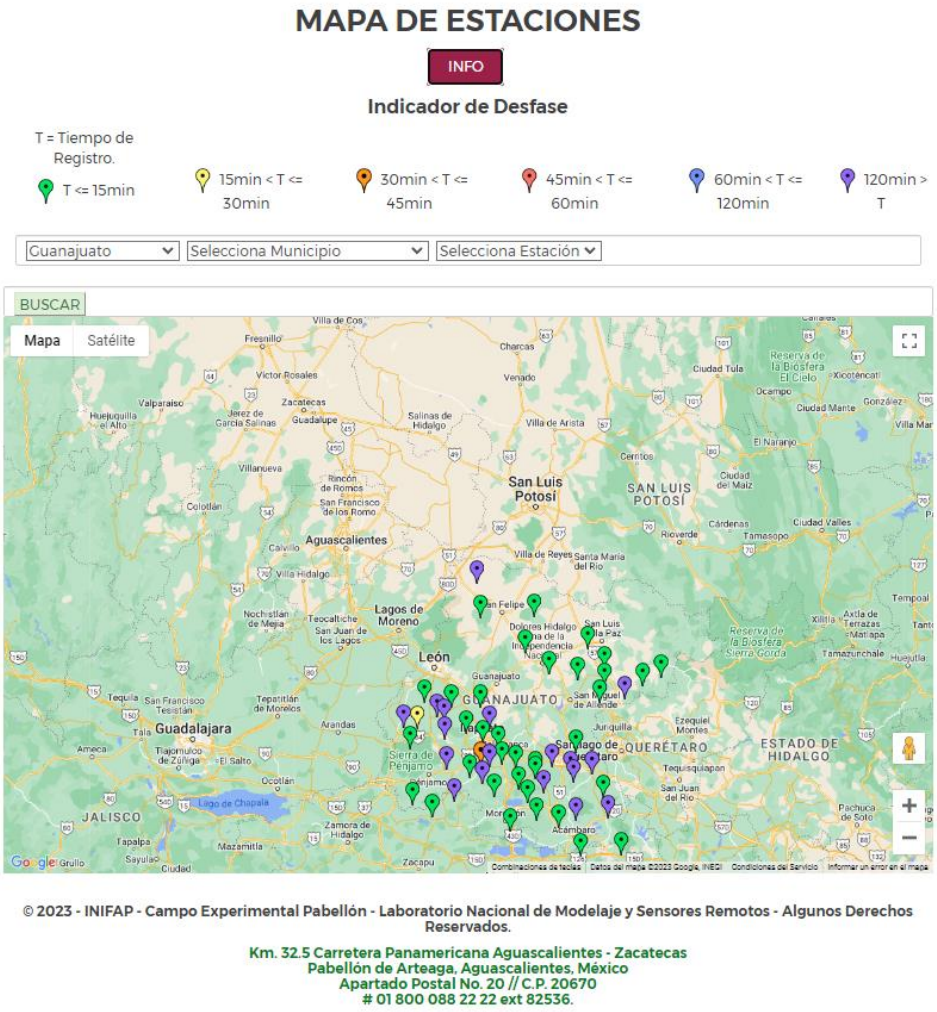

Figure 4.4 National Laboratory for Modeling and Remote Sensing, administered by INIFAP.

Although the National Remote Sensing and Modeling Laboratory stations do not measure evapotranspiration, they could help to indirectly estimate potential evapotranspiration.

On the other hand, INIFAP developed an Agroclimatic Information System, corresponding to two regions; Mexico and Central America, that traditionally lack this type of information. This information system is made up of monthly, seasonal and annual images, corresponding to climatic and agroclimatic parameters.

This investigation required daily and monthly climatic data derived from various sources of information. The data was subject to review processes, elimination of useless data and estimation of missing data. Among the sources of information, we can mention a Network of Automated Agrometeorological Stations, global data assimilation models, national meteorological networks. In addition, models were used for the estimation and adjustment of agroclimatic variables.

The results report an Agroclimatic Information System composed of raster images of parameters whose availability had been restricted until today, such as potential evapotranspiration adjusted to the Penman Monteith Method and Growing Season, as well as relative humidity and solar radiation. In addition, the Agroclimatic Information System of Mexico and Central America (SIAMEXCA, http://www.inifapcirpac.gob.mx/siamexca.html) includes the variables precipitation, maximum temperature, and minimum temperature, from which it is possible to derive other variables such as humidity index (potential precipitation evapotranspiration), daytime temperature, nighttime temperature, thermal oscillation and others, through simple routines in any Geographic Information System (GIS) software.

The thematic raster images that make up the SIAMEXCA are referred to in the WGS84 system and have a resolution of 30” arc; they can be used in any GIS software. This system can be very useful to characterize the spatial variation of the main agroclimatic parameters and the crop potential of the agricultural areas of Mexico and Central America (see Ruiz-Corral et al., 2018).

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4.3.1 Eddy covariance sites

The Eddy Covariance (EC) has been the most widely used for estimating net ecosystem exchange by direct measurement of vertical fluxes of mass and energy across a horizontal plane above the canopy. This technique is in situ and non-destructive, and can be applied to time scales ranging from fractions of an hour to years; it is therefore ideal to capture the flux dynamics across different weather conditions from diurnal cycles to long-term environmental changes (Vargas et al., 2013).

Briefly, turbulent exchanges of momentum, heat, water vapor, CO2, and in general any scalar, can be mathematically defined as the covariance between the instantaneous deviations or fluctuations of the scalar in question (e.g., temperature, concentration of water vapor or CO2 mixing ratio) and vertical wind velocity over a specific time interval (e.g., 30 min).

The installation of a micrometeorology tower with particular equipment located at a suitable height is required to ensure the representativeness needed for the exchange surface in all directions (see Figure 4.5). An EC system includes basic equipment to measure hydrometeorological variables (e.g., precipitation, temperature, relative humidity, soil temperature and moisture), and the surface available energy (i.e., the net radiation, and ground heat flux).

The blue arrows in Figure 4.5 represent the flows of the hydrological cycle: precipitation P, infiltration I, and evapotranspiration ET (which includes E as soil evaporation and T as vegetation transpiration) and runoff as horizontal flow. The green arrows correspond to the carbon fluxes: ecosystem respiration R_{eco} (which includes soil respiration R_{soil}, and vegetation respiration R_{plant}) and carbon inputs to the ecosystem via photosynthesis or gross primary productivity (GPP). The zigzag arrows represent components of the energy balance: sensible heat flux H, ground heat flux G, latent heat flux LE, and net radiation R_n. The horizontal arrow in the water represents the exchange of matter and energy between the continent and the ocean. The figure shows an eddy covariance (EC) tower at the center for monitoring ecosystem fluxes and environmental variables. In the background, in the urban part, the emissions from burning fossil fuels due to anthropogenic activities are shown with a gray arrow.

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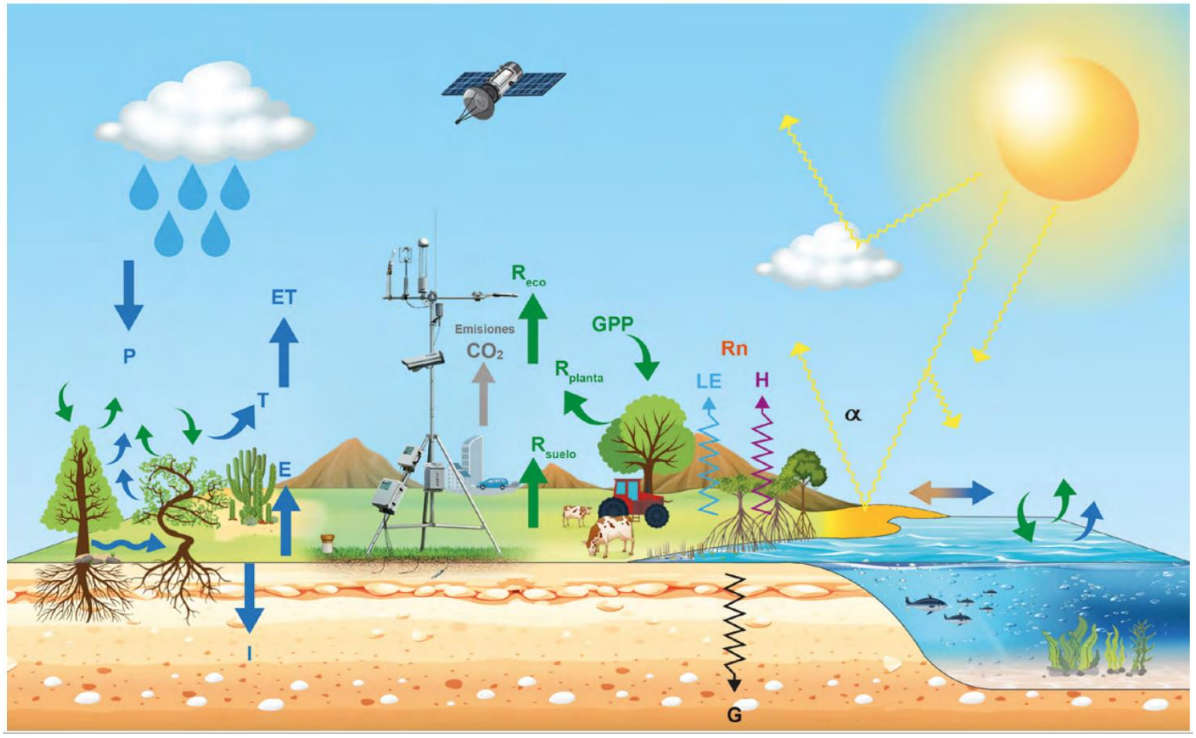

Figure 4.5 Energy balance and ecosystem flows of carbon and water in terrestrial, aquatic, coastal and marine ecosystems

Source: Tarin-Terrazas et al., (2020)

During the last decades, several networks for monitoring ecosystem processes and attributes have been established (e.g., International Long Term Ecological Research Network, [ILTER], and Human and Biophysical Dimensions of Tropical Dry Forests in the Americas [Tropi-Dry], among others). These networks have standardized experimental protocols, which have allowed collecting a large amount of information and created regional synthesis reports. Another example is FLUXNET—the global network for flux measurements of water vapor, CO2, and energy in terrestrial ecosystems (Baldocchi et al., 2001). FLUXNET is considered a network of networks that consists of several regional networks (e.g., AmeriFlux in the United States of America, CarboEurope in Eu-rope). FLUXNET has several primary functions. First, it provides infrastructure for compiling, archiving, and distributing carbon, water, and energy flux measurement, and meteorological, plant, and soil data to the science community. (Data and site information are available online at the FLUXNET Web site, https://fluxnet.org/). Second, the project

supports calibration and flux intercomparison activities. This activity ensures that data from the regional networks are intercomparable. And third, FLUXNET supports the synthesis, discussion, and communication of ideas and data by supporting project scientists, workshops, and visiting scientists. The overarching goal is to provide information for validating computations of net primary productivity, evaporation, and energy absorption that are being generated by sensors mounted on the NASA Terra satellite.

Current knowledge of the dynamics of carbon and water fluxes in Mexican ecosystems is very limited. Unfortunately, there is a lack of a strategic governmental program to ensure long-term funds for the establishment and continuity of these types of studies. However, in Mexico there is a small red network for measuring Greenhouse Gas flows and energy flows of terrestrial, urban, coastal and marine ecosystems called MexFlux (Figure 4.6, the size of the symbols indicates the number of years with data for each of the observatories). Its main objective is to generate scientific knowledge on the role of the dynamics of Mexican ecosystems in the face of global environmental change. Mexico currently has 14 study sites using the Eddy Covariance technique and has more than 30 site-years of water vapor and CO2 flux data.

In order to access the database of the stations that make up the MexFlux network, it is necessary to request the information directly with the principal investigators (PI) of each of the sites. The list of stations and principal investigators can be found in table 2 presented by Tarin-Terrazas et al., (2020).

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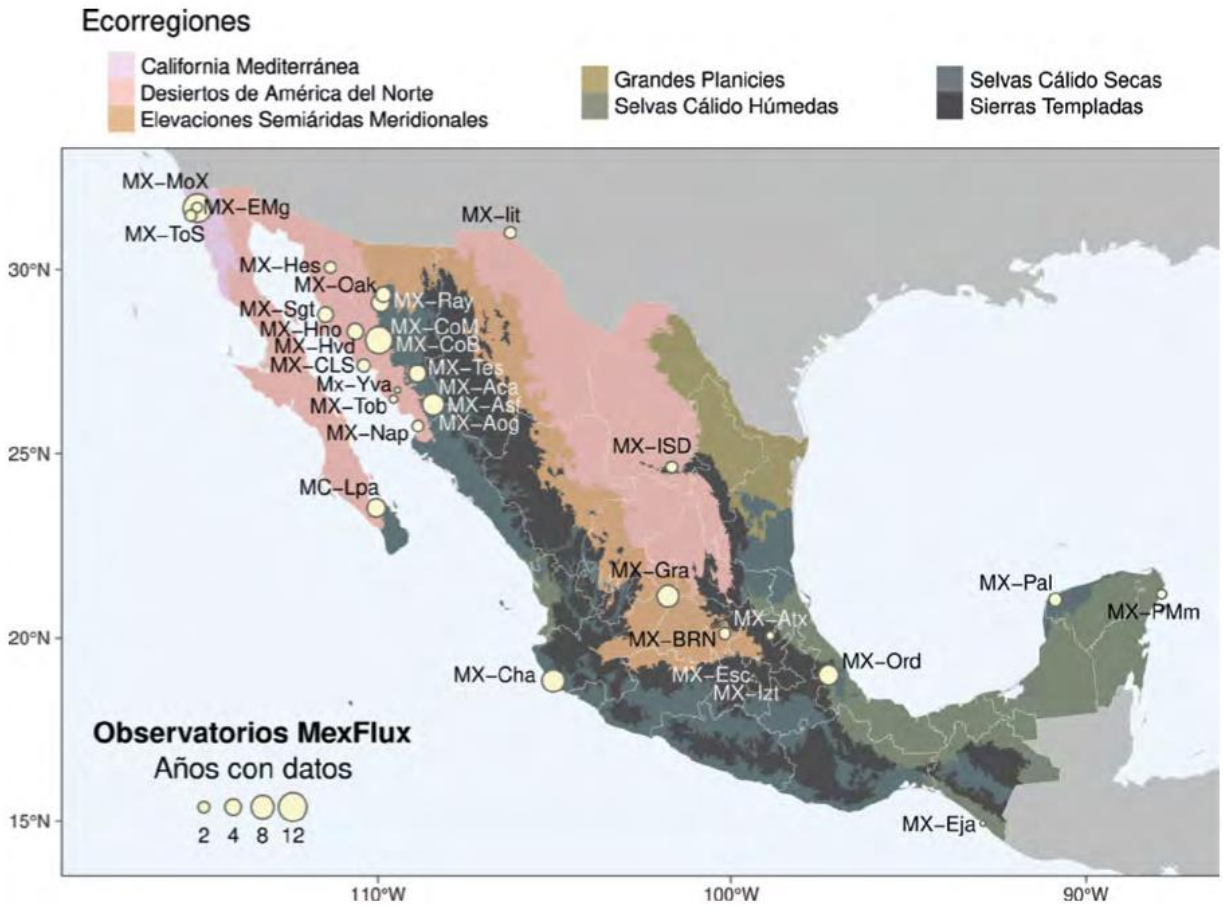

Figure 4.6 Observatories of CO2, water and energy flows of the Mexican Network of Ecosystem Flows (MexFlux) and their representativeness in the ecoregions and states of Mexico.

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5 Overview of target regions

5.1 Chihuahua

The states of Chihuahua and Sonora are located in the northern part of Mexico; among their common characteristics it can be mentioned that they present climatic conditions that go from dry to very dry. Among its economic activities are agriculture, livestock and mining, as well as the manufacturing industry that is increased by being on the border with the United States of America.

Regarding the international relationship with the United States of America, due to its waters and basins, two agreements have mainly been generated that impact the states of Sonora and Chihuahua: (1) the 1944 Treaty between the Mexican government and the government of the United States of America, on the distribution of the international waters of the Colorado, Tijuana and Bravo Rivers, from Fort Quitman, Texas to the Gulf of Mexico and (2) the 1906 Treaty for the equitable distribution of waters of the Rio Bravo. The latter is of main interest for the state of Chihuahua, since it involves the area called Valle de Juárez; while the 1944 Treaty presents an interest for the states of Sonora and Chihuahua for the Rio Bravo. This international relationship over water resources has represented conflicts but has also generated collaboration between both countries (Dévora Isiordia & Cervantes Rendón, 2019).

Regarding groundwater, 23% of the overexploited aquifers in Mexico are found between these two states (Sonora and Chihuahua), which confirms that the availability and demand of water is one of its major problems.

5.1.1 Location

The state of Chihuahua is located in the north of Mexico and is bordered to the north by the United States of America, to the east by the United States of America, Coahuila de Zaragoza and Durango; to the south, with Durango and Sinaloa and to the west with Sinaloa, Sonora and the United States of America.

The official area of the state is 247,455 km², which represents 12.6% of the national territory, being the largest state in Mexico. Its border with the United States of America is 908 km, of which 262 km are delimited by international monuments and 646 km by the Rio Bravo, which functions as a physical

border, with international treaties for water management between the governments of Mexico and the United States.

Figure 5.1 shows the location of the state and the regions considered in the Chihuahua State Water Plan 2040 (JCAS & IMTA, 2018). The state is made up of 67 municipalities and 10,648 localities, which are organized into 17 inter-municipal regions.

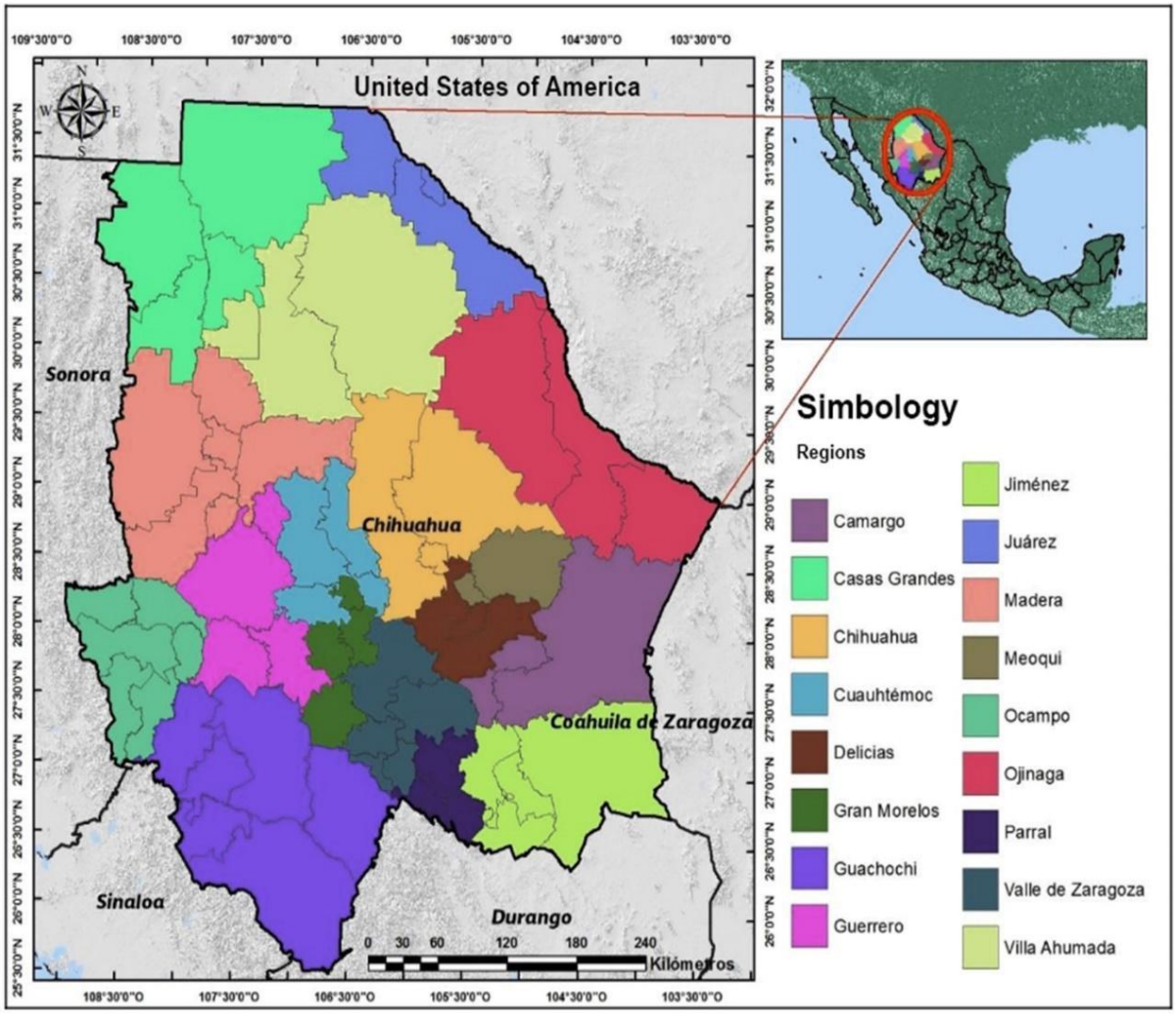

Figure 5.1 Geostatistical Framework of Chihuahua

Source: JCAS & IMTA, (2018)

5.1.2 Surface and groundwater hydrology

For national water administration purposes, the state is subdivided into five hydrological regions, with 10.4% belonging to Hydrological Region (RH) 9 Sinaloa, 10.3% to RH 10 Sonora Sur, 31.8% to RH 24 Bravo-Conchos, 35.5% to RH 34 Cuencas Cerradas del Norte and 12% to RH 35 Mapimí. The RH 34 Cuencas Cerradas del Norte and RH 24 Bravo-Conchos stand out for their territorial extension, which together comprise 67.3% of the state (JCAS & IMTA, 2018). Figure 5.2 shows the location of these hydrological regions.

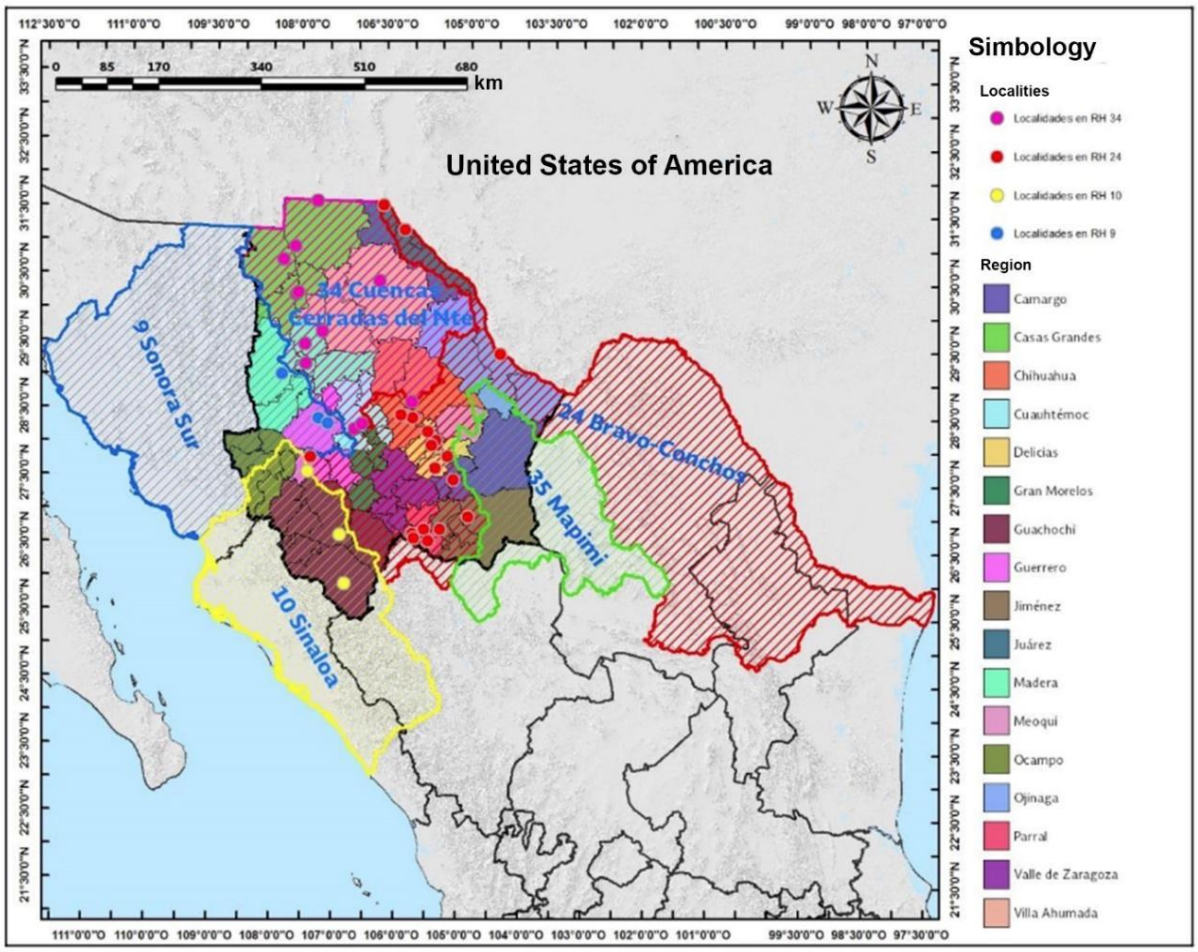

Figure 5.2 Hydrologic Regions of Chihuahua

Source: JCAS & IMTA, (2018)

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The main streams in the state are the rivers: Bravo, Conchos, Balleza, Nonoava, San Pedro, Florido, Parral and Chuviscar located in the Bravo-Conchos Hydrological Region; the Casas Grandes, Santa María and El Carmen rivers in the Cuencas Cerradas del Norte Hydrological Region; the Papigochic, Moris and Bavispe rivers in the South Sonora Hydrological Region; while in the Sinaloa Hydrological Region the main currents are the Verde, Chínipas, San Miguel, Otero and Urique rivers. In the Mapimí Hydrological Region there are no important streams. Figure 5.3 shows the water bodies and the hydrographic network of the state of Chihuahua (JCAS & IMTA, 2018).

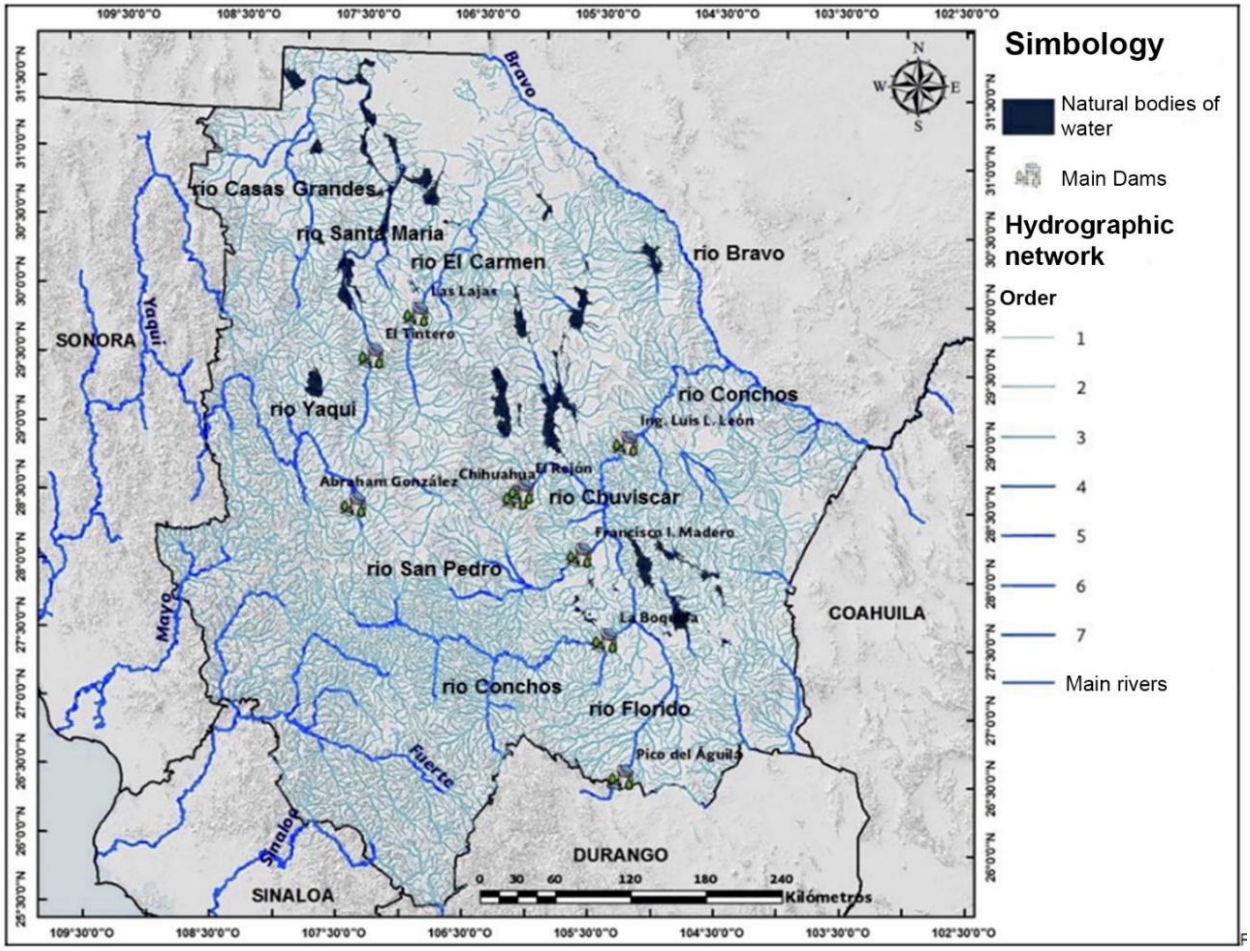

Figure 5.3 Water bodies and the hydrographic network of the state of Chihuahua.

Source: JCAS & IMTA, (2018)

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The state has a surface water availability[1] of 1,712 hm³ (6.045 871 ×10^{10} [ft³]), RH09 Sonora Sur with 75.86 hm³ (2.678 971 ×10^{9} [ft³]), RH10 Sinaloa with 500.14 hm³ (1.766 228 ×10^{10} [ft³]), RH24 Bravo-Conchos with -936.66 hm³ (deficit, -3.307 784 ×10^{10} [ft³]), RH34 Cuencas Cerradas del Norte with 1 146.37 hm³ (4.048 367 ×10^{10} [ft³]) and the RH35 Mapimí with 132.35 hm³ (4.673 896 ×10^{9} [ft³]).

The causes of the water deficit in the basins of the state of Chihuahua are due to population growth, which demands more water for food production and agriculture.

On the other hand, in the state of Chihuahua there are 69 aquifers, the main source of water supply for the population and economic activities, of which 61 are awarded to the state and the rest to Sonora and Sinaloa[2]. According to the latest publication on the availability of groundwater, published in the Official Gazette of the Federation (DOF) on January 4, 2018, of the 61 aquifers belonging to the state, 31 have availability and the remaining 30 have a deficit. Figure 5.4 shows the spatial distribution and degree of exploitation of the aquifers located in the state. In general, there is a deficit of 2,588 hm³ (9.139 436 ×10^{10} [ft³]), which is equivalent to an over-concession of 67% of the average annual total recharge.

Between the balance of 2015 and 2018, the deficit of the aquifers in the state of Chihuahua increased considerably, going from 462 hm³ (1.631 538 ×10^{10} [ft³]) in 2015 to 2,004 hm³ (7.077 059 ×10^{10} [ft³]) in 2018. The difference is due to the fact that in the calculation of the average annual availability of subsoil water published in 2015, as mentioned above, the volume of extraction from exploitations in areas with provisional suspension of “Libre alumbramiento” (free exploitation) was not considered in the calculation, nor the volume of extraction pending holder, while in the calculation of the availability of 2018 these volumes are considered, giving as a consequence that from 19 aquifers with deficit in 2015 there were 30 aquifers classified as over-concessed in 2018 (JCAS & IMTA, 2018).

[1] Refers to the volume of water in the river: Balance between the water that enters the system through precipitation and what is lost through evaporation in bodies of water and through plant evapotranspiration. The difference between what rains and evaporates and what runs off on the surface (in streams and rivers)
[2] The decision of the water administration is based on the CONAGUA's Hydrological Administrative Regions (RHA). According to CONAGUA, the country is divided into Basin Organizations or local directorates, which do not necessarily correspond to territorial or state limits, and it is based on these RHAs that it is decided which state or Basin Organization is in charge of managing the Hydrological basins (see Figure 4.2).

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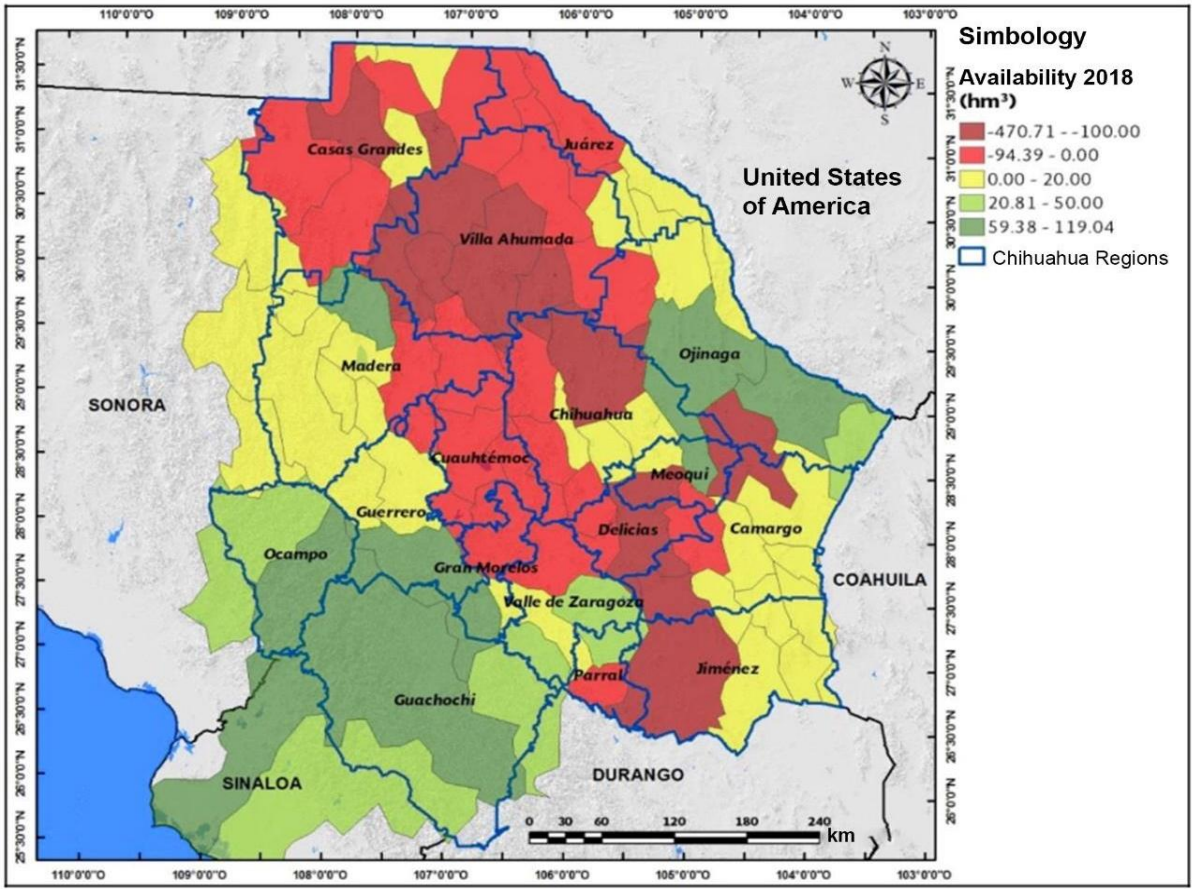

Figure 5.4 Availability of water in aquifers in the state of Chihuahua.

Source: JCAS & IMTA, (2018)

5.1.3 Water demand

The total volumes licensed and assigned in the state of Chihuahua with consumptive use represent a total volume of 5,101.58 hm³/year (1.801 606 ×10^{11} [ft³/year]), where 62.5% comes from aquifers and 37.5% is extracted from surface water. Figure 5.5 shows the distribution of surface and subterranean water uses for the state of Chihuahua.

Groundwater

In 2017, 23,421 users were registered with the Public Registry of Water Rights (REPDA), with a concession volume of 3,190.43 hm³ (1.126 69×10^{11} [ft³]). The main use is agriculture with a concession

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volume of 2,632.1 hm³ (9.295 173 ×10[10] [ft³]), which represents 82.5%, continuing the Urban Public with 437.14 hm³ (1.543 745 ×10[10] [ft³]), which represents 13.7%, and the remaining 3.8% corresponds to other Water Uses (see Table 5.1).

Table 5.1 Groundwater uses in the State of Chihuahua

Uses of water	Users	Concessioned volume (hm³)	Concessioned volume (%)
Aquaculture	2	0.01	0.00000
Agriculture	14904	2632.13	0.82501
Industrial Agriculture	3	0.01	0.00000
Different uses	1989	37.4	0.01172
Domestic	987	1.48	0.00046
Industrial	167	67.92	0.02129
Livestock	1003	6.27	0.00197
Urban public	4294	437.14	0.13702
Services	72	8.06	0.00253
Total	23421	3190.42	1.0000

Surface water

The volume of surface water registered in the Public Registry of Water Rights (**REPDA**) for the state of Chihuahua is presented in Table 5.2. In 2017, 10,679 users were registered with the **REPDA,** with a concession volume of 4,222.29 hm³ (1.491 088 ×10[11] [ft³]). The largest concessioned volume is for the generation of electricity[3], with 2,311.13 hm³ (8.161 679 ×10[10] [ft³]), which represents 54.74 % of the total concessioned volume, followed by agricultural use with 1,832.22 hm³ (6.470 424 ×10[10] [ft³]), which represents 43.39 % of the total, of which 1,212.59 hm³ (4.282 221 ×10[10] [ft³]) are concessioned to the Irrigation Districts and 1.86 % is concessioned for Urban Public, livestock, Industrial, domestic, aquaculture, services and different uses.

[3] This represents a volume for non-consumptive use, related to electric power generation. This volume is fully returned downstream from hydroelectric plants or extraction sites, so that it can be used by other users.

Table 5.2 Surface water uses in the State of Chihuahua

Uses of water	Users	Concessioned volume (hm^3)	Concessioned volume (%)
Aquaculture	15	1.59	0.0004
Agriculture	1038	619.63	0.1468
Electric power generation	4	2311.13	0.5474
Irrigation District	28	1212.59	0.2872
Different uses	94	4.46	0.0011
Domestic	12	0.07	0.0000
Industrial	8	8.1	0.0019
Livestock	3266	11.06	0.0026
Urban public	6203	52.85	0.0125
Services	11	0.81	0.0002
Total	10679	4222.29	1.0000

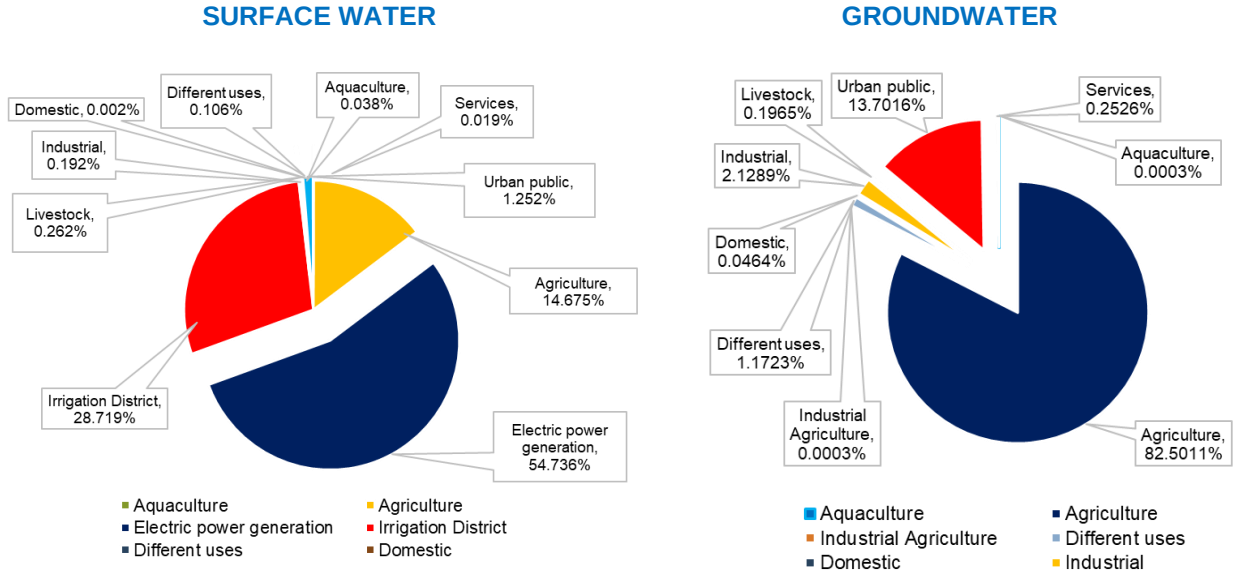

Figure 5.5 Distribution of concession volumes by supply sources and sector in Chihuahua.

Water use in irrigation districts

There are eight Irrigation Districts in the state of Chihuahua. Figure 5.6 shows their location, as well as the total number of hectares they have. Eight Irrigation Districts are located in the state of Chihuahua, whose characteristics in the 2015 - 2016 agricultural year are summarized in Table 5.3

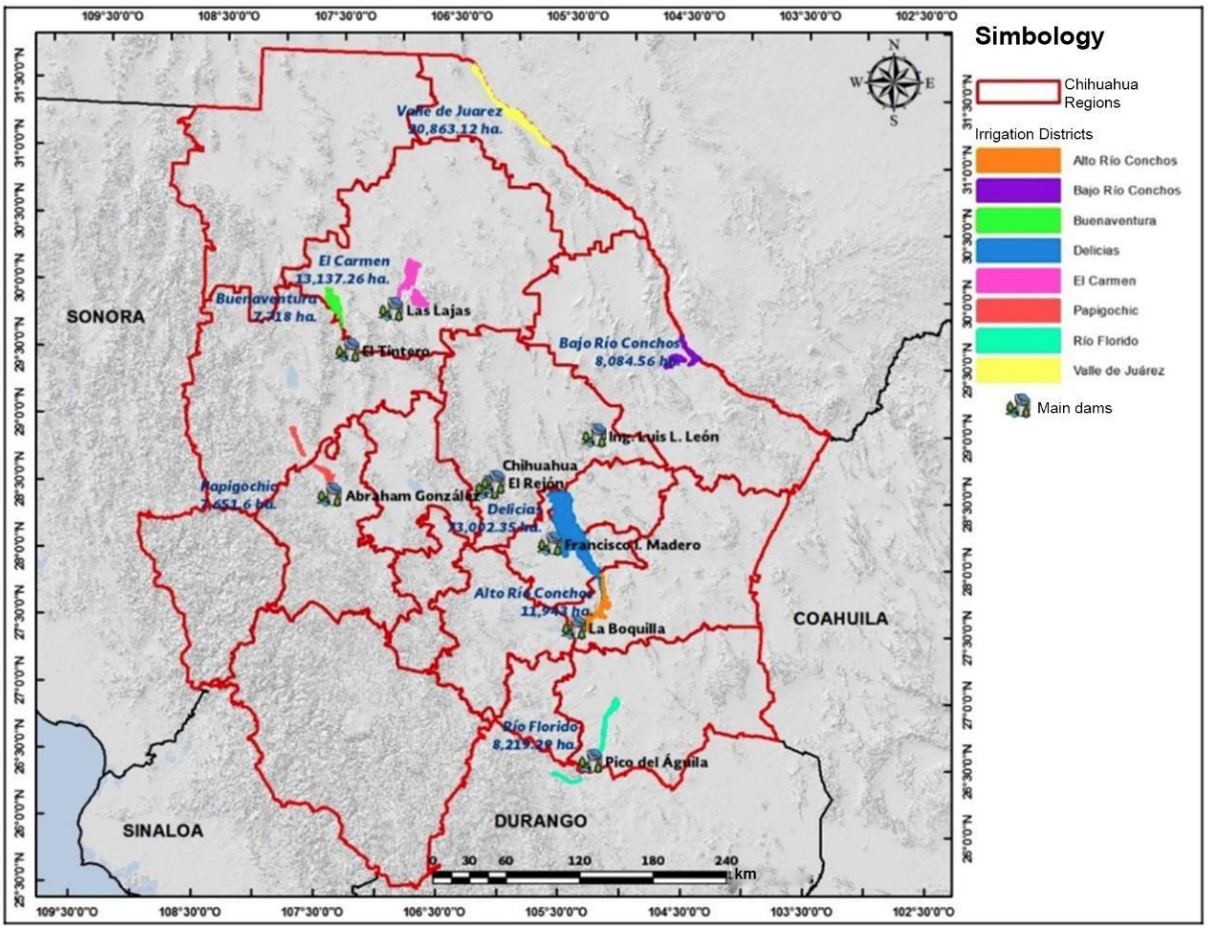

Figure 5.6 Irrigation Districts in the State of Chihuahua

Source: JCAS & IMTA, (2018)

The state of Chihuahua holds the first place with respect to harvested area in irrigation units, with 11.6% of the total harvested area in the country. Regarding the value of production, Chihuahua is located in

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the second national place, only below the state of Michoacán (Estadísticas Agrícolas de las Unidades de Riego, año agrícola 2015-2016, CONAGUA, 2017).

Regarding their location, the irrigation units are not well delimited or controlled, so there is no map of their exact location, however, the approximate location of Seasonal Agriculture in the State can be obtained using the vector data of land use and vegetation at a scale of 1:250.00 issued by the National Institute of Statistics and Geography (https://www.inegi.org.mx/temas/usosuelo/, see Figure 5.7)

Table 5.3 General characteristics of the Irrigation Districts in the state.

District	# of users[4]	Area [ha]	Physical area irrigated in the year (ha)			Distributed volume[5] (thousands of m³)		
			Surface water	Groundwater	Total	Surface water	Groundwater	Total
005 Delicias	8 107	73 002.4	61 443.1	0	61 443.1	839 795	45 061	884 856
009 Valle de Juárez	1 017	20 863.1	9 266.0	0	9 266.0	126 837	6 691	133 528
042 Buenaventura	1 077	7 718.0	4 633.1	0	4 633.1	53 100	29 344	82 444
083 Papigochic	635	7 651.6	4 376.0	0	4 376.0	30 747	0	30 747
089 El Carmen	662	13 137.3	3 265.0	6 975	10 240.0	39 357	105 193	144 550
090 Bajo Río	540	8 084.6	3 988.5	0	3 988.5	64 451	0	64 451
103 Rio Florido	1 392	8219.3	4 670.0	0	4 670.0	69 880	180	69 880
113 Alto Río Conchos	2 699	11 943.0	4 253.0	0	4 253.0	77 390	0	77 390
Total	16 129	150 619.3	95 894.7	6 975	102 869.7	1 301 556	186 289	1 487 846

[4] Physical or moral person legally possessing the right to use the services provided by the irrigation district or the civil association of users, and is registered in the user registry
[5] Gross volume, at the supply source level, that is delivered to the users of an irrigation district.

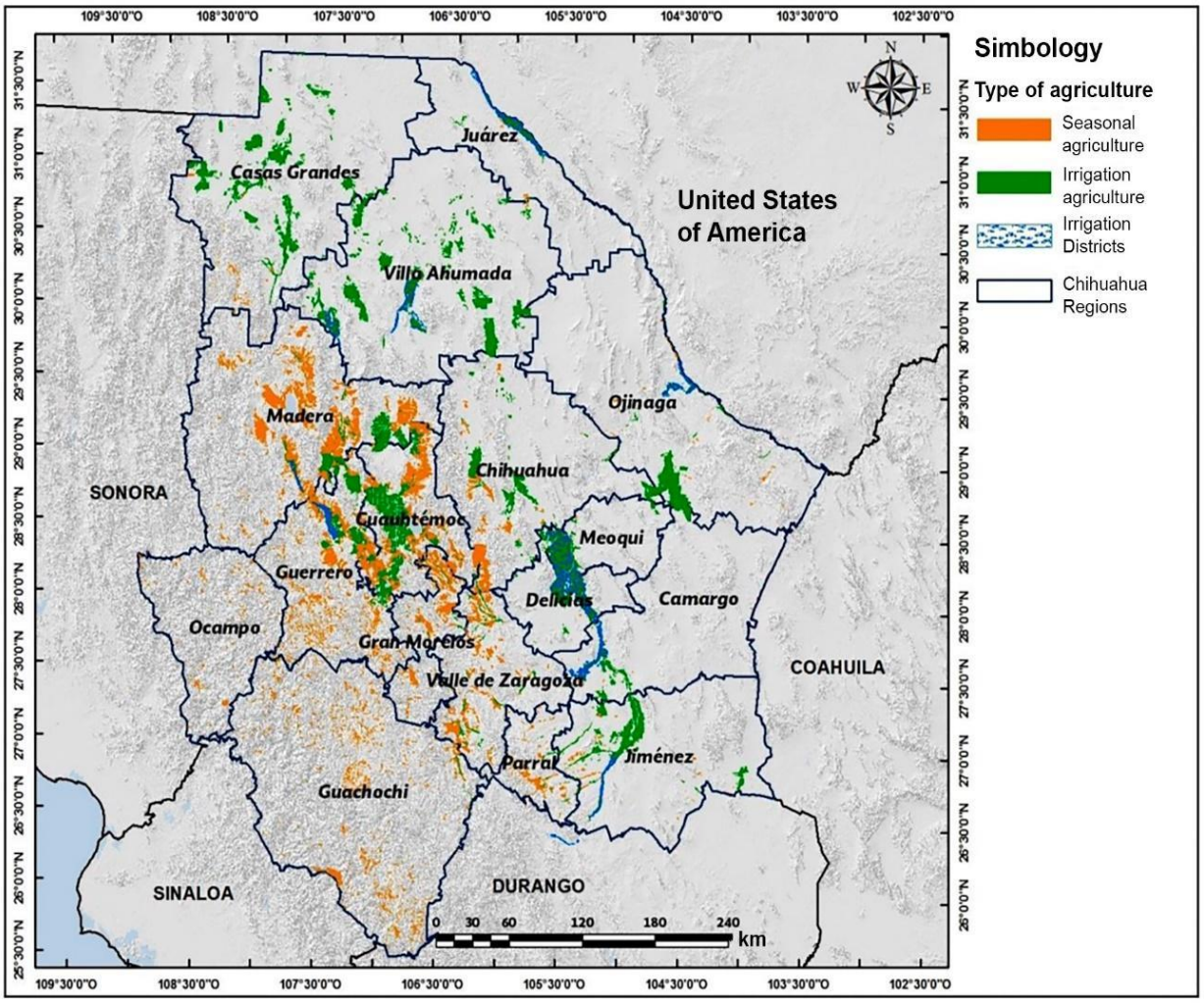

Figure 5.7 Agricultural zones in the state of Chihuahua. Source: IMTA elaboration with the use of soil and vegetation at a scale of 1:250.00, INEGI Series VI, 2016[6].

Source: JCAS & IMTA, (2018)

[6] Seasonal agriculture means that is rainfed

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5.1.4 Main issues

The biggest problem in terms of water issues in the state of Chihuahua is related to the following issues:

Over concession of surface water

The state has a total availability of surface water of 1,712 hm^3 (6.045 871 $\times 10^{10}$ [ft^3]), the availability in the Hydrological Regions that conform the state are: RH09 Sonora Sur has an availability of 75.86 hm^3 (2.678 971 $\times 10^{9}$ [ft^3]), RH10 Sinaloa has an availability of 500.14 hm^3 (1.766 228 $\times 10^{10}$ [ft^3]), RH24 Bravo-Conchos has a deficit of -936.66 hm^3 (3.307 784 $\times 10^{10}$ [ft^3]), RH34 Cuencas Cerradas del Norte has an availability of 1,146.37 hm^3 (4.048 367 $\times 10^{10}$ [ft^3]) and RH35 Mapimí has an availability of 132.35 hm^3 (4.673 896 $\times 10^{9}$ [ft^3]).

One of the most important basins within the state is the Conchos-Río Bravo River basin, which belongs to the "six tributaries" hydrological subregion and is made up of eleven sub-basins, identified by CONAGUA as: 2401, 2402, 2405, 2406, 2408, 2409, 2410, 2411, 2412, 2413 and 2414, this subregion presents an availability deficit of 936.66 hm^3 (3.307 784 $\times 10^{10}$ [ft^3]). This limits its growth since the deficit it presents is due to the fact that its surface waters are compromised by the international water treaty of 1944 between Mexico and the United States and the concessions to the irrigation districts of the region.

On the other hand, in this basin of the Río Conchos-Río Bravo, are the main cities of the state: Juárez, Chihuahua, Delicias, Parral, Jiménez, Meoqui, Camargo and Ojinaga, its surface water concession volume is very small. If it is required to use surface water for public use, a transfer or purchase of water titles from agricultural public use to urban use would have to be carried out.

The Conchos-Bravo river basin is the one that concentrates the main Irrigation Districts (DR) of the state: DR 005 Delicias, DR 009 Valle de Juárez, DR 090 Bajo Río Conchos, DR 103 Río Florido and DR 113 Alto Río Conchos (Figure 4.6), of which their irrigation programming depends on the filling of the dams: La Boquilla, Luis L. León, Francisco I. Madero and Pico del Águila, a singular case is the Irrigation District 009 Valle de Juárez, which its irrigation programming depends mainly on the water that comes from the residual discharges of Ciudad Juárez and the other part of the volume that is used is what the United States government delivers as part of the international treaty of 1904.

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Over concession of groundwater

According to the Official Gazette of the Federation (DOF), the state of Chihuahua went from 19 overexploited aquifers with a deficit of 1,197 hm^3 (4.227 166 $\times 10^{10}$ [ft^3]), (DOF-04-20-2015) to 30 overexploited aquifers with a deficit of 2,588 hm^3 (9.139 436 $\times 10^{10}$ [ft^3]), (DOF-04-01-2018), in three years the number of overexploited aquifers increased by 11 and its deficit by 1,391 hm^3 (4.912 27$\times 10^{10}$ [ft^3]).

This is exacerbated since there is competition for groundwater between agricultural users and the urban public, the main cities of the state: Juárez, Chihuahua, Cuauhtémoc, Parral, Delicias, Camargo, Meoqui and Jiménez, are located above over-exploited aquifers and groundwater is their only or main source of drinking water supply to the population.

Irrigation technology

Irrigated areas of the country that are located in arid and semi-arid regions, such as those of the state of Chihuahua, are exposed to high climatic variability, and this is invariably reflected in the uncertainty of the available volumes of surface water in reservoirs, which leads to a situation of greater dependence on aquifers through the extraction of water resources with deep wells.

Due to its high profitability and market security, there is a tendency to increase the area of perennial crops, mainly walnut and alfalfa, which are high consumers of water (gross sheet greater than 180 cm/ha). Considering the water footprint, each kilogram of walnut produced requires approximately 15 m^3 (529.72 [ft^3]) of water in the reservoir; around 11 m^3 (388.46 [ft^3]) at the level of consumption on the parcel within the Irrigation Districts, and 9 m^3 (317.83 [ft^3]) in the Irrigation Units. According to SAGARPA (Ministry of Agriculture and Rural Development) statistics, in the state of Chihuahua, the area planted with the walnut crop registers an annual growth rate of 4.8% for the period 2007-2017, which is equivalent to an increase of around 3,000 ha/year.

On the other hand, the state of Chihuahua is the main national exporter of bovine cattle with more than 400,000 heads per year, for which it is necessary to satisfy the local demand for fodder, causing an increase in the demand for water for these crops, among them alfalfa.

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In the state of Chihuahua, the expansion of agricultural areas with irrigation service is noticeable, supplied mainly with groundwater, used for the production of different crops, with a predominance of perennials.

On the other hand, the application of plot irrigation in the Irrigation Districts of the state is primarily by gravity, with application efficiencies of less than 50%. However, the biggest problems are concentrated in the Irrigation Units, due to the next reasons:

- There is no specific location of the irrigation units[7]
- There is no solid organization of irrigation users[8]
- There is uncertainty about the number and type of users
- Deficient production and technical area statistics with a breakdown of irrigation systems
- There are no irrigation plans and there is no adequate control of the volume derived from surface and underground sources.

The lack of measurement, systematization, and control of the information from both reservoirs and wells makes it difficult to monitor and follow up in detail on the volumes used for irrigation, which in turn limits agricultural planning and ordering that allows for regulated use management. of water in agriculture in Chihuahua.

An alternative to make efficient use of water in agriculture is the irrigation technification at the level of parcel application, but the constant increase in production costs, mainly in pumping and inputs, greatly limit the irrigation technification.

Reuse of treated wastewater

The current use as reuse of wastewater in the state of Chihuahua is very low, despite the fact that it has a high potential for its use in different uses, especially in the agricultural sector, which can be offered the substitution of first-use water from the aquifer that they use to irrigate their crops, for treated water

[7] set of complete irrigation sections that are supplied by common control points. It can consist of one or several irrigation modules, normally with surfaces between 5,000 and 50,000 ha
[8] This problem refers to the Irrigation Units. The irrigation units have the same objectives as the irrigation district, however, they are autonomous and are not supervised by a federal entity, and since they are dispersed throughout the country, they do not have a good organization.

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that complies with the regulations established to irrigate fruit forage or crops whose fruit is above 1.0 m above ground level.

In several localities there is a "tolerated" use of treated and even raw wastewater by agricultural producers who have their plots adjacent to the PTAR (Wastewater Treatment Plants, WWTPs) and this action is facilitated before discharging to the receiving body or entering the Treatment Plants, from connections in the arrival and discharge sender. The Municipal Boards of Drinking Water and Sanitation (JMAS) and the Rural Drinking Water Boards in the state (JRAS) do not carry out interventions to regularize these actions by the producers, due to various factors such as lack of vigilance due to insufficient personnel or agreements established for the use of land for the construction of WWTPs at the time.

Soil and water conservation

Agriculture in Chihuahua is carried out mainly under irrigation and conservation practices or technologies are rarely considered in its production systems, quite the contrary, agricultural residues or waste are burned mainly on the surfaces destined for corn and wheat crops. According to SAGARPA, the demand for water in the situation of irrigated agriculture in the state is presented below:

- Alfalfa, walnut and apple trees demand 99.25% of irrigation water, destined for perennial crops (total demand 1 971.89 million meters cubic).
- Cotton, corn for grain and green chili demand 92% of irrigation water, destined for annual crops in the spring-summer cycle (1,774.16 million cubic meters).
- Wheat for grain, green fodder oats and onion demand 95% of irrigation water, destined for annual crops in the autumn-winter cycle (137.56 million cubic meters).
- Approximately 50% of irrigation water is used for perennial crops.
- Irrigation agricultural activity is concentrated in the valleys of the central strip of the state of Chihuahua due to soil-climate-water availability conditions.

5.1.5 Water governance

The Chihuahua State Water Law regulates the planning, administration, conservation of projects and works related to water resources within the framework of state development, as well as the

administration and conservation of waters under state jurisdiction in terms of article 27, fifth paragraph, of the Political Constitution of the United Mexican States, and coordinate between the State of Chihuahua, its Municipalities and the Federation, to carry out actions related to the use and exploitation of water, conservation of its supply sources, and water resources surface and underground.

The Executive Power of the State has faculties in matters of water, among others, to propose, formulate and promote the policies that guide the promotion and hydraulic development of the State, as well as guarantee the access of any person to water for personal and domestic consumption, in a sufficient, healthy and affordable way, as well as the sanitation of wastewater and its disposal.

The Executive Power of the State, through the operating agencies, will be in charge of defining and establishing policies to achieve sustainable development in hydraulic matters, through integrated management, administering state waters, setting strategic policies, program objectives and the rules for optimal use, beneficial use and equitable distribution among the various communities of the state.

The State Hydraulic Council, provided for in the Chihuahua State Water Law, has powers to formulate, monitor, evaluate and update the planning and programming of the state's water development, carrying it out in a participatory manner with all the social and private.

In the state of Chihuahua, the provision of drinking water service in localities is attended by 32 Municipal Water and Sanitation Boards and 17 Rural Water and Sanitation Boards. In addition, there is a structure of 327 water committees (neighborhood committee constituted from the construction of infrastructure for its administration, service and maintenance), serving the same number of rural localities, and the rest of the localities are self-sufficient supported by the Central Board of Water and Sanitation when required.

To strengthen the integrated and sustainable management of water, it is necessary to modernize and expand the measurement of the water cycle and the strengthening and permanent improvement of the government and governance of water to increase its effectiveness through social participation and inter and intra-institutional coordination to reduce the risk of conflicts. Social participation is a fundamental element and condition to enable good governance in the integrated management of water resources.

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5.1.6 Strategies for water sustainability

The 2014-2018 National Water Plan (CONAGUA, 2014) establishes six objectives, aligned with the National Development Plan, on which the water policy in our country must be based. These are the six objectives:

1) Strengthen integrated and sustainable water management.
2) Increase water security in the face of droughts and floods
3) Strengthen the water supply and access to drinking water, sewerage and sanitation services
4) Increase the technical, scientific and technological capacities of the sector.
5) Ensure water for agricultural irrigation, energy, industry, tourism and other economic and financial activities in a sustainable manner.
6) Consolidate Mexico's participation in the international context regarding water

The objectives of the 2014 - 2018 National Water Plan are taken up again in the Chihuahua State Water Plan 2040, and in turn are the framework in which actions are proposed to achieve the established objectives to contribute to solving the problems that afflict the state.

Objective 1. Strengthen integrated and sustainable water management:

To change the trend of overexploitation and seek the stabilization of aquifers, a set of actions is required that contribute to reducing extractions through actions of various sectors, reallocating rights to water resources, increasing availability with new sources of water such as reuse of wastewater or the transfer of water between basins.

- Order[9] and regulate the uses of water in basins and aquifers
- Order the exploitation and use of water in basins and aquifers
- Modernize and increase the measurement of the hydrological cycle

Objective 2. Increase water security in the face of droughts and floods

[9] it refers to adjusting concessions and allocations to the real supply and availability of water and regional priorities.

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It is proposed to reinforce the actions to avoid the invasion of riverbeds and federal zones and to advance in coordination with the three orders of government in the relocation of settlements in areas of high risk of flooding. When the above is not possible, flood protection and control infrastructure will be built. These actions include the following:

- Strengthen or, where appropriate, create specialized emergency care groups trained and equipped.
- Update the dam operation policies prioritizing the protection of population centers.
- Strengthen early warning systems and prevention and mitigation actions in case of emergencies due to hydrometeorological phenomena.
- Increase the participation and co-responsibility of states and municipalities for adaptation actions against climate change or climate variability.
- Create or strengthen financial funds for adaptation to climate change and for the maintenance and rehabilitation of hydraulic infrastructure.
- Increase the exchange of information with national and international bodies.

Objective 4. Increase the technical, scientific and technological capacities of the sector at the state level

These actions are aimed at informing the population of the effects on the hydrological cycle due to the indiscriminate exploitation of resources, and raising awareness of the need to make rational use of water. On the other hand, it is proposed to promote technological development and research through alliances between various public and private actors linking research institutions and universities, where the challenge should be mainly in the agricultural field in more efficient irrigation systems and scheduling, alternative crops for productive reconversion and water productivity.

- Promote continuous education and certification of stakeholders in the water sector
- promote scientific research and technological development to achieve the objectives of the sector
- Generate and provide information on water

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Objective 5: Secure water for agricultural irrigation, energy, industry, tourism and other economic and financial activities in a sustainable manner

The withdrawal of water from aquifers for agricultural use represents an average of 85 % of total withdrawals. To balance the extraction and recharge of aquifers, it is necessary to reduce the volumes used for agricultural use. To achieve this, it is proposed to reduce the agricultural area that is supplied by overexploited aquifers together with the increase in efficiencies in the conduction and application of irrigation, through appropriate irrigation techniques for regions with arid conditions and low rainfall. Additionally, the cultivation pattern must be changed, since the current crops that have proliferated in the region due to their high economic yield require large amounts of water, causing social and environmental effects, leading the region to exceed the natural availability of the water sources. The following actions are listed:

- Improving water productivity in agriculture
- Sustainably use water to promote development in areas with availability

Finally, in the context of the State Water Plan 2040, the modernization of irrigation areas that are currently supplied with gravity irrigation systems (flood irrigation) should be considered, which would obtain the following benefits:

- Increased extraction, conduction and application efficiencies
- Greater availability of water
- Hydraulically more efficient structures
- Less pumping time.
- Reduction of extractions
- Reduction of losses due to filtration and operation
- Conservation of aquifers

The boost to the modernization of irrigation should be done with pressurized systems and the incorporation of solar technology, but, above all, emphasize small producers of Irrigation Units (UR) considering as a prerequisite a producer-government agreement so that the use of the volumes saved is applied to other uses, such as the urban public.

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As previously indicated, the modernization must be carried out primarily in the irrigation units, for which the following short-term actions are identified:

- UR inventory: location, number and type of users, statistics and technical area, with breakdown of irrigation systems
- Consolidate user organization.
- Development of technical packages
- Develop the legal bases of the agreement for destination of saved volumes

5.1.7 Opportunities for OpenET in Chihuahua

Based on the background, the description of the water problem in the state of Chihuahua and the results obtained from the analysis of the interviews presented in chapter 7, some of the most relevant opportunities that the OpenET platform has in Chihuahua are listed below:

- OpenET can be of valuable help in arid areas such as the state of Chihuahua, where better water management is required.
- For irrigation districts, OpenET can influence the modernization of irrigation, as well as management, monitoring and support for producers.
- Increase the technical, scientific and technological capacities of the sector at the state level
- Implement more efficient and sustainable schemes of agriculture in the state.
- Having access to evapotranspiration information would allow a better quantification of hydrological behavior and anthropic activities (water extraction).
- OpenET could help to better manage the uses of water, both from surface and underground sources.
- Evapotranspiration data can help to carry out water balances or irrigation programming in real time, as well as to carry out climate change projections at the basin scale.

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5.2 Mexicali Valley: Río Colorado Basin

5.2.1 Location

The Colorado River Basin is considered one of the most important water systems in North America (Figure 5.8). Since its source, generated from the melting that occurs in the Rocky Mountains, the Colorado River flows southwest towards the Gulf of California with an approximate length of 2,334 km, crossing seven states of the U.S.A, and covering the last 160 km between the limits of the states of Sonora and Baja California in Mexico.

Figure 5.8 Hydrological Basin of the Colorado River.

Source: (National Research Council, 2007)

The basin has an area of 637,137.08 km², of which 97.58 % corresponds to U.S.A territory and 2.42 % to Mexican territory.

The annual volume of water that flows through the Colorado River is estimated at 19,735 hm³ (6.969 349 $\times 10^{11}$ [ft³]). There is a high seasonal variation in the river flows: 2,800 m³/s during snowmelt (May to July) and 140 m³/s (4 944.053 CFS) during autumn and winter.

5.2.2 Distribution of water volumes between Mexico and the United States

The distribution of water volumes between Mexico and the United States is regulated in the International Water Treaty, agreed between Mexico and the United States on February 3, 1944. In this binational agreement, Mexico is guaranteed the annual delivery of 1,850.23 hm³ of water, of which 1,677.54 hm³/year (90.7%) are delivered to the North International Boundary (IBC), at the Morelos Dam, and 172.69 hm³/year (9.3%) to the South International Boundary, through the Canal Sánchez Mejorada, in San Luis Río Colorado, Sonora.

According to the public database of the International Boundary and Water Commission between Mexico and the United States (Comisión Internacional de Límites y Aguas entre México y los Estados Unidos, CILA), the delivery of 1,850.23 hm³/year has been fulfilled without interruption since 2005 (Figure 5.9); even despite the 2010 - 2011 drought event, which produced the lowest level in Lake Mead since it was filled in the 1930s (1,082.36 ft).

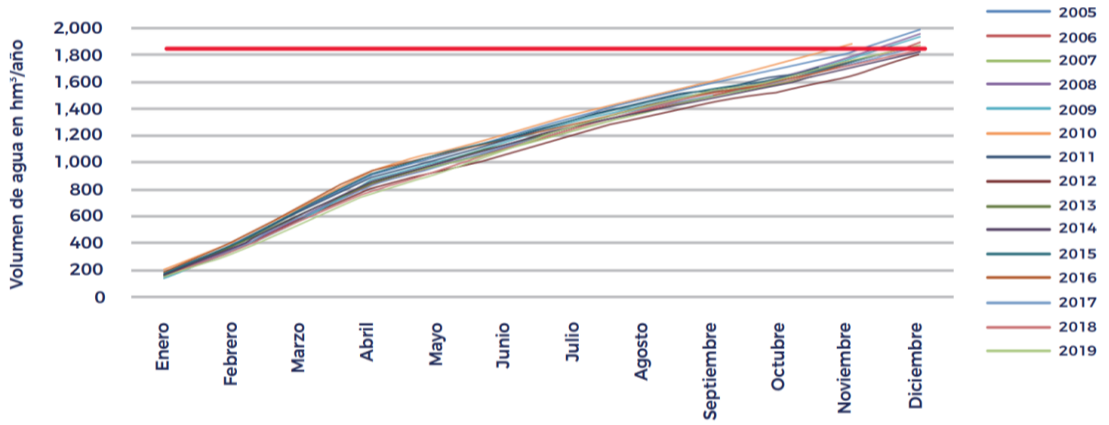

Figure 5.9 Water delivery of volumes from the transboundary basin of the Colorado River to Mexico.

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5.2.3 Water Supply for the Valley of Mexicali

Surface and underground source of water

The Mexicali Valley is supplied by the Colorado River (surface water) and the aquifers of the Mexicali Valley and the San Luis Río Colorado Valley (groundwater). The surface water supply source has an annual volume of 1,862.75 hm^3, of which 1,729.08 hm^3 are under concession, an ecological flow of 1.25 hm^3 and an annual availability of surface water of 132.42 hm^3 (restricted volume[10]) are considered. This annual availability is delivered in blocks throughout the year and is subject to local losses due to evaporation and infiltration into the river, which implies that during some times of the year the discharge flow to the Gulf of California is non-existent.

The amount of groundwater stored in the Mexicali Valley aquifer is unknown; however, an annual recharge of 520.5 hm^3 is estimated, according to official data. To keep this aquifer in balance, it is necessary to limit groundwater extractions below the value of the annual recharge.

The natural outlets of the Mexicali Valley aquifer are estimated at 2.5 hm^3 and, additionally, there is a water concession volume of 783.12 hm^3. This means that more water is withdrawn than is naturally recharged and places it in a condition of overexploitation, with an annual deficit of 265.12 hm^3. Therefore, on the Mexican side, groundwater is under an over-concession condition.

Distribution of water between users

The total annual distribution of water in the Mexicali Valley (including the volume of water available by the International Treaty of the Colorado river) corresponds to the sum of the surface (1,729.08 hm^3) and underground (783.12 hm^3) concessions, that is, 2,512.2 hm^3. 85% (2,135.1 hm^3) of the total volume of water under concession in the Mexicali Valley (2,512.2 hm^3) is for agricultural use, while 10.2% (255.9 hm^3) is for industrial use and 4.5% (112.6 hm^3) for urban public use; that is, human consumption. Finally, the remaining 0.3% (8.6 hm^3) is used for other uses, according to data from REPDA (2015). This distribution of volumes is illustrated in Figure 5.10. It is important to point out that with regard to the

[10] In Mexico it is known as “volumen en veda”, and means that it is a restricted volume so it cannot be used for exploitation.

endowment for urban public use, this volume is sufficient to supply 3,085,759 people, considering an endowment of 100 l/inhab/day).

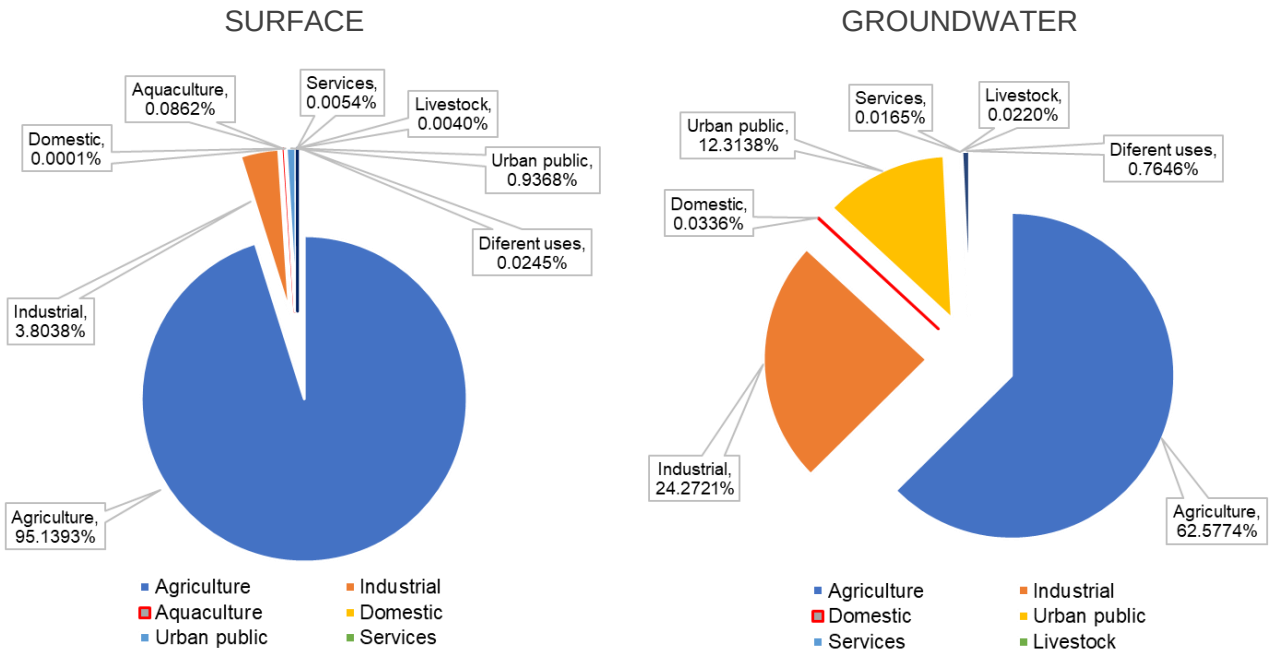

Figure 5.10 Distribution of concession volumes in the Valley of Mexicali.

Water Demand in Mexican territory of the Colorado River

The annual volume of surface water cutoff from the Colorado River is 1,850.23 hm³, while the Mexican portion of the river has an average annual volume of natural runoff of 12.52 hm³, which added to the binational treaty gives us a total annual volume of 1,862.75 hm³, which is distributed as follows:

- **Agriculture**: to irrigate crops in DR 014: 1,645.04 hm³ (88.31% of the surface total).
- **Industrial use**: 65.77 hm³ (3.53% of the surface total).
- **Urban public use**: for the supply of population centers: 16.20 hm³ (0.87% of the surface total).
- **Committed volume downstream, environmental flow**: 1.25 hm³ (0.07% of the surface total).
- **Other uses, includes aquaculture, domestic, livestock, multiple and service uses**: 2.08 hm³ (0.11% of the surface total).
- **Available volume, with restrictions**: 132.41 hm³ (7.11% of the surface total).

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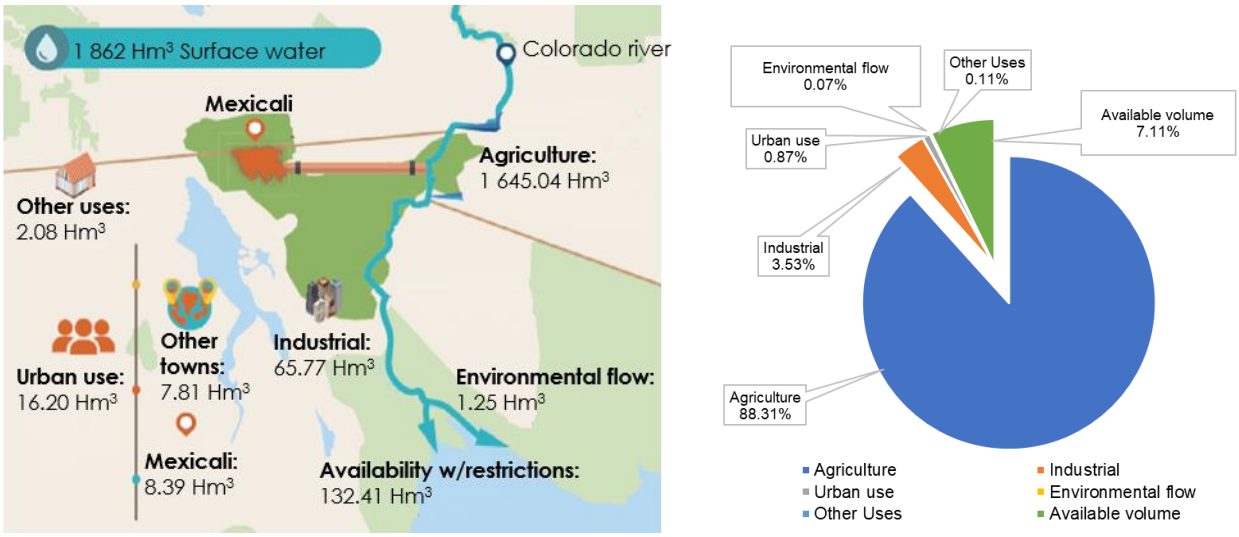

Figure 5.11 Distribution of surface water (Río Colorado) on the Mexican side.

5.2.4 Export of water from the Mexicali Valley to other Mexican cities

The transfer of water to other cities is defined by a total volume of 92.3 hm³ destined for urban public use for the municipalities of Tijuana, Tecate and Ensenada through the Colorado River - Tijuana Aqueduct (ARCT), of which 89.26 hm³ come from the aquifer of the Mexicali Valley and 3.04 hm³ from the San Luis Río Colorado Valley aquifer. These values contrast with those reported by the Baja California State Water Commission, which reports an average annual volume of 135.96 hm³ (Table 5.4). These inconsistencies point to the need for verification and monitoring of concessions in the region.

Table 5.4 Operation of the Rio Colorado-Tijuana Aqueduct.

Year	Total volume pumped ARCT (hm³)	Delivered Volume (hm³)		
		Tijuana	Tecate	Total
2013	117.09	109.39	6.02	115.40
2014	130.40	116.99	6.49	123.48
2015	137.85	118.90	6.84	125.75
2016	145.50	127.81	7.62	135.43

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Year	Total volume pumped ARCT (hm³)	Delivered Volume (hm³)		
		Tijuana	Tecate	Total
2017	148.96	127.50	7.38	134.88
Average	135.96	120.12	6.87	126.99

Water supply to the city of Mexicali

To supply water to the city of Mexicali, the Mexicali State Public Services Commission (CESPM) has an annual concession of 100.83 hm3, a volume of which 8.3% (8.39 hm³/year) is surface water (Colorado River) and 91.7% (92.44 hm³/year) corresponds to groundwater from the aquifers of the Mexicali Valley, the San Luis Río Colorado Valley and San Felipe – Punta Estrella. The distribution of this volume is shown in Figure 5.12, where the three main uses correspond to domestic, with 63.5% (64.04 hm³); operation of the supply system, with 16.8% (16.97 hm3); and commercial, with 7.9 % (8.01 hm³).

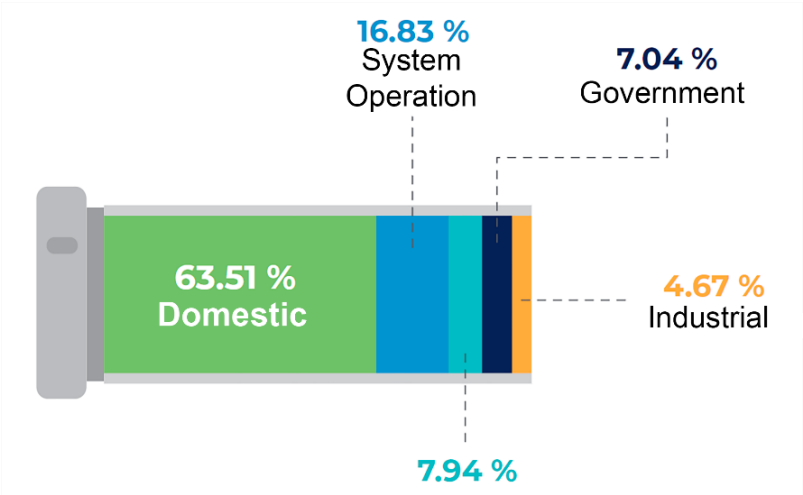

Figure 5.12 Distribution of water resources in the municipality of Mexicali

Source: (Instituto Mexicano de Tecnología del Agua, 2020)

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5.2.5 Water use in irrigation district 014 (DR 014)

Irrigation District 014 (DR 014) is the largest user of water in this region, characterized by its aridity and scarcity. In this sense, an analysis regarding the efficiency in the use of water is necessary. This district includes an irrigable physical area of 204,036 ha, in which an average of around 190,000 ha is irrigated, of which approximately 66% is irrigated with surface water and the remaining 34% with groundwater.

DR 014 is perhaps the only one at the national level that has a guaranteed water supply regardless of the climatic or drought conditions prevailing in the region, since, as seen in the previous section, the United States delivers 1,850.23 hm^3 annually.

DR 014 has an annual concession volume of surface water of 1,645.04 hm^3 from the Colorado River. Additionally, according to the REPDA, with a cut-off date of December 31, 2015, there is an annual volume of groundwater of 490.06 hm^3, coming from the Mexicali Valley aquifer, resulting in a total concession volume of 2,135.1 hm^3. It is important to note that this district has reported an average global efficiency[11] of 40.15 percent (IMTA, 2020).

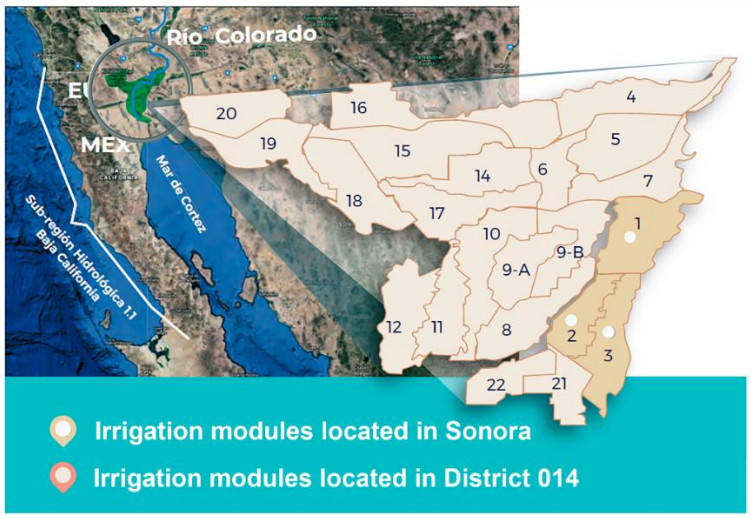

Figure 5.13 Irrigation District 014 Colorado River

Source: (Instituto Mexicano de Tecnología del Agua, 2020)

[11] It refers to an efficiency in the use of water. Specifically, it is an indicator of the conduction efficiency performance (Ec) of the irrigation districts and its relationship with the regulation systems and the capacity of the irrigation canals (Mauro et al., 2018).

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According to the Agricultural Statistics of the irrigation districts, published by the National Water Commission, in the last seven agricultural years, the sown and harvested area in DR 014 has decreased by 5.8%; agricultural production[12] has increased by 6.2%; and for its part, performance has increased by 12.8%, with respect to the data published at the beginning of the 2011 decade.

Table 5.5 Historical record of agricultural statistics in Irrigation District 014 Río Colorado.

Cycle	Surface (ha)		Production	Performance
	Sown	Harvested	(t)	(t/ha)
2011 -2012	181,701	181,701	3,071,180	16.9
2012 -2013	185,122	185,122	3,089,080	16.69
2013 -2014	184,909	184,909	2,948,725	15.95
2014 -2015	188,299	188,299	3,032,863	16.11
2015 -2016	193,203	193,203	3,077,866	15.93
2016 -2017	178,593	178,593	3,169,991	17.75
2017 -2018	171,135	171,135	3,262,486	19.06

Among the main crops are wheat grain and small onion (chives) in the autumn-winter cycle; green forage cotton and sorghum in the spring-summer cycle; alfalfa and bermudagrass (green grass), all year round. The six aforementioned crops together make up an average planted and harvested area of 164,003.55 ha, which represents 80.37% of the total area of DR 014 (204,036 ha). In order to review the efficiency in the use of water for the production of these crops, Table 5.6 shows the minimum and maximum water footprint by type of crop (the water footprint defines the total volume of fresh water used in the production of a crop in tons). This allows establishing reference volumes to contrast them with water.

[12] Agricultural productivity is measured as the ratio between production and factors of production.

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Table 5.6 Water footprint of the main crops of the Irrigation District 014 Río Colorado BC, according to international references

Crop	Water footprint[13] (minimum) m³/t	Water footprint (maximum) m³/t
Wheat	269	785
Small onion	108	345
Cotton	1 990	5 672
Green fodder sorghum	85	181
Alfalfa	166	955
Bermudagrass	80	250

(Chapagain et al., 2006; M. Mekonnen & Hoekstra, 2010; M. M. Mekonnen & Hoekstra, 2011)

The results in table 4 indicate that grain wheat (116.6 %), small onion (129.6 %), green forage sorghum (97.5 %) and green grass (146.7 %), produced in DR 014, they consume a greater volume of water when compared to that used with the maximum water footprint value necessary for their production.

5.2.6 Main issues

The Colorado River Basin is currently recognized as one of the most over concessioned in the world. This problem was identified in 1925 by the U.S. Geological Survey, Eugene Clyde La Rue, who warned that the construction of dams on this river would promote the use of all existing water concessions, which would result in a deficit regime. Thus, ignoring the scientific information at that time, the decisions that would result in the overexploitation that we see today in this basin were implemented on the U.S. side.

Based on the above, on the North American side of the river there is a hydraulic infrastructure that exports water from this basin to meet the water needs of cities located outside of it: Las Vegas, San

[13] The water footprint, is the human appropriation of fresh water, is an indicator both of the volume of water used to produce something, and of its origin: rainwater (green water footprint), surface and groundwater (blue water footprint), and polluted water (grey water footprint).

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Diego and Los Angeles. Additionally, the needs of irrigation districts also located outside the basin are covered: Imperial Valley and Coachella Valley.

Groundwater overexploitation has recently been detected by one of NASA's satellite missions (GRACE), which since 2002 has been monitoring changes in terrestrial water storage. In the case of the Colorado River, Castle et al., (2014) found that for the period 2005 - 2014, the Colorado River basin lost a total of 64,800 hm³ of groundwater. Basin-wide water losses are dominated by groundwater depletion, as shown in. Figure 4.9.

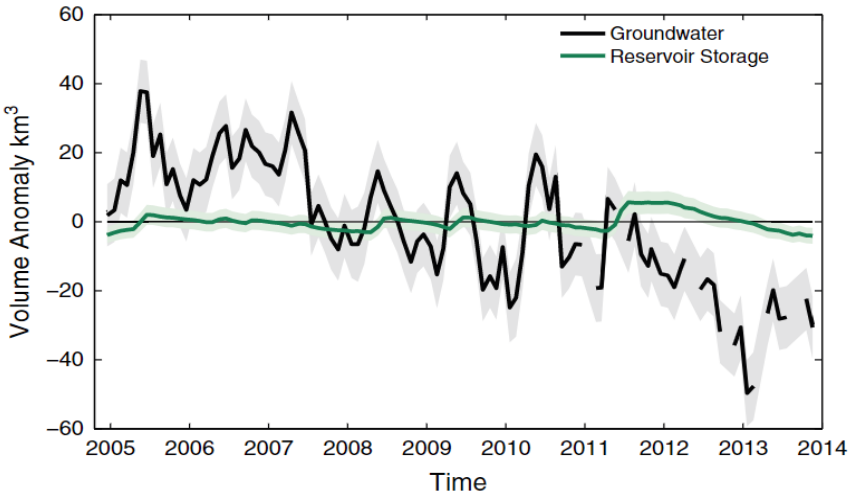

Figure 4.9 Changes in water storage in Colorado River Basin

Monthly groundwater storage (black) and surface storage (green) anomalies for the entire Colorado River Basin from December 2004 to November 2013.

The total water rights granted in the Colorado River basin is 21,586 hm³, while the registered annual volume is 19,735 hm³, so there is an over-concession of 1,851 hm³ of water only on the North American side, it is say, 8.6%. The distribution of the concessioned volume is regulated by an agreement between the North American states that make up the upper basin of the Colorado River, which corresponds to 9,251 hm³, and another agreement between the North American states that comprise the lower basin of the river together with Mexico, which together they have an assigned volume of 12,335 hm³.

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Table 5.7 Water concession between the states that make up, along with Mexico, the Colorado River basin.

Upper basin user	Volume (hm^3/year)	Lower basin user	Volume (hm^3/year)
Arizona	62	Arizona	3,454
Colorado	4,761	California	5,427
Nuevo Mexico	1,036	Nevada	370
Utah	2,019	Additional (generally used in California)	1,234
Wyoming	1,283	Mexico	1,850
Total	9,251	Total	12,335

Vulnerability to Climate Change

Climate change in the Colorado River Basin has altered rainfall and temperature patterns, affecting water availability. Recent studies reported that the flow of the Colorado River has decreased by 9.3 percent for each degree Celsius increase in temperature (Milly & Dunne, 2020). This is attributable to the decrease in snow levels and the consequent decrease in reflection of solar radiation. Numerical models, based on the RCP8.5 (Representative Concentration Pathway) scenario, conclude that river levels will drop between 19 and 31% by 2065, so a future with high risk of water scarcity is anticipated.

Anthropogenic alteration of the water cycle

The hydrology of the river is controlled by a series of dams and reservoirs that use the water for the economic development of cities inside and outside the basin, as well as the mentioned irrigation districts. The Colorado River basin has 48 large dams, of which 32 are in the upper basin, 16 in the lower basin, and only 15 of the totals are in the main current of the river. As a whole, this infrastructure is capable of storing between four and five times the annual flow of the river. The main dams are Hoover and Glen Canyon, which represent 95.45% (68,038.63 hm3) of the total storage of the main dams. To supply water to cities in the western United States, the following agreements are in place: pipelines: the Colorado-Big Thompson Project, which supplies 246 hm3 of water per year to eastern Colorado; the Colorado River Aqueduct, through which 1,480 hm3 of water is supplied per year to southern California, particularly to the cities of Los Angeles and San Diego, and the All American Canal, which carries an

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average of 428 m3/s of the Colorado River to support intensive agriculture in California's Imperial Valley and Coachella Valley.

5.2.7 Strategies for water sustainability

Given the conditions of water scarcity in the Mexicali Valley region, it is necessary to explore strategies that guarantee sustainability in the use of water in such a way that it is possible to guarantee the human right to water for the population and the social and economic development of the region.

As seen in this report, there is overexploitation of groundwater and documented competition for access to surface water among different users under the logic of guaranteeing the human right to water in the city of Mexicali. Therefore, the following measures are suggested:

1. Rehabilitation of the drinking water supply network

The volume granted for urban public use in the city of Mexicali guarantees the supply of approximately three times the current population of Mexicali, which indicates the need to improve the operation of this system, reduce leaks in this infrastructure and consider its expansion.

2. Modernization of irrigation infrastructure in Irrigation District 014

Improve the application of the irrigation sheet and the conduction of water within the district through the use of technology and precision agriculture. Given that agricultural use represents 85% of the total water in the region, a saving of 10% in this user represents a significant volume that can be used to guarantee the human right to water for future generations and the economic development of the region.

3. Data transparency

Due to the high level of socio-hydric conflict in the region, the transparency of the information related to the concessions of the different users, the transfers of water rights, as well as the corresponding discharges, is recommended.

4. Environmental sustainability

Adopt new investment standards that guarantee the fair and efficient use of water. Using for it:

- The water sustainability of the project, quantified through the water footprint

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- Water equity, establishing an equitable distribution of water between uses and users
- Water efficiency, defining threshold values per product related to the conditions
- Climatic of the region
- Water risk and climate change; the climate crisis will redefine the investments of large corporations globally

5.2.8 Opportunities for OpenET in Mexicali Valley

Based on the background, the description of the water problem in Mexicali Valley and the results obtained from the analysis of the interviews presented in chapter 7, some of the most relevant opportunities that OpenET platform has in this region are listed below:

- OpenET can provide free and public access to information throughout the year, which can contribute to the transparency of information in Mexico.
- Application of OpenET platform in the academic and research sector, on hydrological, climatic and ecological processes, and the consumptive use of water.
- OpenET can provide evapotranspiration information for water balances and serve as a tool for the development and restoration of ecosystems in the Colorado River delta.
- OpenET data can be supportive in the crop conversion process
- OpenET can influence to carry out better irrigation control and training of farmers
- OpenET can allow a more efficient planning of irrigation and harvests and its possible application in the modernization of irrigation and implementation of technological development.
- The ET information could help to adapt the hydro-agricultural infrastructure or in the creation of a new public policy in relation to water.

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5.3 Guanajuato

5.3.1 Location

The state of Guanajuato is located between the geographic coordinates to the north 21° 50' 22", to the south 19° 54' 46" north latitude; east 99° 40' 17", west 102° 05' 49" west longitude. The capital of the state is Guanajuato and borders to the north with Zacatecas and San Luis Potosí; to the east with Querétaro; to the south with Michoacán de Ocampo; to the west with Jalisco.

The state of Guanajuato has a total population of 6,166,934 inhabitants, which represents 4.9% of the national population. It has a land area of 30,606.7 square kilometers and a population density of 201.5 inhabitants per km².It is made up of 46 municipalities with 11,458 urban and rural localities, the municipalities with the largest population are: León with 1,721,215 inhabitants, Irapuato with 592,953 inhabitants and Celaya with 521,169 inhabitants.

72.5% of the state surface is land for agriculture, urban areas, areas without vegetation and dams or lagoons; the rest is covered by natural vegetation.

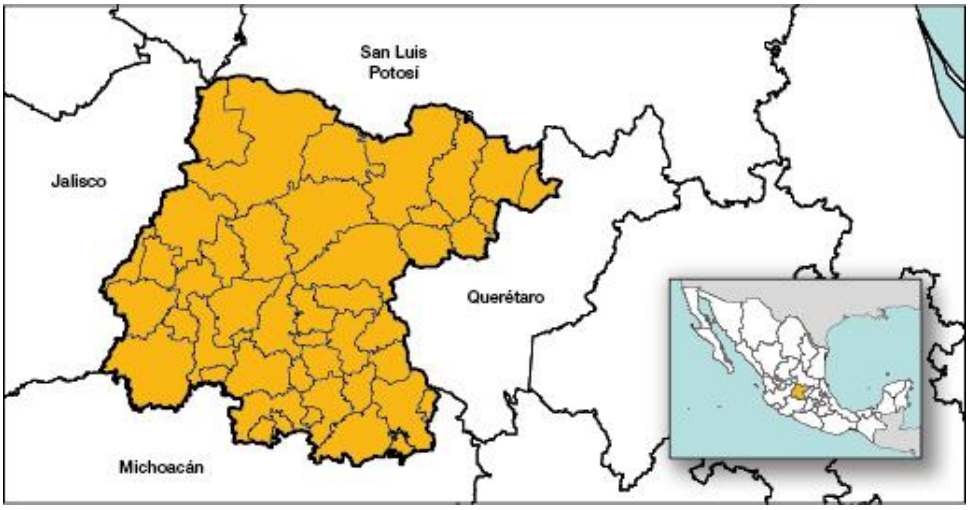

Figure 5.14 Location of the state of Guanajuato.

Source: INEGI, 2023

5.3.2 Surface and groundwater hydrology

Surface hydrology

The territory of the state of Guanajuato belongs to two Hydrological Regions: the Lerma-Santiago Hydrological Region (RH-12) whose waters flow towards the Pacific Ocean and the Pánuco Hydrological Region (RH-26). It also covers three basins: 78% corresponds to the Lerma River, 17% to the Pánuco River and the remaining 5% to the Santiago River.

- Hydrological Region 12 Lerma-Santiago

It basically comprises the Lerma-Chapala basin with 25, 382 km², which represents 83% of the state surface, and is integrated into 3 subregions of Lerma-Chapala, Alto Lerma, Medio Lerma or La Laja and Bajo Lerma; plus a portion of 1,836 km² of the upper part of the Alto Santiago basin.

The Lerma River enters the state territory of Guanajuato almost at the height of the Solís dam, practically where the “Medio Lerma subregion” begins, so it can be said that the state is located in the intermediate part of the basin, precisely where its Orographic and hydro-climatological conditions are more propitious for the use of its water resources, which explains the intense agricultural, urban and industrial development that has unfolded throughout this part of the basin.

The approximate length of the Lerma River from the Solís dam to Lake Chapala is 430 kilometers, of which 174 run within the state of Guanajuato, 152 border between the states of Guanajuato and Michoacán, and the last 104 kilometers correspond to the border between Michoacán Jalisco.

On its way through Guanajuato, the Lerma River receives the waters of the La Laja River between the Solís dam and the city of Salamanca, which drains the northeastern part of the basin. Also in this section are the main irrigation channels of the Bajío area, as well as the channel that artificially feeds the Yuriria lagoon. Later, between Salamanca and San Cristóbal, the Lerma River receives contributions from the Laja, Temascaltío Guanajuato and Turbio rivers on its right bank.

Subsequently, on the left bank, the confluence of the Angulo River is received, which is one of the main sources of that bank towards the Lerma River, which continues its course towards Yurécuaro,

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Michoacán, until it discharges 42 kilometers into Lake Chapala. after the hydrometric station that is located at the height of this town.

As it passes through Guanajuato territory, the Lerma River develops a hydrographic network that can be regionalized into ten hydrological basins, which correspond to the regionalization made by CONAGUA for the Lerma-Chapala basin.

- Hydrological Region 26 Pánuco

The Pánuco river basin belongs to the slope of the Gulf of Mexico, together with the Valley of Mexico, it is limited to the north by the hydrological basin of the Soto la Marina River and the El Salado region; to the west by that of Lerma; to the south by the Balsas River and to the east by the Tuxpan, Cazones and Tecolutla rivers, the surface it occupies is 84 thousand 956 square kilometers.

The Pánuco River receives contributions from numerous streams that originate and flow through the eight federal entities and covers 3,371 square kilometers of the state of Guanajuato; about 17% of the state surface in a single subregion: Alto Pánuco (26B), whose hydrographic network in the state extends into two hydrological sub-basins: Santa María and Extóraz.

The Santa María river is born to the north of the state, 14 km. southeast of the town of Ocampo. It begins its trajectory heading northeast where it receives the Altamira River on the left bank, at this confluence is where it takes the name of Santa María and continues until it reaches the town of Santa María del Río in San Luis Potosí (SLP). Then it changes its trajectory to the southeast advancing through the southern part of SLP to later enter the state of Guanajuato north of the municipality of San Luis de la Paz, maintaining a trajectory parallel to the state limits between Guanajuato and SLP, until entering the state of Querétaro, where it crosses the Sierra Gorda. Within Queretaro territory, it once again changes its trajectory to the northeast, now serving as the natural boundary between SLP and Querétaro until it meets the Verde River and later forms the Tampaón River.

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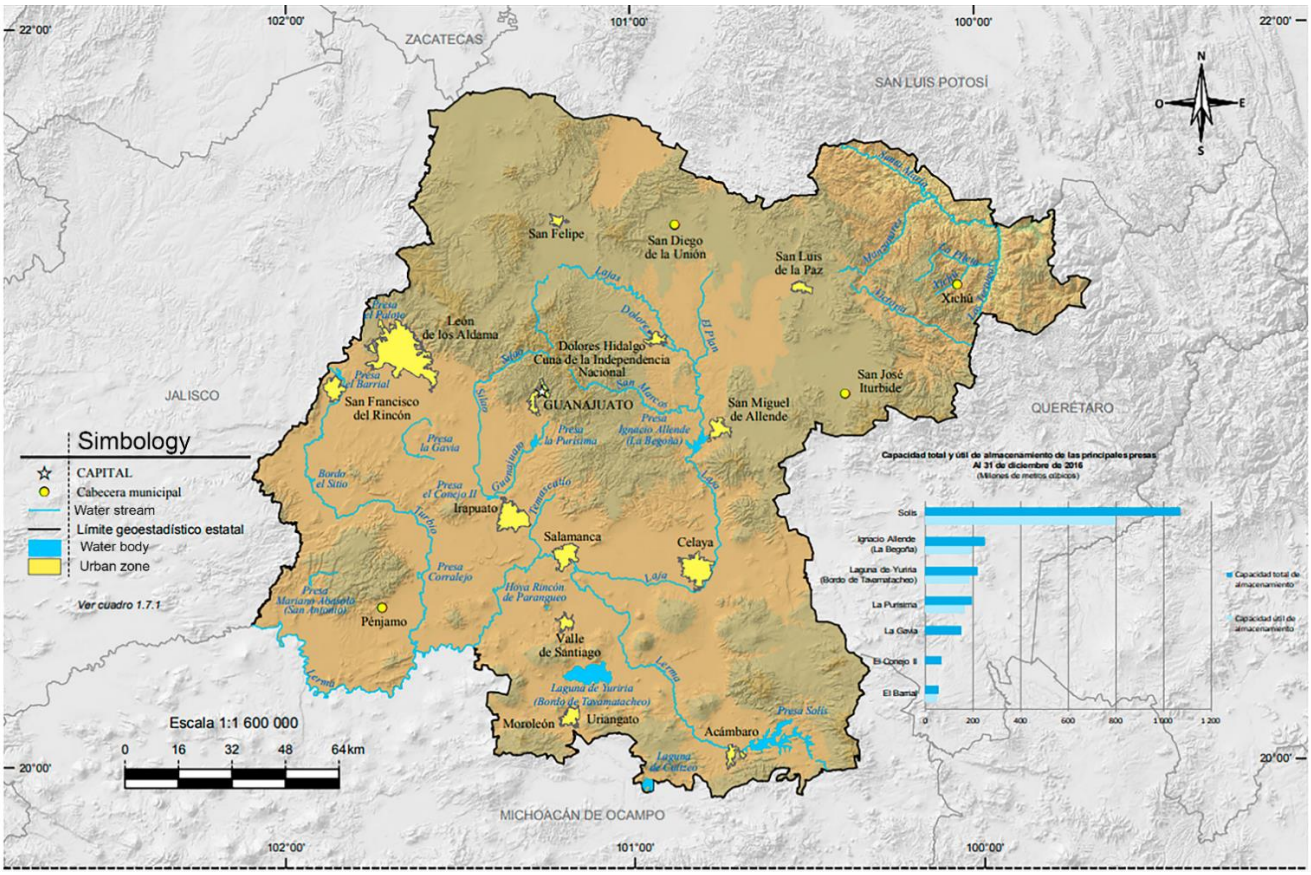

Figure 5.15 Currents and surface water bodies

Source: INEGI, 2017

Groundwater hydrology

Groundwater represents the main source of supply in the state of Guanajuato. CONAGUA has established through an agreement a unique denomination for the aquifers of the Mexican Republic with an official character for the granting of concession, assignment and/or permit titles. For the state of Guanajuato, under these criteria, 18 aquifers have been defined within its territory and two more shared with the state of San Luis Potosí.

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Figure 5.16 Aquifers in the state of Guanajuato

Source: Comisión Estatal del Agua de Guanajuato, (2023)

Based on the regionalization of the entity's groundwater, reconciled in correspondence with the delimitation of the aquifers established by CONAGUA for Guanajuato, the Guanajuato State Water Commission (CEAG) with information derived from the studies carried out, prepared a balance hydraulic for each of the years 1998-2004 (except 2003).

The general balance of the aquifers indicates that from 1998 to the year 2000, the deficit gradually increased, and then it gradually decreased until reaching a deficiency of 1,126 Hm^3 in 2004.

The current conditions of use and exploitation of groundwater force us to continue looking for mechanisms for the application of policies that allow balancing the aquifers in the state.

5.3.3 Water demand

The development of the State of Guanajuato has occurred around specific sites and activities, highlighting the agricultural sector for its preponderance and relevance with respect to other sectors. Based on this, CONAGUA reports that the largest volume of both surface and underground water is used for said sector, which represents approximately 80%. The figure shows the graphs of the distribution of concessioned volumes for both surface and groundwater.

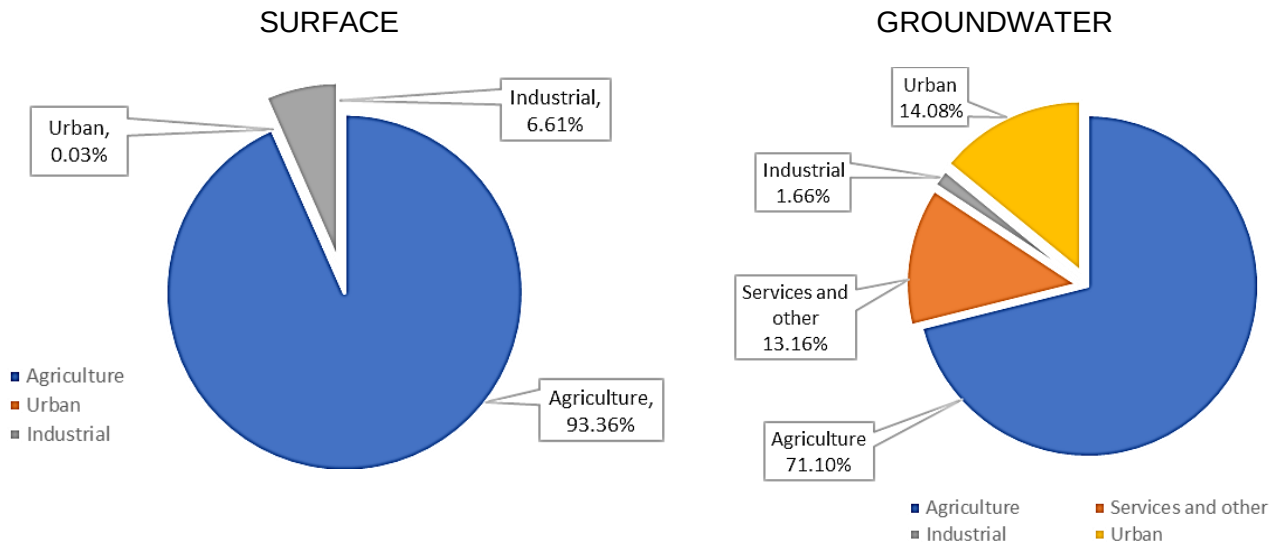

Figure 5.17 Distribution of concession volumes by supply sources and sector in Guanajuato

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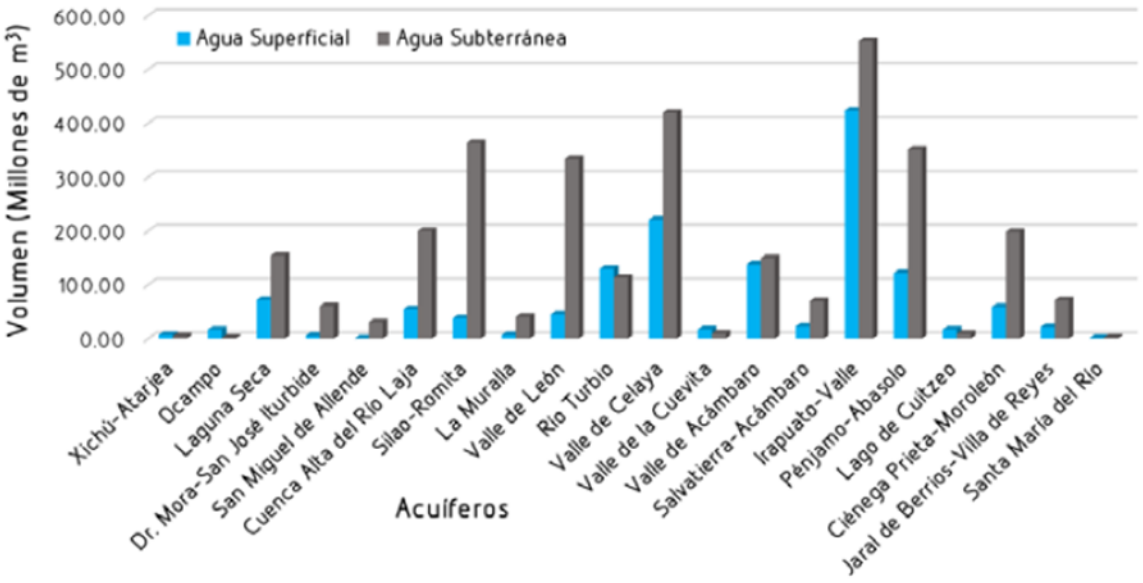

Figure 5.18 Concessioned volumes by aquifer in Guanajuato

Source:

Regarding the volumes concessioned in the State of Guanajuato; According to CONAGUA, there is a total concession volume of 4,556.50 million m³, of which 31.16% corresponds to surface water and the remaining 68.84% to groundwater.

Urban and rural public use

The demand for domestic use depends fundamentally on three factors: the population (the number of users), the provision of water by type of user (the net water requirement for each user) and physical losses (the percentage of water lost due to leaks). For a better approach to the real demands of this sector, the demands of rural areas (towns with less than 2,500 inhabitants), medium urban populations (2,500 to 19,999 inhabitants) and large cities (greater than 20,000 inhabitants) were considered separately, in order to take into account for the latter the number of users by size of the locality, the prevailing climate, as well as the socioeconomic composition in particular, as well as the percentage of physical and commercial losses that affect the level of service of the localities.

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Agricultural use

Data from the 2005 agricultural year, published by the Secretary of Agricultural Development of the State of Guanajuato (SDA), indicate that a total of 1,074,190 hectares were planted in the state; 49.9% in irrigated areas and 50.1% rainfed. The total registered production was 8.54 million tons, reaching an estimated value of 9,845, 000, 000 million pesos.

Irrigated agriculture covers more than a fifth (21.34%) of the state surface, registering an average of 493, 000 hectares per year between 1997 and 2005. It is located mainly in the Lerma River basin, and in small areas in the flood of the Laja river. The greatest use of surface water for agriculture in the state occurs in the Lerma Chapala basin through the Irrigation Districts 011 Alto Lerma and 085 La Begoña.

According to information from the SDA, during the spring-summer and autumn-winter cycles of 2005, 472,515 hectares were planted. The most representative crops in terms of planted area were: sorghum (26%), corn (25%), wheat (23%), barley (9%) and to a lesser extent: broccoli, beans, fodder oats, onion, green chili. and carrots, which together represented 10% of the surface.

On the other hand, during the 2005 agricultural year, 63 thousand 417 hectares of perennial crops were planted. The main perennial crops according to the planted area were: alfalfa (87%), asparagus (5%). pastures and meadows (3%) and strawberries (2%).

Overall, during the 2005 agricultural year, the planted irrigated area reached 535,932 hectares, with a total production of 8.2 million tons and an estimated production value of 9,273 000 000 pesos.

It is estimated that in the state the overall irrigation efficiency is 36%. Using a 90 cm sheet for annual crops where grains predominate and 130 cm for perennial crops where alfalfa is the most representative crop.

The estimated theoretical demand for irrigation water in 2005 was 5,133 Hm^3/year.

Livestock use

It is estimated that in the state there is a surface of one million 387 thousand 706 hectares dedicated to livestock activity, divided as follows: 22.3% of low deciduous forest; 37.0% grassland: 16.7% scrub and

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24.2% forest. Livestock production in the state is concentrated in raising cattle, due to the advantages offered by the Bajo area in terms of forage availability and cost.

To obtain the demand for livestock use, CONAGUA has estimated the water allocations according to each type of livestock.

Based on the number of heads registered by type of livestock by municipality and with the endowment values, the total demand for livestock use is estimated at 42.35 Hm^3/year.

Industrial use

The industrial sector, as a user of water in Guanajuato, uses between 1 and 2% of the total volume according to REPDA data; while this sector generated 26.6% of GDP in 2003.

The results of the last economic census carried out by INEGI showed that a total of 731,350 people is employed in the entity in 22 sectors and 83 subsectors into which economic activity is divided. In the manufacturing industry, 223 thousand 352 people were employed, 30.5% of the total. and within this, the subsectors corresponding to food, textiles and leather products concentrated 55% of the employed personnel.

5.3.4 Main issues

The state is divided into 20 aquifers in accordance with the delimitation established by the National Water Commission, CONAGUA, from which 94 percent of the water allocated for the supply of the population comes, where the main use of water is agricultural, which generates an imbalance in the aquifers. According to the results of the piezometric monitoring of the aquifers carried out by the Guanajuato State Water Commission, CEAG, for 2019 a deficit of 925 cubic hectometers was observed.

According to the results presented in the State Hydraulic Plan of the state of Guanajuato, it was found that there is a deficit in 19 of the 20 aquifers, Xichú-Atarjea being the only one that is in balance. Another relevant aspect was that the deficit reported in the DOF is 484.45 million m^3 lower than that calculated in the Plan. The following table shows the comparison between both balances (official and calculated), as well as the status of each of the aquifers.

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Table 5.8 Balances de agua subterránea por acuífero en Guanajuato. CEAG

CLAVE	NOMBRE	BALANCE DOF (Miles de m3)	BALANCE PROPIO (Miles de m3)	ESTATUS DOF	ESTATUS ANÁLISIS PROPIO
1101	Xichú-Atarjea	4,160.18	200.01	Disp.	Disp.
1103	Ocampo	4,575.79	-5,867.93	Disp.	Deficit
1104	Laguna Seca	-26,056.63	-74,277.43	Deficit	Deficit
1106	Dr Mora-San José Iturbide	-21,906.92	-57,617.28	Deficit	Deficit
1107	San Miguel de Allende	-8,469.73	-20,938.50	Deficit	Deficit
1108	Cuenca Alta del Rio Laja	-60,248.89	-119,610.87	Deficit	Deficit
1110	Silao-Romita	-120,200.00	-140,184.68	Deficit	Deficit
1111	La Muralla	-10,877.06	-51,145.99	Deficit	Deficit
1113	Valle de León	-177,673.45	-49,596.74	Deficit	Deficit
1114	Ro Turbio	-3,334.58	-38,912.34	Deficit	Deficit
1115	Valle de Celaya	-132,875.80	-204,880.66	Deficit	Deficit
1116	Valle de la Cuevita	-4,246.13	-6,640.99	Deficit	Deficit
1117	Valle de Acámbaro	-47,200.00	-25,234.37	Deficit	Deficit
1118	Salvatierra-Acámbaro	-41,589.06	-60,654.08	Deficit	Deficit
1119	Irapuato-Valle	-162,537.71	-331,533.96	Deficit	Deficit
1120	Pénjamo-Abasolo	-126,361.65	-178,034.83	Deficit	Deficit
1121	Lago de Cuitzeo	-2,200.00	-11,469.65	Deficit	Deficit
1122	Ciénega Prieta - Moroleón	-122,100.00	-113,688.14	Deficit	Deficit
2412	Jaral De Berrios-Villa De Reyes	-1.54	-28,899.84	Deficit	Deficit
2417	Santa María Del Rio	-1,677.33	-26,285.78	Deficit	Deficit
	Total	-1,060,820.49	-1,545.274.04		

Based on the disparity found in the global balances of water availability for each of the aquifers, a comparison was made between the output volumes that were calculated for the State Hydraulic Plan and those reported in the Official Gazette of the Federation.

The following figure shows the very marked difference between the volumes extracted and reported for some of the aquifers; Such is the case of Irapuato-Valle, Valle de Celaya, Pénjamo-Abasolo and the upper basin of the Laja River.

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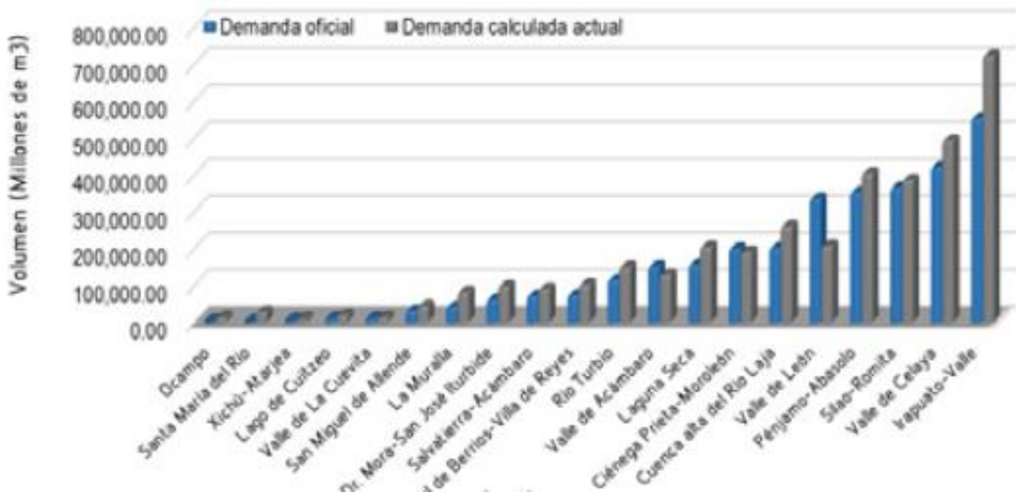
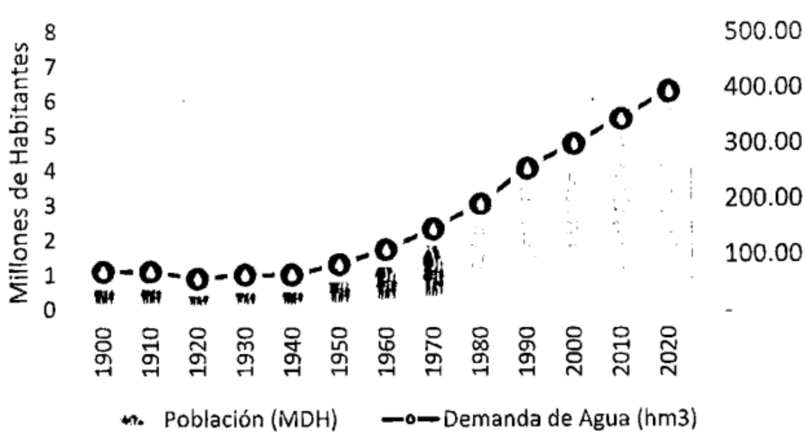


Figure 5.19 Comparative graph between volumes of official demand and those calculated by aquifer in Guanajuato

State dynamics and demographic growth mean that Guanajuato is facing an overexploitation of its aquifers and alterations in the hydrological functioning of its basins. According to the 2020 Population and Housing Census, published by INEGI, the state has 6.16 million inhabitants, who demand approximately 394 Mm³, which has caused a water liability in both groundwater and surface water.



Año	Demanda de Agua (hm³)
1900	70.26
1910	70.26
1920	57.49
1930	63.88
1940	63.88
1950	83.04
1960	108.59
1970	146.91
1980	191.63
1990	255.50
2000	300.21
2010	344.93
2020	371.60

Figure 5.20 Growth in water demand for the state of Guanajuato

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The population has moved to urban centers, which do not necessarily have a regularization of the occupied territories. While in rural areas the settlements that do not have services are small and dispersed communities, which means that per capita investment is high, with increasingly complex projects, where alternatives to conventional forms of supply must be sought.

The consumption of water, on the other hand, leads to the production of wastewater.

- During 2019, in Guanajuato, 250 cubic hectometers of wastewater were generated, of which 123 were treated.

All this wastewater generated by the population must be evicted, to later lead it through collectors and emitters to a final disposal point. Ideally, the end point of the drainage should be a wastewater treatment plant to avoid impacts on the environment.

Derived from climate change, there are more and more risks due to hydrometeorological disasters. In this sense, for Mexico the prospect is for pronounced heat waves for most of the national territory, particularly in the central and northern zone, that is, a severe increase in temperature with the consequent droughts.

In addition, it affects precipitation regimes, alters runoff patterns, generates vulnerability to populations and productive sectors, particularly those of the primary, agricultural sector.

- During 2020, in the state of Guanajuato, the precipitation value was only 74 percent of the historical average. As of June 15, 2021, 47.8 percent of the municipalities were in a severe drought level.

In these periods the consumption of water intensifies, which, combined with the lack of control in the extractions in the aquifers, contributes to the overexploitation of the resource. The foregoing, without counting the changes in the quality of the extracted water, given that a greater depth of extraction can generate the presence of materials unfit for human consumption.

In this way, it can be observed that at a global level, there is a serious problem in terms of water coverage due to the lack of infrastructure and concessioned volumes that can supply water to the different population centers in an equitable and rational manner. Guanajuato state.

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5.3.5 Strategies for water sustainability

In the state of Guanajuato, work is being done to strengthen the sustainable management of water resources through the following objectives:

Table 5.9 Strategies for water sustainability for the State of Guanajuato

OBJECTIVE	GOAL	LINE OF ACTION
Improve the conditions for the use of water resources in the state of Guanajuato	-Achieve a micro measurement coverage of 90.83% in water operator systems.[14] -Maintain at 72.50% the commercial efficiency of water utility agencies.	-Develop a work program for drinking water, drainage, sanitation and reuse in rural and urban areas. -Develop manuals for the Integral management of water systems. -Develop guidelines, formats and stages to formalize the declaration of protection of recharging zones.
Strengthen the sustainable and balanced management of water in the state territory	-Maintain the annual groundwater deficit below 978 hm3. -Achieve that 20.20% of agricultural production units are trained or assisted in irrigation techniques[15].	-Keep groundwater and surface water balances updated. -Monitor the hydrological cycle and water quality. -Develop the state program of Water Culture by sectors -Promote the modernization and modernization of state agricultural land.
Promote timely attention to extreme weather phenomena	-Assist with water supply actions to 80% of the municipalities identified as vulnerable to drought.	-Issue forecasts and early hydrometeorological alerts. -Implement a care program for hydrometeorological phenomena.

[14] It refers to increasing coverage in the measurement of water consumption by users so that these records are the basis for billing them for a service such as water supply.
[15] This refers to a goal that the state has regarding the sustainable use of water.

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5.4 Lagunera region

The Comarca Lagunera represents a desert space, lacustrine today dried up, confined in the center-north of the Mexican Altiplano, within the biogeographic region known as the Chihuahuan Desert and at the confluence of the states of Coahuila and Durango (Figure 5.21). The natural conditions are apparently inhospitable, since they oscillate between arid and semi-arid; however, it is a space that has achieved significant social and economic development despite the precarious environmental conditions caused by water scarcity, which has led to the implementation of complex natural resource management strategies. Despite the limitations of the environment, Comarca Lagunera is one of the most important regions in the north of the country, due to the fact that close to 50% of the milk consumed in Mexico comes from this area; although the environmental costs that sustain this economic boom have degraded the quality and quantity of basic natural resources.

Currently, in the main urban and rural localities of the Comarca Lagunera, the groundwater from the "Principal - Lagunera Region" aquifer is the predominant source for drinking water supply, however, this aquifer has a status of overexploitation according to CONAGUA; and this is one of the main reasons why the Federal Government has implemented the “Agua Saludable para la Laguna” (Healthy Water for the Lagoon) program, where alternatives are sought to continue providing this public service without running out of resources (López López & Sánchez Crispín, 2009).

In the Hydrological Region 36 Nazas - Aguanaval, the "Agua Saludable para la Laguna” (Healthy Water for the Lagoon) project is strategic, whose objective is to provide arsenic-free water to the inhabitants of the Comarca Lagunera, a metalloid that has been present for several decades. Around this project, it will be necessary to link the modernization strategies of the operating agencies, the ordering and rescue of overexploited aquifers (preferably the Principal aquifer - Lagunera Region), the resizing of the Irrigation District 017, the strengthening of actions conservation of the Nazas River basin and the culture of sustainable water use (CONAGUA, 2021).

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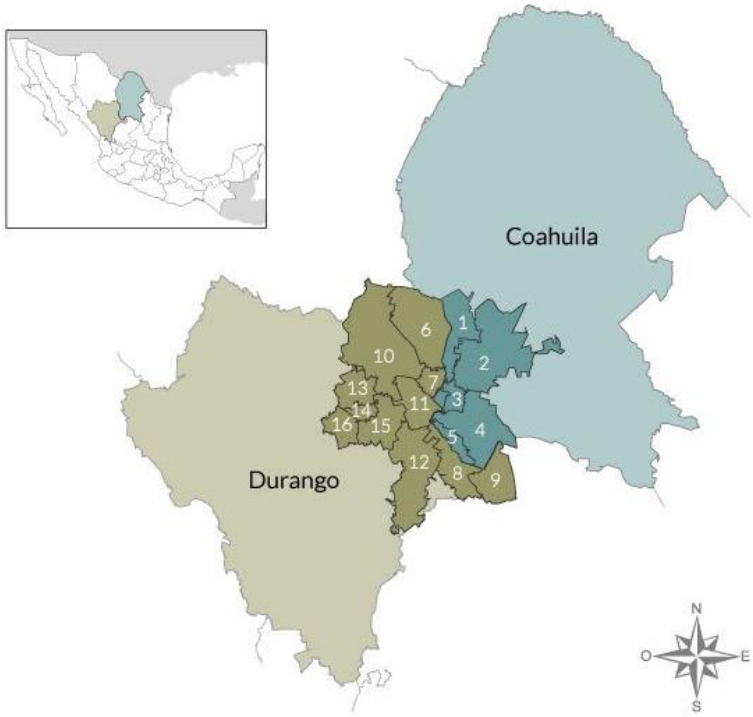
5.4.1 Location

The Comarca Lagunera is located in the north-central part of Mexico and, according to the Economic Development of La Laguna, it is made up of 16 municipalities (5 in the State of Coahuila and 11 in the State of Durango, Figure 5.21).



Comarca Lagunera de Coahuila	Comarca Lagunera de Durango	
1. Francisco I. Madero	6. Tlahualilo	12. Cuencamé
2. San Pedro	7. Gómez Palacio	13. San Pedro del Gallo
3. Matamoros	8. Gral. Simón Bolívar	14. San Luis del Cordero
4. Viesca	9. San Juan de Guadalupe	15. Nazas
5. Torreón	10. Mapimí	16. Rodeo
	11. Lerdo	

Figure 5.21 Location of the Comarca Lagunera in the limits of the States of Durango, Coahuila, Chihuahua and Zacatecas

Source: https://factorcoahuila.com/comarca-lagunera-que-municipios-conforman-la-laguna-y-cual-es-la-importancia-de-la-zona/

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The Lagunera region is part of the Administrative Hydrological Region VII (RHA VII) Northern Central Basins (CCN), which includes the states of Coahuila, Durango, San Luis Potosí and Zacatecas; and belongs to the Hydrological Region 36 Nazas-Aguanaval (Figure 5.24).

The Laguna metropolitan area is located in the Lower Basin of the Nazas and Aguanaval Rivers, which is made up of the cities of Torreón, Matamoros and Franciso I. Madero in the state of Coahuila; and Gómez Palacio y Lerdo in the state of Durango (CONAGUA, 2021). La Laguna covers an area of 7,889 km² with a population of 1,434,283 inhabitants, being 30% of the RHA VII.

5.4.2 Surface and groundwater hydrology

La Laguna belongs to Hydrological Region 36 (RH 36), where adverse climatic and orographic conditions determine an arid-semi-arid climate, with strong seasonal variations and little rainfall, concentrated in the months of July, August and September, ranging from 200 mm per year in the lower part of the basin (where most of the agricultural area is located) to 600 mm in the upper part of the basin (located in the Sierra Madre Occidental), in which the most significant rainfall occurs, generated by surface runoff used for agricultural irrigation (López López & Sánchez Crispín, 2009).

From the hydrological point of view, it corresponds to the Comarca Lagunera-Parras subregion, made up of the lower-middle basin of the Nazas and Agua-naval rivers, including the discharge zone towards the Mayrán and Viesca lagoons (today dry). Due to the fact that they are closed basins, the currents in the area are ephemeral, short-lived and do not reach the lagoons.

Surface Hydrology

The main element of the hydraulic system of the Lagunera region is made up of the runoff from the Nazas and Aguanaval Rivers (Figure 5.22). In the main basin is the Lázaro Cárdenas - El Palmito Dam (Figure 5.23), located in the Nazas River basin, with an average annual runoff of 1150 hm³ (4.061 187 $\times 10^{10}$ [ft³]), with a very irregular regime.

The Nazas River discharges its waters into the Lázaro Cárdenas Dam; it is formed by the confluence of the Ramos and Sextín rivers; In this area, the Francisco Zarco Dam (Las Tórtolas or El Palmito) was built in the vicinity of the town of El Palmito, located to the southwest of the main aquifer, on the border

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with Pedriceña-Velardeña. Later, in its course towards its lower basin, the San Juan, Peñón and Cuencamé streams join it on its right bank, changing course towards the old Lagoon, today the Mayrán Desert, passing through the cities of Lerdo, Gómez Palacio, state from Durango and Torreón, state of Coahuila (CONAGUA, 2020). On the route between the Francisco Zarco dam and the city of Torreón, a particular hydrographic condition is observed, in which short tributaries with a reduced basin and little contribution stand out towards the left bank; in contrast to the tributaries of the right bank, of greater extension and magnitude, and contributions of more significant surface runoffs.

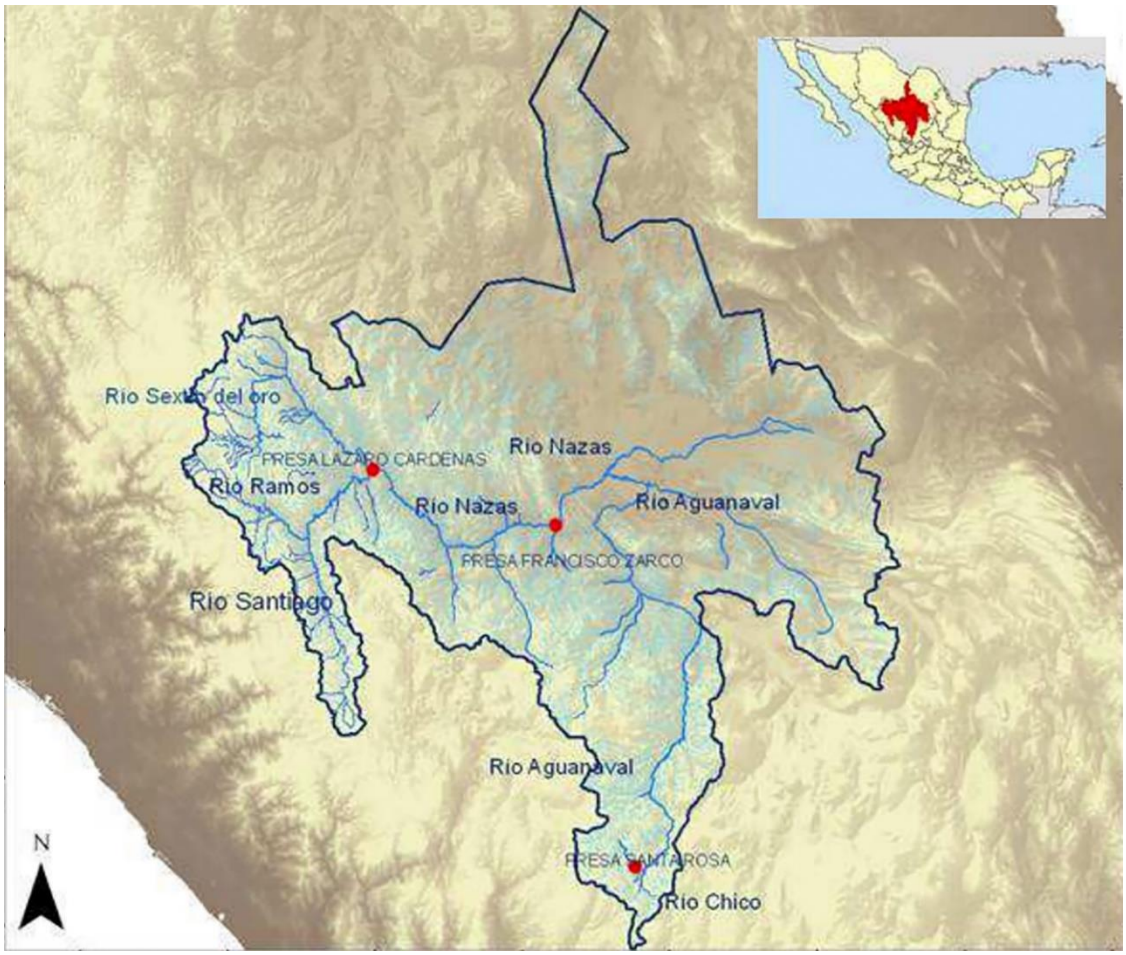

Figure 5.22 Rivers of the Nazas - Aguanaval basin

Source: (Programa Nacional Contra la Sequía, 2014)

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The Aguanaval River originates to the west of the city of Zacatecas with the union of the Saín Alto and Trujillo rivers, it flows in a general south-north direction, passing through the towns of Río Grande and San Francisco, Zacatecas; further north it represents the state border between Durango and Coahuila, to later reach the Laguna de Viesca area, in Coahuila, where its route ends. Its most important tributaries are the Santa Clara, San Francisco, Zaragoza, Tetillas, Calabacillas and Santa Clara rivers, all of them in the state of Zacatecas.

Figure 5.23 Presa Francisco Zarco "El palmito" sobre el río Nazas en el Estado de Durango.

The runoff regime towards the Lázaro Cárdenas - El Palmito Dam is concentrated and stored between the months of July and October of each year. With this, it is possible to sustain the agricultural irrigation cycles of each year, which begin in March and end in July.

Groundwater hydrology

The Principal-Región Lagunera aquifer, defined with code 0523 in CONAGUA's Geographic Information System for Groundwater Management (SIGMAS), is located in the extreme southwest of the state of Coahuila (Figure 5.24), on the border with the state of Durango, between parallels 25°00' and 26°45'

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north latitude and between meridians 102°15' and 103°50' west longitude, covering an approximate area of 12,617 km².

The aquifer belongs to the “Nazas-Aguanaval” Hydrological Region No. 36, “Río Nazas” Hydrological Subregion, “Río Nazas-Torreón” basins, “Laguna de Mayrán y Viesca” and Río Aguanaval”; sub-basins “Río Nazas-C. Santa Rosa”, “Laguna de Mayrán”, “Laguna del Rey” and “Río Aguanaval-Nazareno”. Regionally, the most important rivers are the Nazas, which originates in the state of Durango, and Aguanaval, which originates in the state of Zacatecas, towards which most of the surface runoff flows. The Principal-Lagunera Region aquifer is located in the lower basin of both rivers.

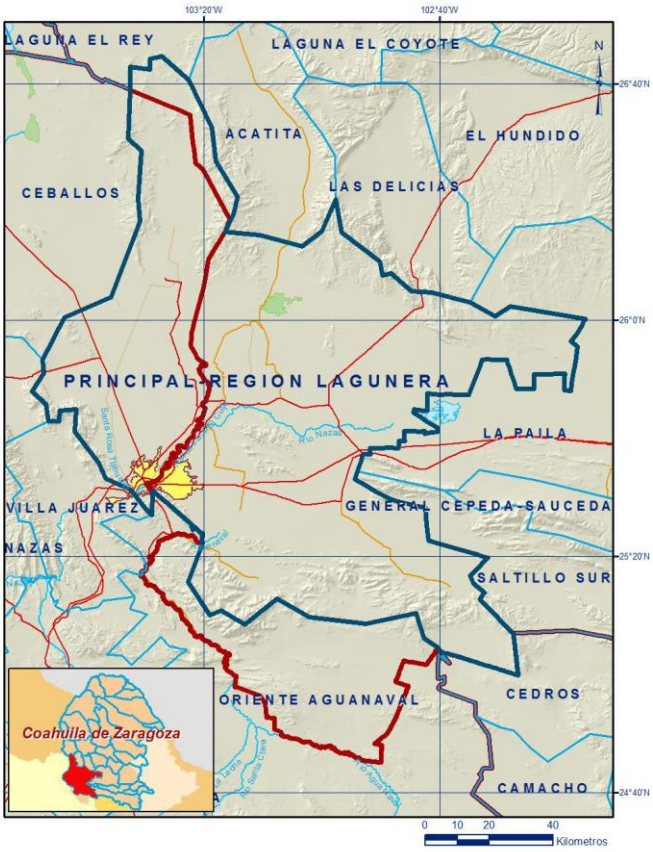

Figure 5.24 Location of the Principal Aquifer Region Lagunera.

Source: (CONAGUA, 2020)

The Principal-Lagunera Region aquifer belongs to the Basin Organization VII "Central Basins of the North" and to the Nazas-Aguanaval Basin Council, installed on December 1, 1998. Almost all of its territory is prohibited and subject to the provisions of two prohibition decrees for the extraction of underground water. In most of the central, northern and western portions, the "Decree establishing an indefinite ban on the supply of subsoil water in the areas of Ceballos and La Laguna, which will include part of the States of Chihuahua, Durango and Coahuila", published in the Official Gazette of the Federation (DOF) on December 6, 1958. This decree establishes a type II ban, in which the capacity of the aquifers only allows extractions for domestic uses. In the eastern, southern and southeastern portion, the "Decree establishing a ban on the supply of subsoil water in the Lagunera Region" is in force, published in the DOF on April 17, 1965. This ban is type III, in which the capacity of the aquifers allows limited extractions for domestic, industrial, irrigation and other uses (CONAGUA, 2020).

5.4.3 Water demand

In La Laguna, all uses of water are considered consumptive, since there is no hydroelectric generation, while aquaculture and recreation are insignificant in relation to other uses (López López & Sánchez Crispín, 2009).

The main user of groundwater is agriculture, in its territory most of Irrigation District 017 "Lagunera Region" is located; the users are organized and constituted in the Groundwater Technical Committee (COTAS) of the Main Aquifer of the Comarca Lagunera, A.C., installed on September 5, 2000.

As of January 2014, the Nazas-Aguanaval Basin Council has a total of 14,980 concession titles, of which 2,751 correspond to surface water and 12,229 to groundwater. Within the scope of the basin, the state of Coahuila has 2,979 surface and underground titles, while Durango has 6,716, and Zacatecas 5,285 concessions. The highest percentage of concession titles is for agricultural use with 35.91%. It is followed by urban public use and livestock with 34.33% and 13.74% of the titles respectively (National Program Against Drought, 2014). The rest of the concession titles are distributed in industrial, domestic, aquaculture, services and other uses.

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The extraction volumes granted for the Nazas-Aguanaval Basin Council are 1,207.25 hm³/year for surface water and 1,288.27 hm³/year for groundwater. Within the scope of the Nazas-Aguanaval Basin Council, the surface and underground concessioned extraction volume for Coahuila is 1,139.13 hm³/year, for Durango 943.79 hm³/year and for Zacatecas 412.60 hm³/year (Table 2.3). As for the number of concessions, the highest volume of extraction corresponds to agricultural use with 84.81% followed by urban public use with 8.06% and multiple uses with 4.90%. The rest of the concessioned extraction volume corresponds to industrial, livestock, services, domestic and aquaculture uses (Programa Nacional Contra la Sequía, 2014).

Table 5.10 Total volume of extraction concessioned from the Nazas-Aguanaval basin by Federal Entity, source and use of water

State	Water source	Water uses (hm³/year)								
		Agriculture	Domestic	aquaculture	services	industrial	livestock	urban public	multiple	Total concession volume
Coahuila	Surface	631.500	0.000	0.000	0.000	0.000	0.155	0.227	0.013	631.90
	Groundwater	324.014	0.346	0.000	0.789	11.710	5.980	109.570	54.823	507.23
Durango	Surface	485.256	0.000	0.734	0.258	0.083	1.669	3.407	0.505	491.91
	Groundwater	303.610	0.222	0.000	0.564	16.550	8.368	61.809	60.753	451.88
Zacatecas	Surface	81.794	0.000	0.011	0.038	0.240	0.043	1.098	0.221	83.45
	Groundwater	290.173	0.222	0.000	0.072	6.950	0.735	25.010	5.995	329.16
Total General	Surface	1198.55	0.00	0.75	0.30	0.32	1.87	4.73	0.74	1207.25
	Groundwater	917.80	0.79	0.00	1.43	35.21	15.08	196.39	121.57	1288.27

Data from the offices of the Public Registry of Water Rights (REPDA) of the Northern Central Basin Basin Organization, January 2014

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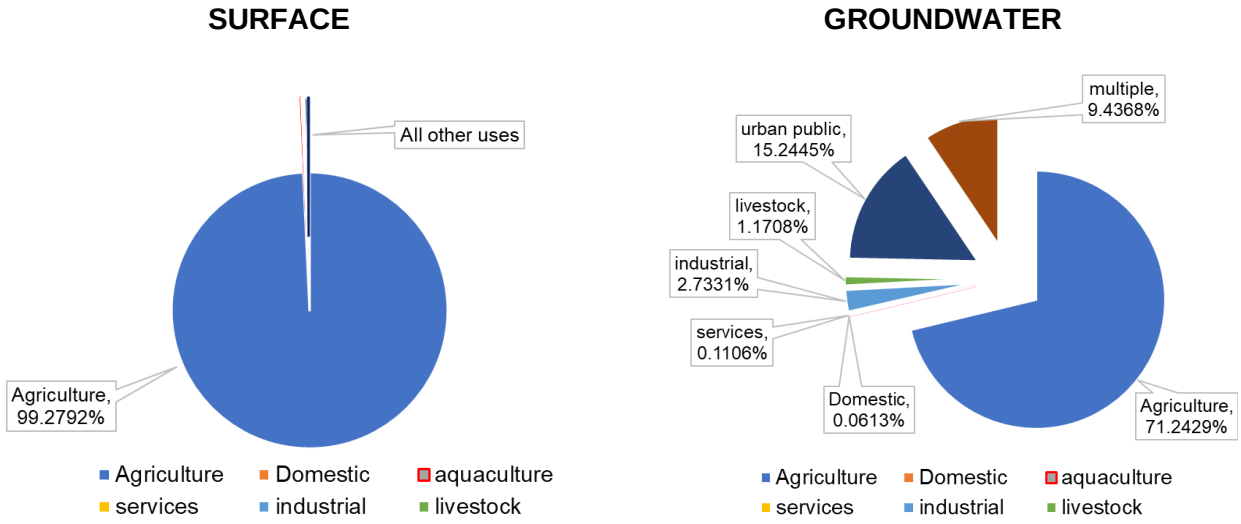

Figure 5.25 Distribution of concession volumes by supply sources and sector in Nazas-Aguanaval basin.

5.4.4 Main issues

The absence of rain has led to the overexploitation of groundwater, causing its overexploitation in the region; which has resulted in depletion effects and loss of water quality in the Principal-Lagunera Region.

The average annual availability of groundwater in the Principal-Lagunera Region aquifer, key 0523, is nil and presents a deficit of 149,045,850 cubic meters per year, therefore there is no available volume to grant concessions or assignments (CONAGUA, 2020).

Water quality

The origin of the arsenic present in the Comarca Lagunera is attributed to geological processes that have acted in at least a period of 60 million years and these are: erosion and dissolution of the surrounding volcanic and sedimentary rocks, being transported by fluvial currents in solution, suspension and content in the sediments and deposited within the endorheic basin that makes up the Mayran Lagoon, other minor factors that contribute arsenic are hot springs, which have been concentrating largely due to the intense evaporation of water

In Mexico, in 1958, it was recognized that the Comarca Lagunera is an area with chronic hydroarsenicism, a time when the first effects on health became visible, which manifested as skin, liver,

gallbladder, prostate, bladder and lung disease, as well as black foot disease, sterility, and miscarriages. The first epidemiological studies were carried out in the 70s and 80s, concluding that these were mainly due to the consumption of water with high arsenic content. The National Water Commission, for its part, determined that arsenic concentrations in water exceed 300 micrograms per liter, when the World Health Organization (WHO) suggests 10 micrograms in water as suitable for human consumption (Castro de Esparza, 2004; Rivera Carranza, 2016).

Drought in the Comarca Lagunera

In the case of the Nazas-Aguanaval basin and particularly in the lower basin (Comarca Lagunera) the drought has worsened in three periods in the last 70 years: 1950-1953, 1994-2003 and 2011-2013 (Programa Nacional Contra la Sequía, 2014).

5.4.5 Strategies for water sustainability

Agua Saludable para la Laguna (Healthy Water for the Lagoon)

The purpose of the Agua Saludable para la Laguna project is compliance with article 4 of the Constitution of the United Mexican States, which establishes that every person has the right to access, disposal and sanitation of water for personal and domestic consumption in a sufficient, healthy, acceptable and affordable form. It is considered a work with relevance to meet basic needs by providing the resource for at least one million 600 thousand inhabitants.

The development of the Agua Saludable para la Laguna work is the most viable and reliable alternative to provide drinking water to the population of the 9 main municipalities of the Comarca Lagunera, substituting the source of extraction of the resource from the Principal-Lagunera aquifer for water of the Nazas river. With this action, the over-exploitation that is currently exerted on this body of water, from which the water consumed by the population is mainly extracted, is reduced, in parallel, the resource continues to be provided without generating social discrepancies and ups and downs in economic activities, such as agriculture, livestock and the dairy sector, which is characteristic of the economy of the lagoon area. In other words, one of the objectives of the design of the work is to reduce the ecological stress that is currently experienced in the area (Gutiérrez de la Rosa, 2013).

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The Agua Saludable para la Laguna project is located in the north of the country, specifically in the municipalities of Lerdo, Gómez Palacio and Torreón, located in the Comarca Lagunera, however, it is considered to benefit another 6 municipalities surrounding the aforementioned and belonging to the same area, being Mapimí, Tlahualilo, as well as Matamoros, Francisco I. Madero, San Pedro and Viesca, located in the states of Durango and Coahuila, respectively.

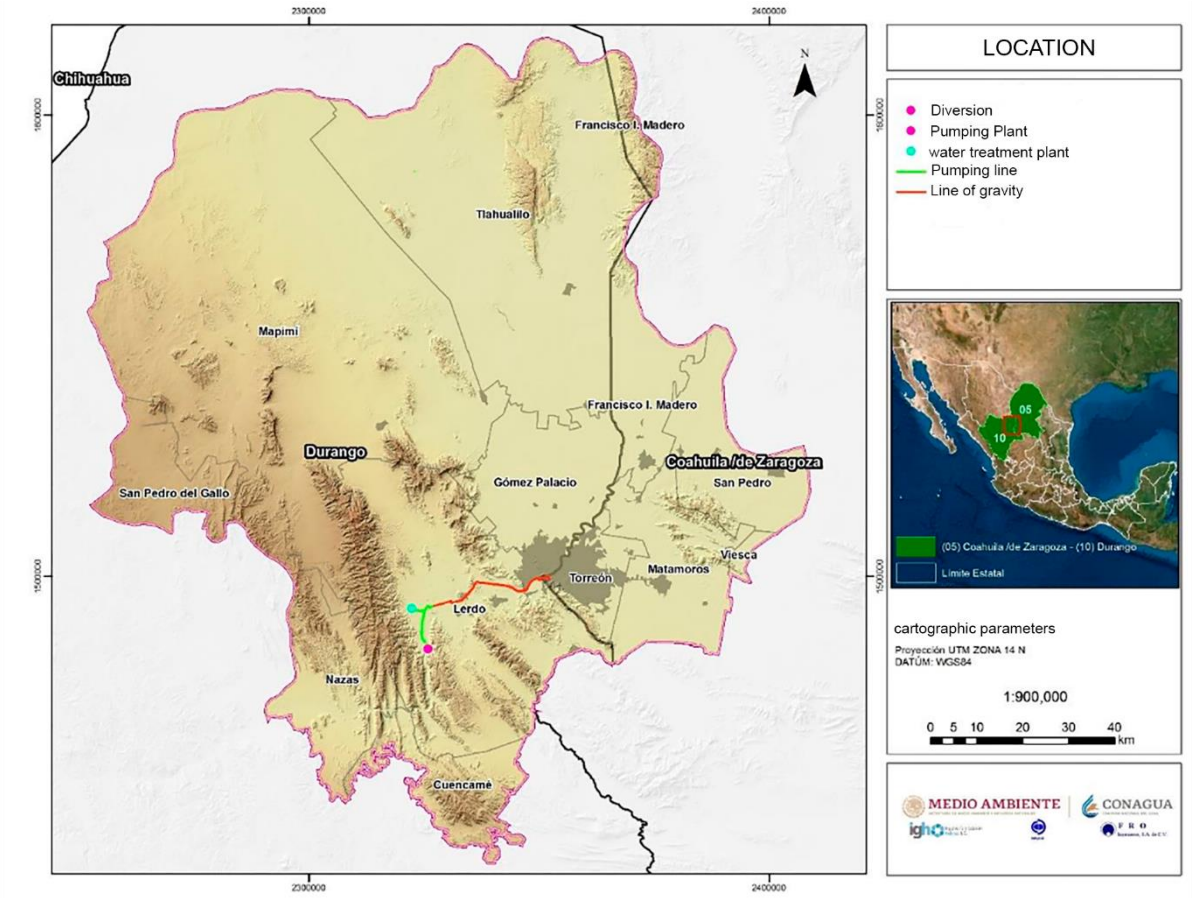

Figure 5.26 Location of the healthy water project for the lagoon

The works consist of: a diversion dam, a pumping plant, two pressure aqueducts, a water treatment plant, two aqueducts that will carry the water by gravity to regulation tanks, to continue with the distribution of the water through branches to deliver it to strategic points. Among the main benefits, the following stand out: the reduction in the risk of endemic chronic hydroarsenicism, a lower consumption

of electrical energy for pumping drinking water, a decrease in the use of groundwater for public use, stabilization of the cost of drinking water under a use of sources with greater balance and finally, a benefit to the Fernández Canyon on the Nazas River (Colegio de Ingenieros Civiles de México, 2022).

5.4.6 Opportunities for OpenET in Lagunera Region

Based on the background, the description of the water problem in Lagunera region and the results obtained from the analysis of the interviews presented in chapter 7, some of the most relevant opportunities that OpenET platform has in this region are listed below:

- Producer associations would be willing to participate as they are quite interested in making their production systems more efficient.
- Application of OpenET platform in the academic and research sector, on hydrological, climatic and ecological processes, and the consumptive use of water.
- OpenET can allow a more efficient planning of irrigation and harvests and its possible application in the modernization of irrigation and implementation of technological development.
- OpenET can allow a better operation, and carry out design of irrigation systems.
- The utility of OpenET would be the data query speed and its resolution.
- It is a tool that contributes to solving one of the variables that influence the efficient use of water, which can contribute to the efficient use of water, essentially for the "Healthy Water for the Lagoon" program, which is what it is about, to make more efficient water and recover the volumes that are being lost, recover them to be able to dedicate them to healthy water, to drinking water in the case of the population.

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6 Field visits and work meetings

6.1 Visit to state of Chihuahua

6.1.1 Fourth SMARTWATER State Forum

On December 1 and 2, 2021, IMTA participated in the fourth SMARTWATER State Forum; made in the city of Chihuahua, Chihuahua. During this event, a presentation was made on the *Irrigation Alert and Monitoring System in Real Time*, by the Master of Engineering Mario Alberto Montiel Gutiérrez; and on the other hand, Dr. Iskra Mejía Estrada also participated with the presentation on the *OpenET platform in Mexico.*

Figure 6.1 SmartWater Forum in Chihuahua, Chihuahua, Mexico.

The SMARWATER Forum is a state event with a regional scope that brings together more than 400 attendees from various institutions related to the water sector in Chihuahua. The event is organized by the Central Board of Water and Sanitation of the State of Chihuahua (JCAS) and has the objective of

presenting technological advances and developments in the water sector, with direct applications to the different uses of water in the State of Chihuahua.

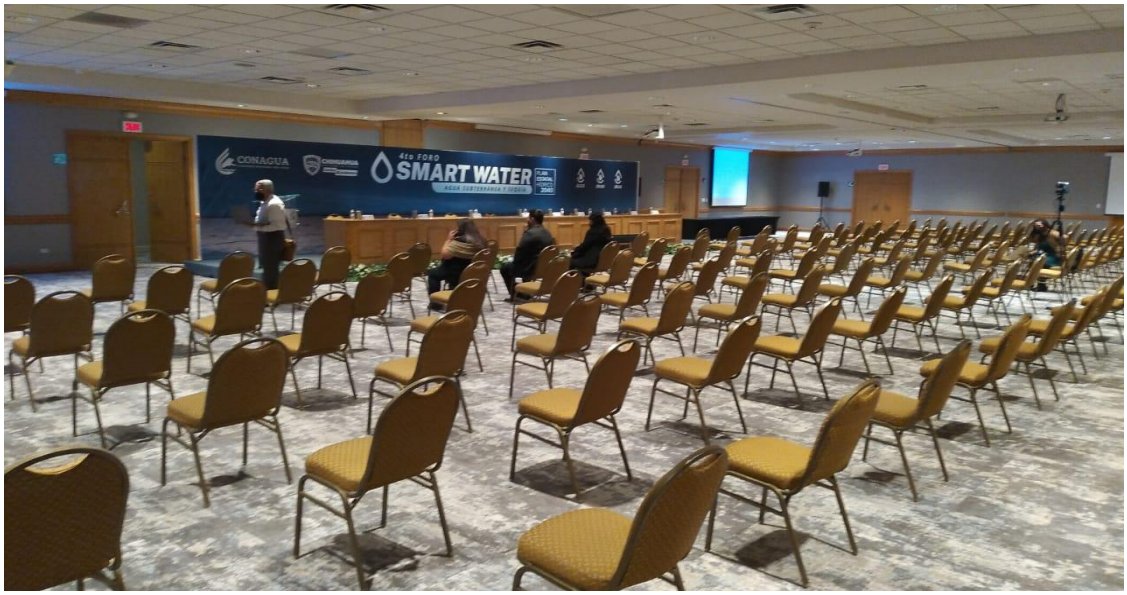

Figure 6.2 SMARTWATER 2021 Auditorium.

Both presentations took place on December 1, 2021, at the facilities of the Chihuahua City Convention Center. The following day, as part of a special invitation from the Secretary of Rural Development of the Government of the State of Chihuahua, a meeting was held to present the "*Open Et Platform for The Estimation of The Quantification of Evapotranspiration and Volumes Used in The Areas of Irrigation*" to the various institutions of the Water Sector in the State.

During this meeting, the presentation of the OPEN ET platform was in charge of Dr. Iskra Mejía Estrada, and the attendees were Lilia Merodio Reza (Secretary of Rural Development of the State Government), Roberto Lara Rocha (Executive Director of the Water Board and Sanitation, JCAS), Ramón Morga Saravia (President of the Rio Grande Basin), Salvador Alcantar Ortega (Head of the Department of Agriculture of the SDR of the State of Chihuahua), Mario Mata Carrasco (Federal Deputy) and Ángel Félix Sánchez (Local Director of the National Water Commission in the state of Chihuahua). Figure 6.3 shows the attendance list of the meeting.

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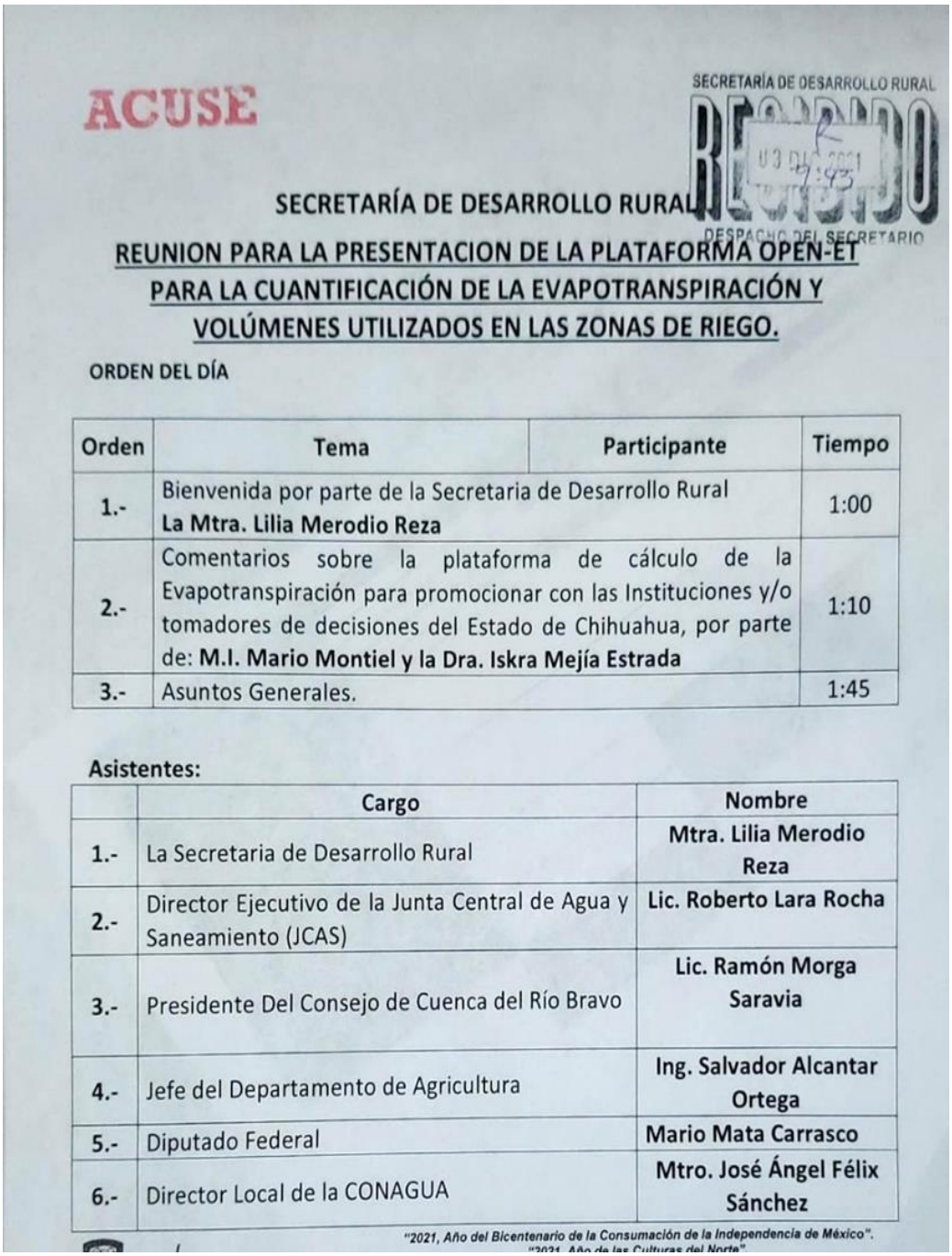

ACUSE

SECRETARÍA DE DESARROLLO RURAL

RECIBIDO

DESPACHO DEL SECRETARIO

SECRETARÍA DE DESARROLLO RURAL

REUNION PARA LA PRESENTACION DE LA PLATAFORMA OPEN-ET PARA LA CUANTIFICACIÓN DE LA EVAPOTRANSPIRACIÓN Y VOLÚMENES UTILIZADOS EN LAS ZONAS DE RIEGO.

ORDEN DEL DÍA

Orden	Tema	Participante	Tiempo
1.-	Bienvenida por parte de la Secretaria de Desarrollo Rural **La Mtra. Lilia Merodio Reza**		1:00
2.-	Comentarios sobre la plataforma de cálculo de la Evapotranspiración para promocionar con las Instituciones y/o tomadores de decisiones del Estado de Chihuahua, por parte de: **M.I. Mario Montiel y la Dra. Iskra Mejía Estrada**		1:10
3.-	Asuntos Generales.		1:45

Asistentes:

	Cargo	Nombre
1.-	La Secretaria de Desarrollo Rural	**Mtra. Lilia Merodio Reza**
2.-	Director Ejecutivo de la Junta Central de Agua y Saneamiento (JCAS)	**Lic. Roberto Lara Rocha**
3.-	Presidente Del Consejo de Cuenca del Río Bravo	**Lic. Ramón Morga Saravia**
4.-	Jefe del Departamento de Agricultura	**Ing. Salvador Alcantar Ortega**
5.-	Diputado Federal	**Mario Mata Carrasco**
6.-	Director Local de la CONAGUA	**Mtro. José Ángel Félix Sánchez**

"2021, Año del Bicentenario de la Consumación de la Independencia de México".

Figure 6.3 Chihuahua meeting attendance list, Chihuahua

Figure 6.4 Presentation of the OpenET Platform at the Ministry of Rural Development in the State of Chihuahua.

Once the presentation of the OpenET Platform was finished and the concerns of the attendees were resolved, the first impressions revealed great interest on the part of the attendees. All the attendees found that OpenET platform is an excellent tool that could be quite useful for the state of Chihuahua in relation to the following issues:

- Well monitoring
- Monitoring of crops and planted area
- Control of water allocation
- Monitoring of consumed volumes
- Water balances in hydrological studies

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- Monitoring of climate change impacts
- Deforestation and land use change
- Evaporation in reservoirs
- State agricultural statistics

6.2 Lagunera region, visit to the City of Torreón Coahuila and Gómez Palacios, Durango.

The visit to the Región Lagunera took place from February 17 to 18, 2022, with the participation of Dr. Agustín Breña Naranjo, IMTA Water Security Coordinator; Dr. Pamela Iskra Mejía Estrada Sub-coordinator of Hydrometeorology and the M.E. Mario Alberto Montiel Gutiérrez, Water technologist from the Sub-coordination of Water and Food.

The first meeting was held in the city of Gómez Palacios Durango, at the facilities of CENID RASPA (NATIONAL CENTER FOR DISCIPLINARY INVESTIGATION IN WATER SOIL PLANT ATMOSPHERE RELATIONS) belonging to INIFAP (NATIONAL INSTITUTE FOR AGRICULTURAL AND LIVESTOCK FOREST RESEARCH). This is an Institution of scientific and technological excellence with leadership and national and international recognition for its ability to respond to the demands for knowledge and technological innovations for the benefit of agriculture, livestock and society in general. (agricultura.gob.mx).

In this first meeting, the attendees were Dr. Juan Estrada Avalos, Director of CENID RASPA, and his research staff related to the topic presented and the Area of Irrigation Engineering: Dr. Ernesto Alonso Catalán, Dr. José Alberto Urrieta Velazquez and the M. Sc Gerardo Delgado Ramírez.

The presentation of the OpenET platform was in charge of Dr. Iskra Mejía Estrada and the comments and conclusions by Dr. Agustín Breña Naranjo. M.E Mario A. Montiel presented a possible irrigation application of the platform, such as the Irrigation Monitoring and Alert System in Real Time.

As a result of the presentation, the attendees commented that the platform is an excellent tool that could help the project: "Agua Saludable para la Laguna" (Healthy Water for la Laguna, see in chapter 5.4.5).

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This project was implemented by CONAGUA and is part of the presidential commitments of this six-year term.

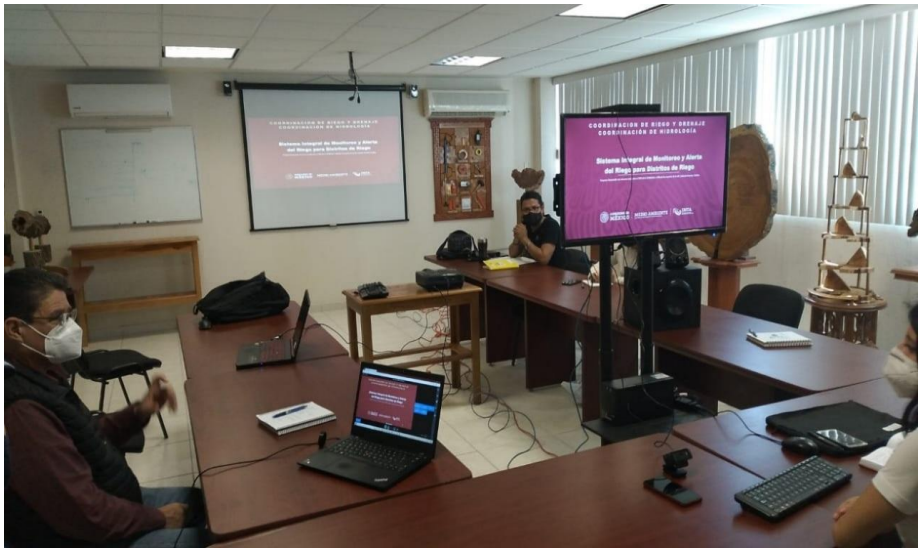

Figure 6.5 Meeting at CENID RASPA in Gómez Palacios, Durango

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The second meeting was held in the city of Torreón, Coahuila, at the facilities of Organismo de Cuencas Centrales del Norte (OCCN) de la CONAGUA (North Central Basin Organization). On this occasion we were received by Engineer Luis Vitar Soto, Director of Hydro-agricultural Infrastructure of the OCCN.

On this occasion, Dr. Agustín Breña Naranjo and together with Dr. Iskra Mejia, presented the OpenET Platform in Mexico. Applications for fruit crops, alfalfa and fodder were exemplified, which are widely used in the Irrigation District 017 Lagunera Region. The Engineer Adolfo Marín Barraza, Chief of Irrigation District 017 of the Lagunera Region, was the assistant of this meeting.

Once the platform has been presented and the concerns of the attendees have been resolved; In general, all attendees found it to be an excellent tool that could be quite useful for use throughout the Basin Organization and its Irrigation Districts, which partially includes the States of Durango, Zacatecas and Coahuila.

As a result of the presentation, CONAGUA showed interest in the OpenET Platform for its application in the following topics:

- Monitoring of crops and planted area
- Control in the allocation of water for irrigation and cities
- Monitoring of consumed volumes
- Water balances in hydrological studies of basins
- Monitoring of climate change impacts
- Evaporation in reservoirs
- Agricultural statistics of the Irrigation Districts of the River Basin Organization.

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Figure 6.6 Meeting in CONAGUA CUENCAS CENTRALES DEL NORTE, Torreón Coahuila

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6.3 Visit to the state of Sinaloa

6.3.1 Expo Agro Sinaloa 2022 in the City of Culiacán, Sinaloa

The visit to the City of Culiacán Sinaloa took place in March 2023, and Dr. Agustín Breña Naranjo, Dr. Pamela Iskra Mejía Estrada and M.E. Mario Alberto Montiel Gutierrez. Additionally, Marco Antonio Sánchez, IMTA Communication Sub-coordinator, and Indira Franco, IMTA water technologist, also participated.

The Expo Agro was held at the *Fundación Produce Sinaloa* Innovation Center located in Aguaruto, Culiacán, Sinaloa. The Expo Agro Sinaloa is a business generating forum and the ideal place to exhibit the products and services of the companies that year after year trust in the quality of the most important agricultural exhibition in the Northwest of Mexico.

Figure 6.7 IMTA participation in EXPOAGRO Sinaloa 2022

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IMTA participated from March 15 to 17, 2022 with a STAND, where advances and applications of Digital Agriculture in Mexico were presented. On the other hand, Dr. Agustín Breña gave the conference on Large-Scale Smart Agriculture within the Expo Agro Sinaloa 2022 Forum. In this conference, Dr. Breña mentioned that OpenET platform is an innovative tool for determining the crop evapotranspiration.

Figure 6.8 Conference on Large-Scale Smart Agriculture given at the Agribusiness Forum of Expo Agro Sinaloa 2022.

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Figure 6.9 shows a photograph of the IMTA stand, where the dissemination of the platform and its different uses was carried out.

Figure 6.9 IMTA participation in the EXPOAGRO SINALOA 2022 Stand.

6.4 Visit to state of Guanajuato

6.4.1 Meeting in the Hydraulic Committee of the Irrigation District 011 Alto Río Lerma in the State of Guanajuato.

The visit to the State of Guanajuato took place from March 29 to 31, 2022 to hold different meetings in person and present the OpenET platform to different actors in water sector in the State of Guanajuato.

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The first meeting was with the Irrigation Users of the Irrigation District 011 Río Lerma SRL of IP de CV, an organization that brings together and represents the 12 Civil Irrigation Associations of the largest Irrigation District in the State of Guanajuato (111,242 ha. Approximately).

Figure 6.10 Facilities of the SRL of the Irrigation District 011 Alto Río Lerma, Guanajuato.

In this first meeting (held on March 29, 2022), representatives of CONAGUA attended, through engineers José Alberto Masías Segura Head of Irrigation District 011 and 085 Alto Río Lerma, and Engineer Alejandro Quintero Head of Operation of DR 011. The Engineer Jose Abraham Soto Avila of the State Water Commission in Guanajuato. On behalf of the Users was Mr. Agustín Robles Montenegro, President of the SRL of DR 011 and the representatives of all the 11 Civil Irrigation Associations that in total represent 26,677 ha. The image in Figure 6.11 shows the invitation to the Hydraulic committee with the agenda.

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MEDIO AMBIENTE | **COMITÉ HIDRAULICO**
DISTRITO DE RIEGO 011 "ALTO RÍO LERMA", GTO.
CONAGUA

CONVOCATORIA: C.H. 2022. - 03

Celaya, Gto. A 24 de marzo de 2022

SECRETARIO DE DESARROLLO AGROALIMENTARIO Y RURAL DEL GOBIERNO DEL ESTADO DE GUANAJUATO, REPRESENTANTE DE LA SADER EN EL ESTADO DE GUANAJUATO, DIRECTOR GENERAL DE LA COMISIÓN ESTATAL DEL AGUA DE GUANAJUATO, AGENTE ESTATAL FINANCIERA NACIONAL DE DESARROLLO, AGENTE DE OFICINA FIRA IRAPUATO, ENCARGADO DE LA JEFATURA DEL DISTRITO DE RIEGO 087 "ROSARIO MEZQUITE", REPRESENTANTES DEL IMTA.

PAMSDRAC

Por medio de la presente, me permito invitarles a la Reunión Ordinaria de Comité Hidráulico del Distrito de Riego 011 "Alto Río Lerma", Gto., que tendrá verificativo en: Auditorio Miguel Ángel Solís Montemayor del D.R. 011 Río Lerma S. de R.L. de I.P. de C.V., sita en carretera Irapuato-Salamanca, N°. 5690 Fracción "B" de la Exhacienda Buenavista, Municipio de Irapuato, Gto., en punto de las 11:00 horas del día 29 de marzo del 2022, bajo el siguiente:

ORDEN DEL DÍA

1. Palabras de Bienvenida.
2. Lista de Asistencia y verificación de Quórum.
3. Lectura de acta de reunión anterior.
4. Presentaciones por parte del Instituto Mexicano de Tecnología del Agua
   a) Plataforma SINMAR: Sistema Integral de Monitoreo y Alerta del Riego. Por el M.I. Mario Alberto Montiel Gutiérrez, Tecnólogo del Agua del IMTA.
   b) OPEN ET en México: La plataforma para el cálculo de la evapotranspiración en zonas de riego. Por la Dra. Iskra Mejía Estrada.
5. Avance del Plan de Riegos 2021-2022.
6. Avance del PACOT.
7. Avance en DPSAB.
8. Asuntos Generales.

En espera como siempre de su puntual asistencia. En seguimiento y atención a la emergencia sanitaria SARS-CoV-2 (Covid-19), se solicita una asistencia limitada a un vocal representante de la Asociación. Asimismo, se deberá considerar las medidas preventivas de sana distancia, cubre bocas y uso de gel antibacterial.

Sin otro particular reciban un cordial saludo.

ATENTAMENTE
EL PRESIDENTE DEL COMITÉ

ING. JOSÉ ALBERTO MASÍAS SEGURA
JEFE DE LOS DISTRITOS DE RIEGO 011 Y 085

Figure 6.11 Invitation to the work meeting on March 29 and agenda.

Figure 6.12 Hydraulic Committee of the Irrigation District 011 Alto Río Lerma in the State of Guanajuato.

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The following table shows the characteristics of the District Irrigation Modules, whose representatives attended the meeting:

Table 6.1 Characteristics of the Irrigation modules of District 011 Alto Río Lerma

Modulo	Superficie (ha)	Superficie de riego (ha)	Número de usuarios
Acámbaro	8,459.02	8,426.00	2,234
Salvatierra	16,389.96	16,246.00	6,441
Jaral	6,753.86	6,739.54	1,589
Valle	13,389.91	13,341.58	2,462
Cortazar	18,376.51	18,316.22	3,687
Salamanca	14,071.86	13,599.52	2,951
Irapuato	8,392.76	8,361.00	1,507
Abasolo	14,985.80	14,890.85	2,850
Huanímaro	3,864.98	3,823.35	1069
Corralejo	1,575.99	1,575.99	342
La purísima	4,981.90	4,979.40	1,479
Total	***111,242.55***	***110,299.45***	***26,611***

The presentation of the OpenET platform was in charge of Dr. Iskra Mejía Estrada. During her presentation, some examples of the calculation of Evapotranspiration in crops that are of interest to users in the region were presented, particularly: wheat, corn and forage.

Once the OpenET presentation was concluded, some users indicated that the platform is very useful for monitoring the planted areas, mainly from the wells that are irrigated within the perimeter of the Irrigation District and for which there are no real statistics.

They also considered that if there is an interdisciplinary project at the state level and in collaboration with the different institutions, they would agree to participate in the integration and adaptation of the platform in the irrigation areas under their responsibility.

6.4.2 University of Guanajuato

On March 30, 2022, the University of Guanajuato was visited in the city of Guanajuato. This meeting was attended by academic staff and students of the University. Additionally, Dr. Gustavo Magaña Sosa (Secretary of Agricultural Development of the State of Guanajuato), attended this meeting remotely.

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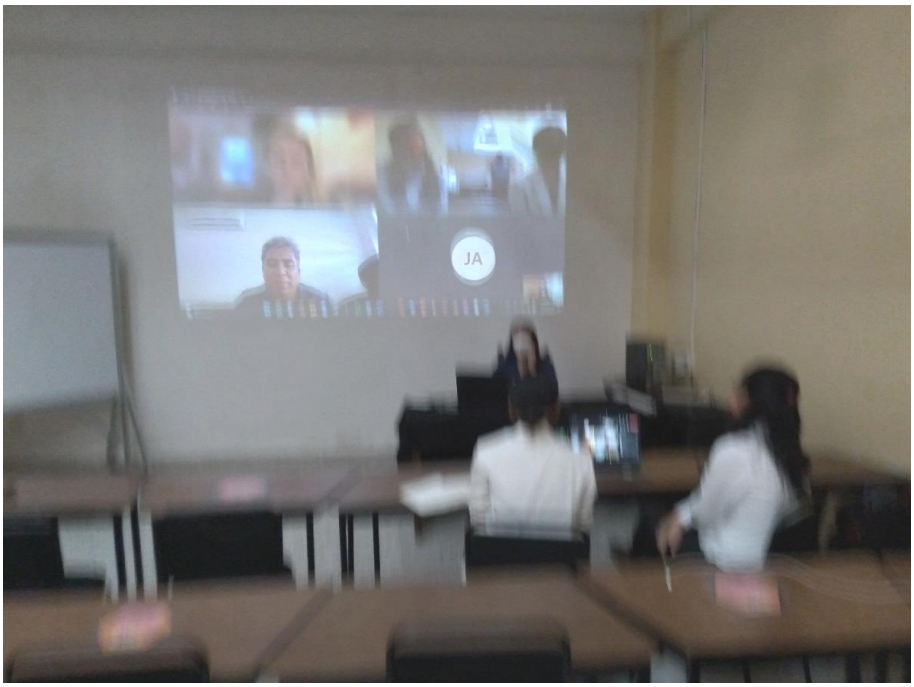

Figure 4.12. Meeting on March 31 with the University of Guanajuato and the Secretary of Agricultural Development of the State of Guanajuato.

At the conclusion of this meeting, the academics and government officials believed that the development of the OpenET platform in the State is very important because it would help in the following issues:

- Accounting of the water used in the different uses
- Water market at the level of the Lerma River Basin with the State of Jalisco
- Irrigation programming at the plot level
- Report on the consumptive use of water of the different crops for volumetric endowment purposes.
- Contribute to the State's agricultural statistics
- Monitoring of volumes in wells with the Technical Water Councils of the State of Guanajuato (COTAS)
- Other academic uses such as crop identification
- Use of satellite images

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6.5 Visit to Baja California Peninsula Basin Organization in the city of Mexicali, Baja California.

This visit took place from April 4 to 6, 2022 and Dr. Iskra Mejía Estrada and Master of Engineering Mario Alberto Montiel Gutiérrez participated. Prior to the meeting at the Baja California Peninsula Basin Organization, IMTA invited all the participants to attend on April 5 at 12 AM for the presentation of the OpenET platform (see Figure 6.13).

In total, more than 10 representatives (see Table 7.1) of the following institutions were invited:

- NATIONAL WATER COMMISSION BASIN ORGANIZATION BAJA CALIFORNIA PENINSULA
- CILA MEXICO
- NORTH FRONTERA COLLEGE
- IRRIGATION DISTRICT 014 COLORADO RIVER OF THE CONAGUA
- IRRIGATION DISTRICT RIO COLORADO SRL DE IP DE CV
- SECRETARY OF AGRICULTURAL DEVELOPMENT OF THE GOVERNMENT OF THE STATE OF BAJA CALIFORNIA
- STATE WATER COMMISSION
- NORTECH WATER SPECIALTIES SA DE CV
- PRONATURE
- UNIVERSITY OF BAJA CALIFORNIA (UABC)

The call was successful and all representatives and guests attended. In this meeting, the presentation of the OpenET platform was in charge of Dr. Iskra Mejía Estrada and the comments and conclusions by Mario A. Montiel; who also presented a possible irrigation application of the platform, such as the Irrigation Monitoring and Alert System in Real Time.

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MEDIO AMBIENTE | IMTA

COORDINACIÓN DE HIDROLOGÍA
OFICIO No. R3E.03.- 013
ASUNTO: Presentación de la plataforma OpenET
Jiutepec, Mor., a 28 de marzo de 2022

ING. HERIBERTO MONTOYA ANGULO
PRESIDENTE DEL DISTRITO DE RIEGO RÍO COLORADO S. DE R.L. DE I.P. DE C.V.
COMISIÓN NACIONAL DEL AGUA
P R E S E N T E

Me dirijo a usted como uno de los principales actores del sector hídrico en Baja California para la presentación de la Plataforma OpenET, por parte del Instituto Mexicano de Tecnología del Agua (IMTA).

Esta plataforma fue desarrollada en Estados Unidos para el cálculo de la evapotranspiración, a partir de modelos e imágenes de satélite, y está actualmente implementada en 5 millones de km^2 al oeste de dicho país. La plataforma, una vez instalada y calibrada en una región, permite monitorear y estimar las superficies sembradas y calcular los volúmenes de agua evapotranspirados en cada parcela de una zona de riego a gran escala.

Actualmente, el Environmental Defense Fund (uno de los miembros del consorcio fundador de OpenET) y el IMTA están realizando un estudio de prospección para instalarla en cuatro estados pilotos en México, uno de los cuales es Baja California. Debido al interés de contar con opiniones de expertos en el tema, lo invitamos a una reunión para presentar dicha plataforma de manera presencial en la Sala de Juntas del Organismo de Cuenca Península de Baja California en Mexicali, el próximo martes 5 de abril de 2022 a las 12:00 pm. El objetivo es recabar información relevante y necesaria para la puesta en marcha de la plataforma OpenET en el Estado de Baja California.

Mucho agradeceré confirmar su asistencia a dicha reunión con la Dra. Pamela Iskra Mejía Estrada al correo iskra_mejia@tlaloc.imta.mx.

Sin otro particular por el momento, le saludo cordialmente.

A T E N T A M E N T E
EL COORDINADOR

DR. JOSÉ AGUSTÍN BREÑA NARANJO

c.c.p. Archivo.

2022 Flores Magón

Figure 6.13 invitation by IMTA to Mr. Heriberto Montoya Angulo, President of the Irrigation District Rio Colorado SRL of IP de CV.

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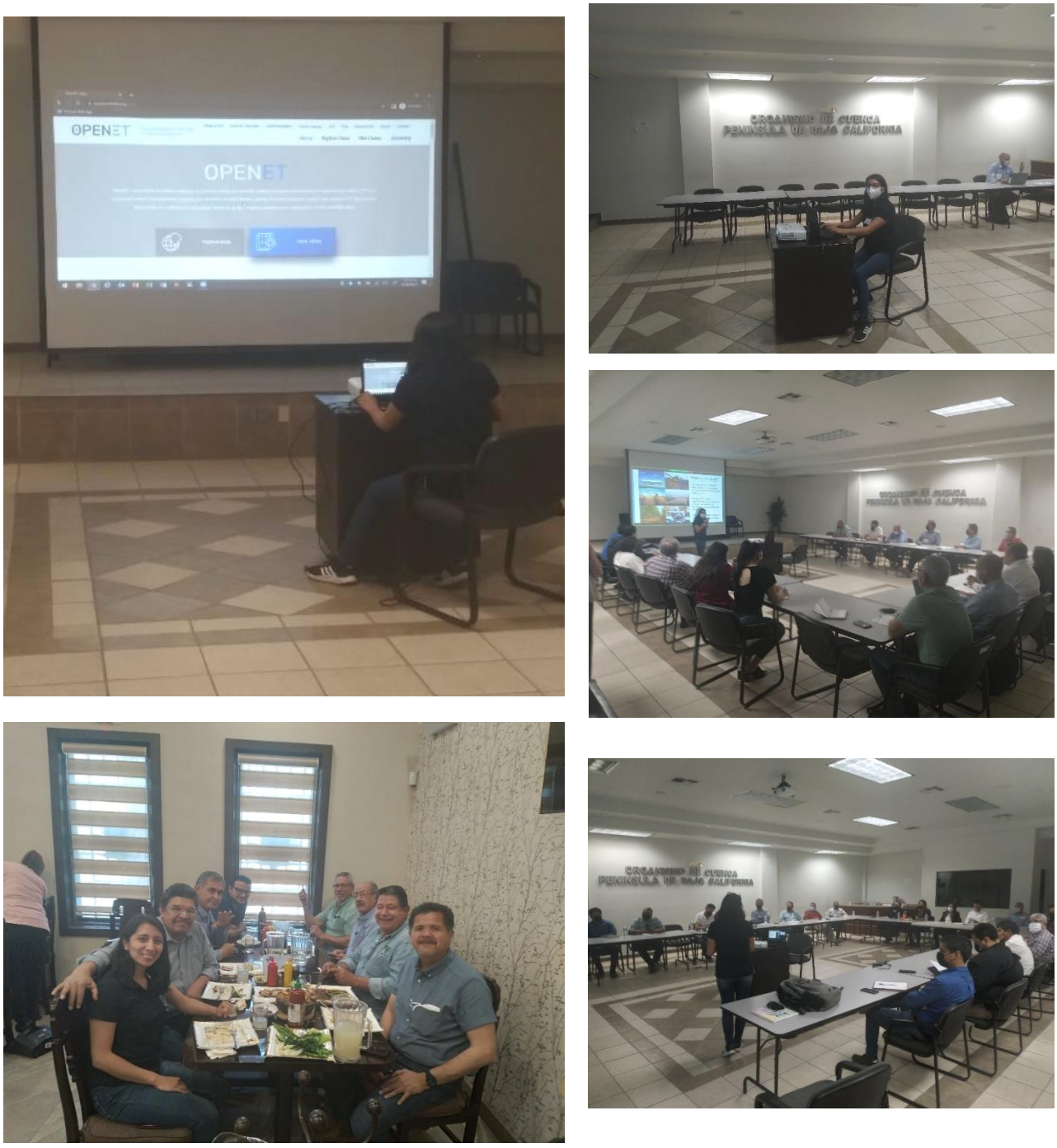

Figure 6.14 Meeting on April 5 at the Baja California Peninsula Basin Organization in the city of Mexicali BC

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Once the platform was presented and the doubts and concerns of the attendees were resolved, in general, everyone found that OpenET platform is an excellent tool that could be quite useful for use within the Valley of Mexicali. The platform seemed to them an excellent method to quantify the volumes of the different uses of water, such as, Agriculture and Industry mainly. The applications mentioned by the attendees are listed below:

- Monitoring of crops and planted area
- Control in the allocation of water for irrigation and cities
- Monitoring of consumed volumes
- Water balances in hydrological studies of basins
- Monitoring of climate change impacts
- Evaporation in reservoirs (USA)
- Monitoring of volumes in wells
- Agricultural Statistics of the Irrigation District

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7 Stakeholder Interview Guide and analysis of the information collected

Derived from the field visits described in the previous chapter, contact information of the stakeholders was collected. During the process of conducting the interviews, it was possible to collect more information from the stakeholders, and as a result of continuous communication, new people were added to the initial list. The following tables present the contact information, as well as the record of which people did respond to the interview and which did not.

Table 7.1 Mexicali valley contact list

No.	Stakeholder	Institution	Position	Classification	Phone number	Email	Answer to the interview
1	Dr. Alfonso Andrés Cortez Lara	Colegio de la Frontera Norte (COLEF)	Researcher at the Department of Urban and Environmental Studies	Government, academic, research	(686) 554 7445	acortez@colef.mx	Yes
2	Ing. Heriberto Montoya Coronado	Distrito de Riego Río Colorado, SRL de IP de CV	Administration Counsel President	Irrigation District	(686) 1356601	titos.alegria@gmail.com	No
3	M. en I. Edgar Carrera Villa	The Nature Conservancy Mexico	Colorado River Delta Program Coordinator	Nonprofit research organization		edgar.carrera@tnc.org	Yes
4	M. en I. Roberto Real Rángel	The Nature Conservancy Mexico		Nonprofit research organization		-	
5	Arq. Juan Meléndrez Espinoza	Gobierno del Estado de Baja California	Secretary of the Field and Food Security	Government	(686) 559 5600 Ext. 234	jmelendreze@baja.gob.mx	No
6	Ing. Francisco A. Bernal Rodríguez	National Water Comission	Director of the Baja California Peninsula Basin Organization	Government		mcota@ceabc.gob.mx; francisco.bernal@conagua.gob.mx	No
7	Ing. Aracely Favela Uriarte		OCPBC Hydro-Agricultural Infrastructure Director	Government		cynthia.lopez@conagua.gob.mx; aracely.favela@conagua.gob.mx	Yes
8	Dr. Julio Navarro Urbina		Irrigation District Chief 014 Río Colorado B.C.	Government	686 55 16 400 ext. 2301	julio.navarrou@conagua.gob.mx	

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No.	Stakeholder	Institution	Position	Classification	Phone number	Email	Answer to the interview
9	Ing. Victor Maldonado		Operation Chief	Government		-	
10	Dr. Jorge Ramírez Hernández	UABC	Head of the Department of Geophysics, Hydrology and Environmental Impact	Public University	Tel: (686) 566 4150 y (686) 841 8237 ext. 44513	jorger@uabc.edu.mx; jorgerh@hotmail.com	No
11	Dra. Jesús Eliana Rodríguez Burgueño	UABC	Researcher	Public University		eliana.rodriguez@uabc.edu.mx	Yes
12	Ing. Adriana Beatriz Carolina Reséndez Maldonado	CILA México	Mexican Commissioner of the CILA Mexico - USA	International organization	Direct: (656) 639-7959 switch: (656) 639-7950, (656) 613-73-11 Ext:7959	aresende@cila.gob.mx	Yes
13	Ing. Daniel Adrián Galindo Peña				656-639-7672	dgalindo@cila.gob.mx	

Table 7.2 Chihuahua contact list

No.	Stakeholder	Institution	Position	Classification	Phone number	Email	Answer to the interview
14	Maestra Lilia Merodio Reza	Secretaría de Desarrollo Rural	Secretaria de Desarrollo Rural	State Government	656 166 8139	lilia.merodio@chihuahua.gob.mx	No
15	Ing. Mario Mata Carrasco	Junta Central de Agua y Saneamiento de Chihuaha JCAS	Director	State Government	(614) 439-35-00 Ext. 22001	mario.mata@chihuahua.gob.mx	No
16	Lic. Ramón Morga Saravia	Comisión Nacional del Agua, Consejo de Cuenca del Río Bravo	Presidente	State Government	818 248 4512 - Ext. 4010, cel:8112125683	rmorga@sadm.gob.mx	No
17	Jesus Ochoa Rivero	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias	Investigador	Governmetn	6142794802	ochoa.jesus@inifap.gob.mx ; jochoarivero@gmail.com	Yes

No.	Stakeholder	Institution	Position	Classification	Phone number	Email	Answer to the interview
18	Ing. Salvador Alcántar Ortega	Gobierno Local	Diputado Federal en la Cámara de Diputados o Secretario de la Comisión de Recursos Hidráulicos y Agua Potable de la Cámara de Diputados	Local Government	639 114 1004	aurech.2019@gmail.com	No
19	ccp: Alán García		Jefe de departamento de usos sostenible del agua	Local Government	whatsapp: 614 163 99 24	luisalan.garcia@chihuahua.gob.mx	No
20	Maestro José Angel Felix Sánchez	Comisión Nacional del Agua, División de Chihuahua	Director Local	Government	6623005760	jose.felix@conagua.gob.mx	Yes
21	ccp: Castanedo Guerra Leonid Vladimir.		SUBDIRECTOR TÉCNICO	Government		leonid.castanedog@conagua.gob.mx	
22	Fernández Carrasco Lauro Antonio.		Residente General	Government		lauro.fernandez@conagua.gob.mx	
23	Ing. Martín Parga	Director de Aurech		Asociación de usuarios de Riego	6394653066	martinpargac@hotmail.com	No
24	Lic. Paola Ramírez	Comité Técnico de Aguas Subterráneas del Acuífero del Valle de San Juan del Río	Gerente Operativo	Government	442 128 5287	cotas.sanjuandelrio@gmail.com	Yes
25	Dr. Victor Salas	Researcher	Profesor en la Universidad Autónoma de Ciudad Juárez	Public University	614 285 89 19	victor.salas@uacj.mx	Yes

Table 7.3 Guanajuato Contact list

No.	Stakeholder	Institution	Position	Classification	Phone number	Email	Answer to the interview
26	Dra. Yanmei Li	University of Guanajuato	Researcher	Public University	4737405659	yanmeili@ugto.mx	Yes

No.	Stakeholder	Institution	Position	Classification	Phone number	Email	Answer to the interview
27	Esther Camacho	NUUP	Program Manager Cauce Bajío	Social Enterprise		ecamacho@nuup.org	Yes
28	Braulio Torres Beltrán	NUUP	Director of Impact Learning				
	Humberto Vergara Gonzalez	NUUP	Agronomist Coordinator and Promoter of Field Solutions				
29	Joel Arredondo	Guanajuato-Cauce Bajío Water Fund	Former manager		477 727 0646	joel.arredondo@caucebajio.com Nuevo correo: arredondo.joel@gmail.com	No
30	Oscar Leal	Guanajuato-Cauce Bajío Water Fund	Director			oscarlealmx@outlook.com	Yes
31	Zhiyu Hu	University of Guanajuato	PhD Student			z.hu@ugto.mx	No
32	Ing. José Abraham Soto Avila	Guanajuato State Water Commission	Director General de Planeación	Government	473 73 5 18 00 EXT.182	asotoavi@guanajuato.gob.mx	Yes
33	Ing. J. Cruz Angeles Gómez	Guanajuato State Water Commission, Superficial Water Directorate	Head of the Department of Surface Hydrology		473 73 701 60	jangelesg@guanajuato.gob.mx	
34	Josué Gutiérrez Leiva	Surface Water Directorate				-	
35	Mario Barajas	Surface Water Directorate				-	
36	Gustavo Magaña Sosa	Cauce Bajío	Director of Technification and Use of Agriculture Water		461 662 6500 ext. 8211	gmagana@guanajuato.gob.mx	No

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Table 7.4 Coahuila Contact list

No.	Stakeholder	Institution	Position	Classification	Phone number	Email	Answer to the interview
36	Ing. Eduardo Fuentes Silva	North Central Basins, CONAGUA (OCCN)	Director General del Organismo de Cuenca	Government	871 747 9394	eduardo.silva@conagua.gob.mx; eduardo.fuentes@conagua.gob.mx	No
37	Ing. Luis Alejandro Vitar Soto	North Central Basins, CONAGUA (OCCN)	Director de Infraestructura Hidroagrícola del Organismo Cuencas Centrales del Norte (CONAGUA)	Government	(492) 492 74 11	eduardo.silva@conagua.gob.mx; luis.vitar@conagua.gob.mx	No
38	Dr. Juan Estrada	National Institute of Forestry, Agriculture and Livestock Research (INIFAP)	Director del Centro Nacional de Investigación Disciplinaria en Relación Agua, Suelo, Planta, Atmósfera (CENID RASPA) del INIFAP	Government Research Institution	871 346 1656	juan.estrada@inifap.gob.mx; estrada.juan@yahoo.com	Yes

7.1 Interview and interview guide

The interview is "a directed conversation between the researcher and an individual or group of individuals with the purpose of collecting information".

It is important to note that interviews are used to:

- Get to what is important to the interviewee and hear it in their own words.
- Allow to explore perceptions, points of view, ideas, etc. of the interviewee.
- Provide data that is interesting and relevant to analysis and that has the potential to reveal interesting themes that explain the phenomenon studied.
- Guarantee 100% responses.

Interviews are indispensable in qualitative research. There are different types of interviews, for example, structured or open; however, there are other types of verbal exchange that also serve the investigative purpose.

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On the other hand, the survey is a method used to collect information among the population and is used to obtain large-scale data from a given population. The survey is a research method in which various data collection techniques and instruments are used, such as the interview and the questionnaire.

7.1.1 Questionnaire

A questionnaire is a data collection instrument through a series of questions that are intended to collect information from study participants. It is mainly used as an instrument in surveys. The advantages of using questionnaires include the following:

- They help to collect general information from the participants.
- They are useful for getting feedback.
- They are reliable, can be applied before and after events, and can compare responses.
- Data analysis is made easy.
- Open questions can be included, with the consequent difficulty in carrying out the analysis.
- Some disadvantages of the questionnaire are:
- That need to be piloted before they are applied.
- Participants tend to resist answering it.
- Participants do not return it, so you have to constantly request them.
- They usually dictate the agenda, making it difficult to find out what the participants are thinking and what is important to them.

According to the above, a questionnaire was generated based on what was required by the OpenET team. The questionnaires were prepared in such a way that the interview was semi-structured. Semi-structured Interviews consist of a combination of open and very specific questions on the subject of study, and many other closed ones, in which the interviewer gives answer options.

A questionnaire composed of four subtopics was formulated: 1) evapotranspiration information, 2) technical requirements, 3) general considerations, and 4) particular considerations. For this last subtopic, the questions were formulated according to the particular conditions of each of the regions of interest, so they constitute different specific questions for each region.

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The questions formulated and classified by subtopic are listed in Table 1.

Table 7.5 Sections and questions of the questionnaire

About OpenET	Questions
About evapotranspiration data	1. What decisions are impacted or informed by evapotranspiration information?
	2. What types of stakeholders use evapotranspiration information in your organization?
	3. If available, what are the current sources of evapotranspiration information?
	4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?
	5. What is the most useful data visualization format?
	6. From what device do you think you and/or your colleagues will access the information?
About technical requirements	7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work?
	8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?
	9. How do you find it useful to have ET data summarized?
	10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?
	11. Do the polygons in Question 10 contain private or sensitive information?
	12. Which geospatial software tools (or Geographic Information Systems) does your organization use?
About general considerations	13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?
	14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?
	15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?
	16. What other applications do you think the evapotranspiration data could have?
	17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?
	18. Do you have suggestions of other partners?
About particular considerations	19. Guanajuato: How can OpenET platform serve as a support tool in determining the irrigated and planted area in the state?
	20. **Guanajuato**: How can the OpenET platform serve as a support for the recovery and regulation of overexploited aquifers in the Guanajuato State Basins? Should the State COTAS use it in their daily operations?

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About OpenET	Questions
	Valle de Mexicali: Do you consider that OpenET as a platform will serve to support the producers of the Irrigation District 014 Río Colorado in their processes of programming, monitoring, operation, ¿design and evaluation of their irrigation systems? **Chihuahua:** How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Chihuahua State Basins as established in the State Water Plan? **Coahuila:** Do you consider that OpenET will serve as a support for the recovery and regulation of overexploited aquifers of the Organismo de Cuencas Centrales del Norte?
	21. **Guanajuato:** What do you see as the most important potential applications for OpenET in Irrigation District 011 Alto Río Lerma and RD 087 Rosario Mezquite in their processes of programming, monitoring, operation, design and evaluation of their irrigation systems? **Valle de Mexicali:** Do you consider that the OpenET platform has the ideal conditions and the greatest advantage to be installed in the Mexicali Valley, since it is installed in the neighboring Imperial Valley District (IID)? **Chihuahua:** What do you see as the most important potential applications for OpenET in Irrigation Districts 005 Delicias, 090 Ojinaga, 009 Valle de Juárez, 090 Buenaventura, 089 El Carmen, 103 Río Florido, 113 Camargo in their processes of programming, monitoring, operation, design and evaluation of their irrigation systems? **Coahuila:** Do you consider that OPEN ET as a platform will serve to support the producers of the Irrigation Districts 017 Laguna Region and 034 Zacatecas State in their programming, monitoring, operation, design and evaluation of their irrigation systems?
	22. ¿Cómo considera que la plataforma OpenET será útil para regular y ordenar las concesiones de las Unidades de Riego existentes …?

7.2 Analysis of the interviews

Two analyzes were carried out, the first consisted of the analysis of the interviews, question by question, and the second was an analysis of empathy encompassing all the answers.

The analysis of the interviews was carried out in two stages: 1) making the transcriptions of the videos of each interview and 2) reviewing the answers to each question. In the case of open questions, and in order to build complete ideas that would satisfy the objective of each question, textual citations were recorded to facilitate the search and identification of the most frequent keywords and concepts among

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the interviewees. While for the closed questions, only a count of the frequency of the responses was made, and the results were presented in circular and bar graphs.

7.2.1 Empathy analysis

The most characterizing and critical step along the Design Thinking process is the empathy phase, in which stakeholder analysis is performed by looking at a given scenario from the perspective of different stakeholders. Such a methodology, that applies at an analysis level the well-known social concept of empathy, aims to enable systematic information gathering and organization that results in a deep understanding of actual problems, needs and expectations from most relevant or target stakeholders. In order to make such a process as effective as possible, especially in a team-work and multi-disciplinary contexts, analysis based on empathy is normally supported by simple specific visual tools known as empathy maps (Pileggi, 2021).

One of the main reasons, if not the main one, to apply empathy is to have a better and deeper understand the various stakeholders in a given context. For these reasons, and in order to identify the needs of the stakeholders and their perception of the evapotranspiration data; in a more concise and efficient way, an empathy analysis was carried out based on the empathy map methodology.

Empathy mapping is an attempt to analyze a given scenario from the perspective of single stakeholders. Therefore, the context of the problem is defined accordingly as a semantically enriched composition of interactions and facts involving target stakeholders

The context of the problem aims to provide a description as formal as possible of the target scenario. In the context of the proposed framework, it is defined according to the model represented in Figure 7.1, which includes three different key concepts as follows:

- Stakeholder. As in a common meaning, stakeholders are understood as the actors which have an interest or concern in a given context, which is object of attention or analysis.
- Key Relationship. It is some kind of relationship or interaction among stakeholders. The understanding and meaning may vary very much from case to case.

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- Relevant Fact. It characterizes the scenario by providing situation- specific data and factual information. Such information normally aims to particularize a generic scenario involving stakeholder to reflect a more concrete and richer situation that include data and facts.

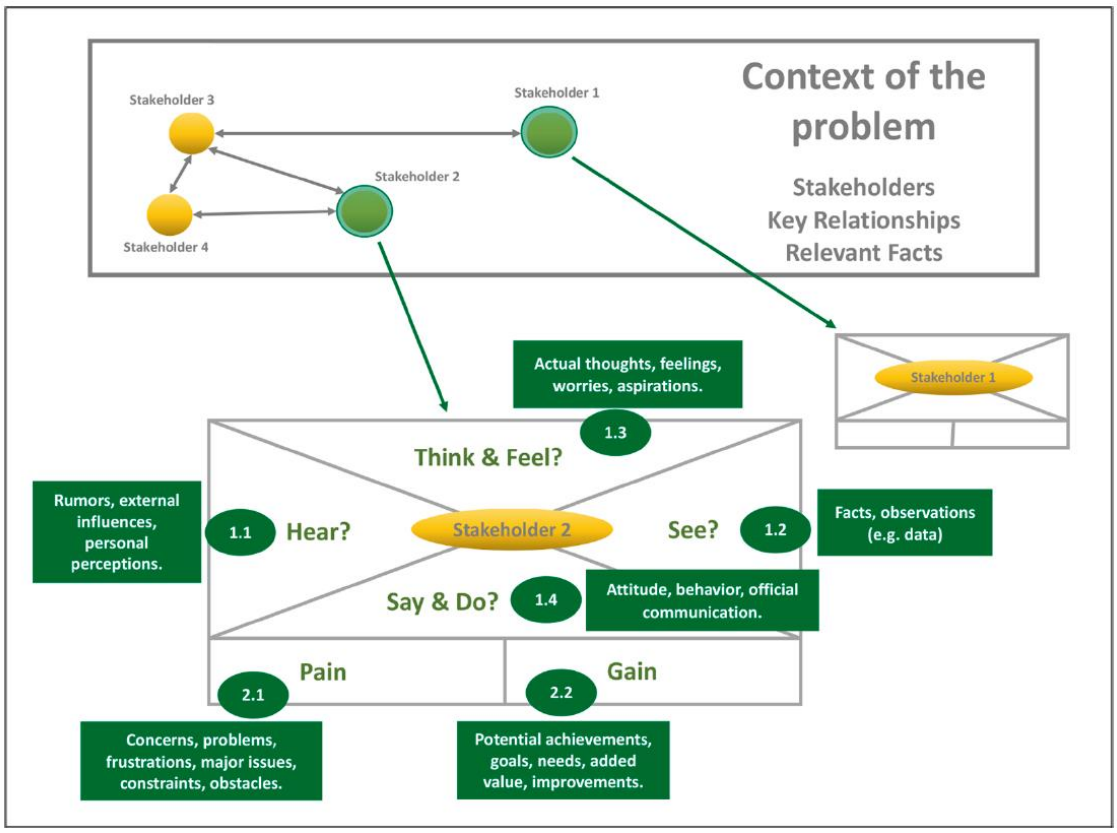

Figure 7.1 Typical Empathy map

Source: (Bland, 2012)

In accordance with this methodology, the chapter 8.3 presents the empathy map built from the analysis of the responses of the stakeholders.

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8 Results and discussion

8.1 General analysis of the responses to the questionnaire

8.1.1 About evapotranspiration data

1. What decisions are impacted or informed by evapotranspiration information?

Among the decisions that can be influenced by the use of OpenET are mainly those related to agriculture, specifically in the improvement of irrigation management and planning; including the estimate in the calculation of consumption and volume of water required by crops at different levels (from parcel to regional level), and the efficiency in its application.

Other decisions mentioned were the management of water resources, agronomic, ecological, natural resources; in the balance and water security; everything related to the calculation of the water footprint, public policies regarding the water sector, availability of water in the dams.

2. What types of stakeholders use evapotranspiration information in your organization

The actors that use the information are mainly farmers and operators. In second place, with equal frequency, are the researchers and area directors, in third place are advisors, decision makers, irrigation modules, students and technical agents, and in fourth place are IT specialists[16]. In this section the term researchers refer to both academics and people who use evapotranspiration data to do research at universities or research institutes. Area directors are those people who have a decision-making level within the government.

[16] The IT specialist definition is a technical professional that is responsible for the implementation, monitoring, and maintenance of IT systems. IT support specialist job descriptions include specialization in network analysis, system administration, security and information assurance, IT audits, database administration, and web administration.

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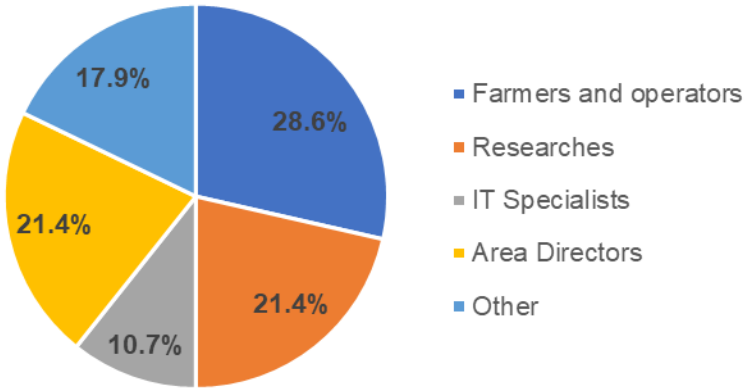

Figure 8.1. Actors using evapotranspiration information.

3. **If available, what are the current sources of evapotranspiration information?**

The sources of information mentioned were:

- National Institute of Forestry, Agriculture and Livestock Research (INIFAP)
- Agroclimatological stations installed by the state government (Guanajuato and Mexicali)
- Technical Department of Basin Organizations
- Private stations
- CONAGUA and INIFAP automated weather stations
- Weather stations from other institutions
- Satellite imagery or remote sensing data
- OpenET
- Own software
- Software like “IRRInet” and “Cropwat”

4. **At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?**

Based on the answers, the evapotranspiration information is mainly required throughout the year, but there may be times when it is more important to know it, such as before the growing season in spring-

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summer and autumn-winter. Other less common answers included the months between June-August, May-June, August-September, March to September, during the development of the crop, in the dry season and after the rains, or simply monthly or at the beginning of the year.

5. **What is the most useful data visualization format?**

The preferred display format was maps, followed by tables and in third place graphs:

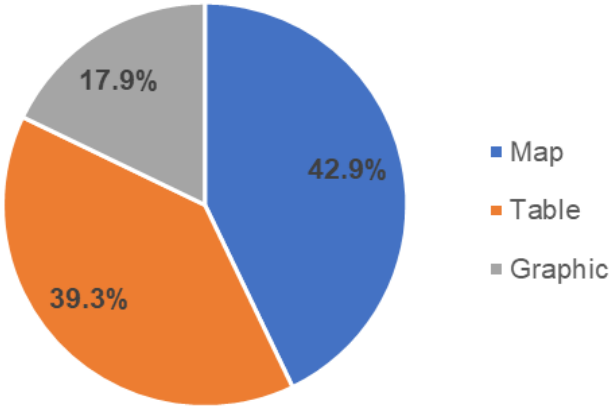

Figure 8.2 Most useful display format of evapotranspiration data

6. **From what device do you think you and/or your colleagues will access the information?**

The preferred device was the laptop, followed by the desktop computer, the cell phone, and lastly the tablet. As such, none of the interviewees mentioned another device, but they did mention the option of accessing the data offline, by those actors without internet access, such as some farmers who they considered would benefit the most from having the offline option.

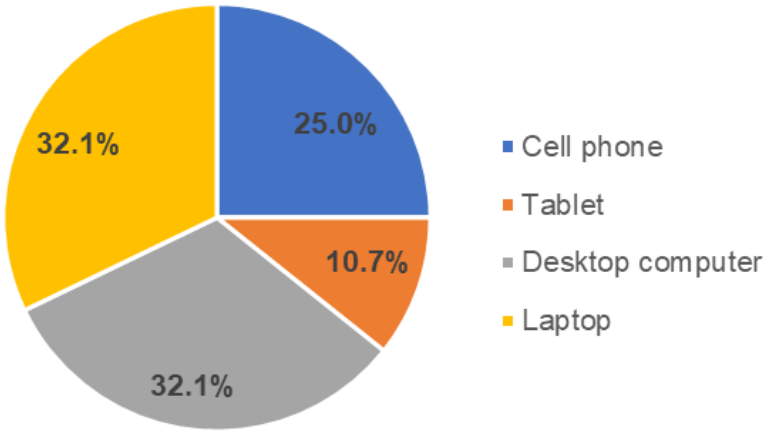

Figure 8.3 Preferable devices for access to evapotranspiration data

8.1.2 About technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work?

Regarding spatial resolution, they mentioned several options within each answer. The way to analyze them was by counting the frequency of a given spatial resolution of all the interviewees. Some answers were only mentioned once.

They commonly responded that the higher the resolution, the better. It was possible to distinguish the range that contained areas less than or equal to one hectare, which was the most repeated answer, followed by 50 and 5,000 hectares. The parcel was mentioned twice, the answers mentioned once were 5, 20 and 500,000 hectares.

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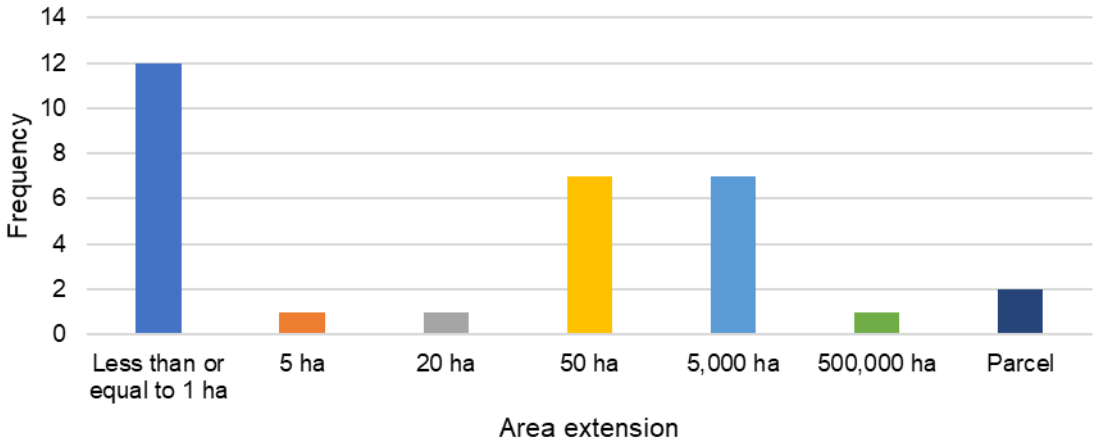

Figure 8.4 Frequency of the mentioned spatial resolutions.

8. **For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?**

As in the previous question, the interviewees mentioned several options per answer, so the way of analyzing them was the same.

The recurring time resolution was to have the data on a daily basis. Frequencies within the range equal to or less than 10 days, monthly, every 6 months and annually were also mentioned (see Figure 8.6)

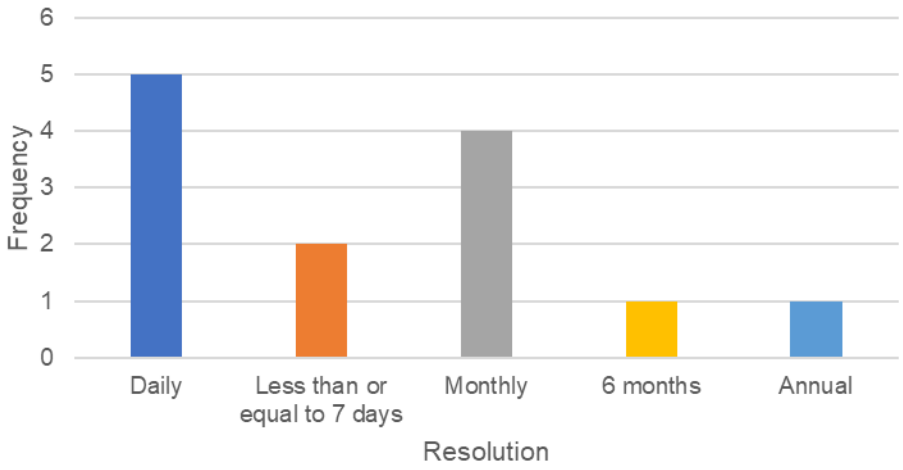

Figure 8.5 Frequencies of temporal resolutions mentioned

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The time latencies of the data available were mostly those in the range equal to or less than 15 days. The monthly range was the second most mentioned, and the annual, 3-week and daily were only mentioned once.

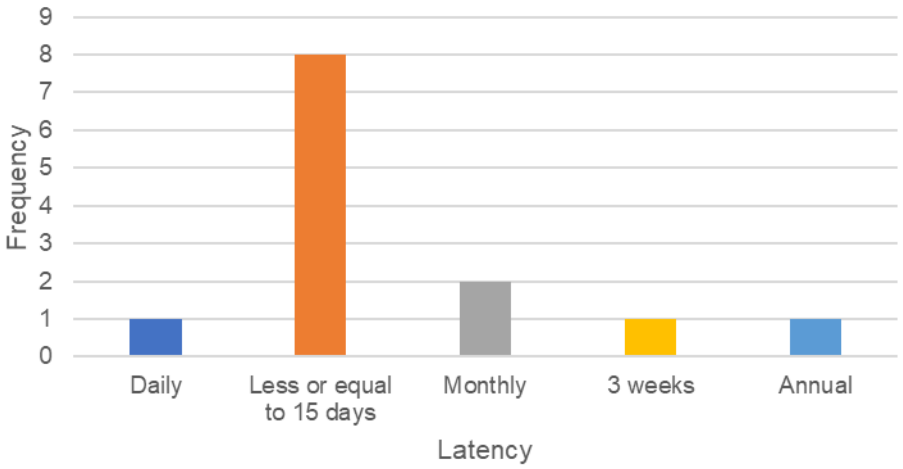

Figure 8.6 Mentioned Time Latency Frequencies

9. How do you find it useful to have ET data summarized?

The preferred scale to present the summary of the evapotranspiration data was the parcel, in second place, the irrigation module and, in third place, the irrigation district, specific area unit and other, among which it was mentioned Basin.

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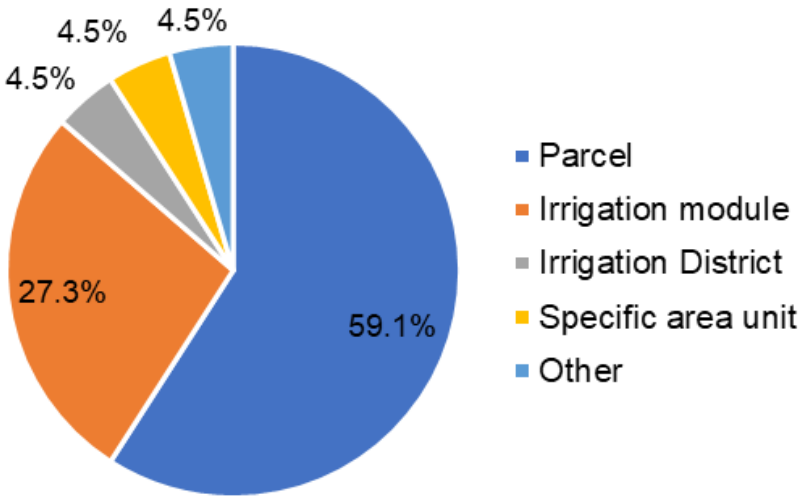

Figure 8.7 desired scales of evapotranspiration data

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

All the stakeholders mentioned having polygons or geospatial units in which they would like to have evapotranspiration data. These are determined by region, irrigation district, parcels, by the type of work they perform, such as polygons where they carry out restoration and reforestation, those defined by a training program, assistance or type of crop, and defined areas that they work for each cycle, and also by aquifer and basin.

11. Do the polygons in Question 10 contain private or sensitive information?

More than half of the participants do not have sensitive information in the polygons with which they work, and those that do, comment that the information corresponds to personal data of the producers or derived from a binational group.

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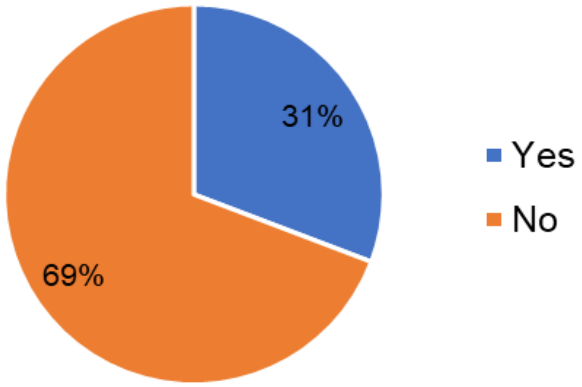

Figure 8.8 Private information in the polygons.

12. **Which geospatial software tools (or Geographic Information Systems) does your organization use?**

The most frequently used software was ArcGIS, followed by QGIS, Google Earth and Google Earth Engine. Python, Sentinel and proprietary software were mentioned the same number of times. The rest of the software that was mentioned only once were Global Mapper, Earth Explorer, MATRi, Riego tech, MATLAB, R, Landsat, Planet, Copernicus, AutoCAD and GRASS GIS (see Figure 8.9).

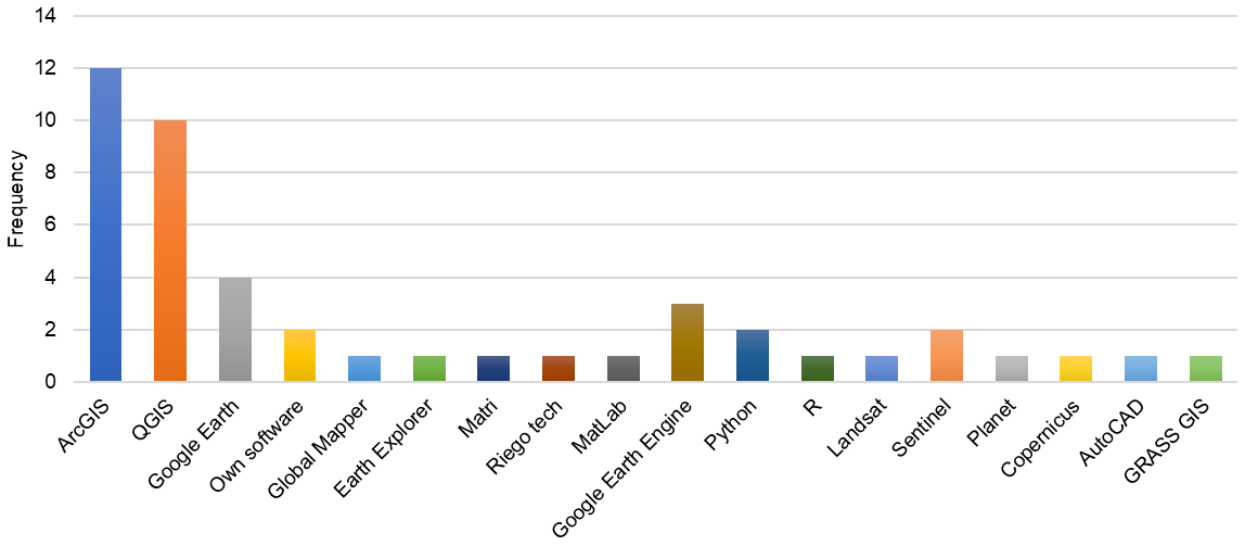

Figure 8.9 Geospatial software used by the stakeholders

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8.1.3 About general considerations

13. 1. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

All the participants showed their approval to the possibility that evapotranspiration data is public for any user.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

Various benefits of the public availability of data were mentioned, the main one being its use in agriculture and support for producers (so that with the data they improve the use of water without having to pay specialists[17]), followed by environmental research and hydrological. Other benefit mentioned was that by having this data, it could contribute to the conservation and restoration of ecosystems, the approach to the population to create ties that contribute to the sensitization and awareness about the uses of water, make its use more efficient, the exchange of ideas to solve water security problems, the generation of general knowledge and for subsequent measurements, access, management and use of information; and improvement in decision-making for the use of water.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

The stakeholders considered that for the data in Mexico it should be taken into account that the platform is not administered by any public institution within the country, since the change in administration may hinder the continuity of the project. There was also talk about the calculation and verification capacity of the data and forecasts by OpenET, as well as the possibility of relating the evapotranspiration data with groundwater.

It was also mentioned that it would be good for the OpenEt team to consider the online publication of both the data and the methodology used for its estimation. Additionally, a request was made for the possibility of having access to historical data through images.

[17] This refers to the need to hire the academy or private companies to improve irrigation systems. Specialists who carry out studies of water balance and efficient use of water resources.

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On the other hand, it was identified that synergies with universities or research centers are required in order to correctly transfer this technology to producers.

Another aspect mentioned was the possibility of considering other agronomic uses and customs[18], in addition to having access to offline data for consultation from remote locations.

Stakeholders also mentioned that some obstacles they could face are the lack of trained personnel and a deficiency in the network of meteorological stations in the country.

16. What other applications do you think the evapotranspiration data could have?

Other possible applications that the participants considered for the OpenET data were its usefulness to develop water balances, its importance in determining sustainability in terms of water requirements, the calculation of water requirements according to the types of crops, the evaluation of water consumption in an area and in the recharge of the aquifer, the management and integration of information for water governance, the modeling of forest fires, the realization of climate change projections at the basin scale, knowing the productive water (used by the plant to generate biomass) and non-productive (lost by infiltration, evaporation and runoff), its use for urban ecology and dasometric management.

17. Would you or your organization be willing to be a partner or collaborator in the development of OpenET for your state or region??

Most of the stakeholders were enthusiastic about a possible collaboration with OpenET. They mentioned several ways in which they could do it, such as the contribution and management of data, information, studies, technical assistance, provision of weather stations, exchange of ideas and experience in working directly with farmers.

18. Do you have suggestions of other partners?

All interviewees proposed potential partners, which are summarized by region in the following table:

[18] The system of uses and customs is a colloquial form of a system of self-government in Mexico practiced by various municipalities with an indigenous population to regulate community life.

Table 8.1 Proposed partners, ranked by state

State	Possible Partners
Guanajuato	- Irrigation modules and districts - Civil associations dedicated to promoting the efficient use of water - Guanajuato water fund - Guanajuato Produce Foundation - PhD Jesús Horacio Hernández Anguiano (ugto) - Bajio Water Fund - Idea Guanajuato -C3 International -University of Guanajuato (ugto) - Secretary of Agrifood and Rural Development (Government of the State of Guanajuato) - Irrigation Districts 011 and 085 - Users - University of Guanajuato San Juan del Río campus - Rio Grande Basin Council - Operating organizations
Mexicali	- Secretariat of the Field and Food Security of the State of Baja California (SEDAGRA) - National Institute of Forestry, Agriculture and Livestock Research (INIFAP) - Baja California State Water Commission - Let's restore the Colorado -Sonora Institute - Northwest Pronature - Colorado River Organizations - University of Sonora - Civil associations of users
Chihuahua	- Remote Sensors Laboratory, INIFAP - National Water Comission - Center for Scientific Research and Higher Education, Baja California (CICESE) - Potosi Institute for Technological Research (IPICYT) - Sonora Postgraduate Pedagogical Institute (IPPSON) - Nuevo León University - The Autonomous University of Chihuahua - Autonomous University of Ciudad Juárez (UACJ) - Systems of Agricultural Products
Coahuila	- Producers and their associations

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8.1.4 About particular considerations

19. How can OpenET platform serve as a support tool in determining the irrigated and planted area in the state?

The participants mentioned that the support for determining the irrigated and planted area can be given in several ways:

Table 8.2 OpenET support in determining the irrigated and planted area

State	Support Possibilities
Guanajuato	- Irrigation calculations at territorial level - Determination of loss and excess irrigation - Establishment of the relationship between sown and irrigated areas - Quantification of the water actually used for irrigation - Determination of efficiency in the system to have fewer losses
Mexicali	- Delineation of areas based on the irrigated area and evapotranspiration - Efficiency in the use of water in the short, medium and long term by type of crop and economic value - Determination of difference between authorized and irrigated volumes - Information for planning
Chihuahua	- Quantification of productive and non-productive water for the state - Determination of balances for decision making - Efficient water management in agriculture - Determination of agricultural areas with higher evapotranspiration - Calculation and determination of the state of irrigated and sown areas with greater precision and without resorting to censuses
Coahuila	- Determination of a single variable (evapotranspiration) for the efficient use of water

- **Guanajuato**

20. How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basins of the State of Guanajuato?

Regarding the recovery and regulation of overexploited aquifers, the participants from Guanajuato commented that the platform can contribute with reliable information and exact measurements available to all; in such a way that it will be possible to quantify more precisely the consumption of water in sources

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of superficial and underground extraction and in agriculture. The most important thing is that the above can be carried out in specific geographical areas, and in this way estimate and determine the evolution in the demand for water. The data would serve as input to be able to determine a regulation.

- **Mexicali**

How can the OpenET platform serve as support to the producers of the Irrigation District 014 Río Colorado in their processes of programming, monitoring, operation, design and evaluation of their irrigation systems?

On the other hand, the participants from Mexicali mentioned that the data generated by the platform can support the producers of the Irrigation District 014 Río Colorado in their processes of programming, monitoring, operation, design and evaluation of their irrigation systems, in the sense of making a better planning based on the volumes of water, with the history created with the help of the platform. Likewise, with the data, better decisions can be made since they would help to plan and demonstrate how much of the water already authorized is being used for irrigation, and this can be more efficient. At the same time, farmers can be trained to make better decisions about how much water they are going to use for their crops during the year.

- **Chihuahua**

How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basins of the State of Chihuahua as established in the State Water Plan?

The interviewees from Chihuahua said that the platform would support to have a more accurate idea of how the hydrological cycle behaves and the effect of anthropic activities, giving way to the search for alternatives to begin to mitigate them and stop the despondency of the region. In addition, irrigation could be programmed based on the area's evapotranspiration, allowing more precise irrigation and more efficient water use. The use of these satellite platforms would help regulation by allowing spatial visibility of where and when irrigation is taking place.

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- **Coahuila**

How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basin Organization "Cuencas Centrales del Norte"?

For this state, they commented that through balances, however, with this information there is only one variable (outputs), but the inflow of water and percolation are not known.

- **Guanajuato**

21. **What do you think would be the most important potential applications of the OpenET platform to support the producers of Irrigation District 011 Alto Lerma and DR 087 Rosario Mezquite in their processes of programming, monitoring, operation, design and evaluation of irrigation systems? irrigation?**

The participants from Guanajuato considered that the potential applications of the OpenET platform to support producers in their processes are the generation of better programming, distribution and use of water, since they could know how much the plants are transpiring, at the same time as they could determine the surfaces that are sown, without the need to make field trips, see which crops are best for a given area, making irrigation more efficient. This would be evidence to convince farmers to invest in irrigation technologies. Other applications mentioned by the participants of this state were the possibility of connecting or sharing and complementing the data with other programs or applications used by them and creating more accurate models of how much water is available, in addition to the fact that the government can count on this information for the creation of laws based on real information.

- **Mexicali**

What do you think would be the most important potential applications of OpenET in the Valley of Mexicali, since it is installed in the neighboring Valle Imperial District (IID)?

The potential applications of OpenET for the Valley of Mexicali are that the data from both sides of the border can be standardized; as well as share experiences and compare methodologies regarding the management of irrigation districts, particularly the Imperial Valley.

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- **Chihuahua**

What do you think would be the most important potential applications of OpenET in the Irrigation Districts: 005 Delicias, 090 Ojinaga, 009 Valle de Juárez, 090 Buenaventura, 089 El Carmen, 103 Río Florido, 113 Camargo, in their programming processes, monitoring, operation, design and evaluation of their irrigation systems?

The participants of this state considered that the application of the platform can potentially serve to migrate the current processes to a more effective technification, in addition to allowing a good management in the irrigation systems and a better scheduling of this, allowing in the future, to implement a management, monitoring and accompaniment for the producer in the area.

- **Coahuila**

What do you think would be the most important potential applications of the OpenET platform to support the producers of the Irrigation District 017 Lagunera Region and 034 State of Zacatecas in their processes of programming, monitoring, operation, design and evaluation of irrigation systems?

The participant from this entity mentioned that, precisely, an application can be to have a better programming, operation and design of the irrigation systems, in addition to the fact that a benefit of the platform would be the speed of obtaining the evapotranspiration data and the scale. An added value could include crop identification, which would be useful for irrigation modules and statistical issues.

22. **22. How do you think the OpenET platform will be useful to regulate and order the concessions of the existing Irrigation Units […]?**

The participants expressed different uses of having the data offered by OpenET for the regulation of concessions:

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Table 8.3 Possible applications for the regulation of concessions

State	Opinions and suggestions
Guanajuato	- Contribution to the hydrological balance - Know if the water levels allowed by the government are being met - Regulate the rules with real information and apply them in a better way - Contribution of technical data for the precise estimation of the volume, frequency and place of water use in irrigation - Verification of the irrigation sheet against what is established in the official concessions - It would not contribute to the regulation as such, since this issue is an administrative one defined by CONAGUA
Mexicali	- It would serve for audit - Having calibrated information, it is possible to estimate how much surface a given volume is using and in what places - It has nothing to do with concessions since they are regulated by user registers. The regulation is of another order
Chihuahua	- As an aid to decision makers in the generation of public policies for the use and management of water in irrigation units - As an input to seek more efficient and sustainable schemes for agriculture in the state - To obtain historical information on evapotranspiration - To determine the cubic meters to irrigate in each zone, crop and area - To order and deliver certain volumes to waste less resource
Coahuila	- It would not be so useful since other types of tools are required, such as timely monitoring of the parcels

8.2 Logistical landscape analysis

This section presents the analysis and a summary of the information collected, regarding the use of evapotranspiration data, current methodologies, and stakeholder perspectives according to the regions of interest.

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8.2.1 To what degree are satellite-based approaches already in use by stakeholders in MX? Which models / approaches are most common?

In general, most of the stakeholders only referred to the availability of this information through conventional and automatic weather stations.

In general, for Mexico, the use of satellite evapotranspiration data is not widely used to carry out the planning of irrigation programs, including comments from the director of Hydro-agricultural Infrastructure of the OCPBC (Mexicali Valley), Ing. Favela Uriarte, the evapotranspiration data is hardly used by CONAGUA. This is because CONAGUA exercise administrative functions only; and those who are in charge of the operation are the modules belonging to the Irrigation District.

CONAGUA is in charge of regulating concessions for the use of water, while global irrigation planning in agriculture is carried out by INIFAP. During the annual planning in Mexicali Valley, the irrigation modules generate their irrigation plans for September, and later CONAGUA collects and presents all the information to the CILA, and together with the United States the volumes of water are programmed.

Based on the above; In the Valley of Mexicali, the issue of evapotranspiration is a concept that is not handled in a practical way in the Río Colorado Irrigation District, and despite the fact that the importance of this parameter is recognized, it has not been possible to implement it in operations, because it is required to monitor specific areas; due to their climate, type of soil and cultivation; to be able to contemplate evapotranspiration in the management and application of irrigation. It is mentioned that the concept of evapotranspiration is too scientific for the farmer. With the objective of achieving empathy with the farmers, training has been given once a year, however, the subject remains too high to put it into practice.

On the other hand, CONAGUA states that they lack the personnel and resources to implement the monitoring of evapotranspiration in crops. For these reasons, the method used to estimate evapotranspiration in the Valley of Mexicali is by collecting evaporation data derived from measurement stations, and considering the areas exposed by sections of the Colorado river. Subsequently, evapotranspiration is obtained by interpolation of tabulated evapotranspiration data that are the result of studies carried out in the field. Additionally, the approach or method used by the irrigation district in

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the Valley of Mexicali to establish the water demands for crops is through a volumetric method; however, these irrigation tests were held many years ago. Currently, for irrigation plans, factors are used that relate water consumption and the surface that is being irrigated (irrigation indices or coefficients). However, the errors or accuracy of these indices are affected by the lack of accurate and real-time information.

Nevertheless; for Mexicali, it was mentioned that INIFAP has evapotranspiration satellite data available derived from Google earth engine.

On behalf of INIFAP in the state of Chihuahua, they do use freely accessible evapotranspiration information from sources such as FAO (Food and Agriculture Organization of the United Nations). Although the products were not mentioned, the use of Landsat and Sentinel satellite imagery was discussed; Planet Satellite Imagery as well as remote sensing information and Google Earth Engine. Additionally, they also use the official sources of information from INEGI and their own information derived from aerial images by drone.

On the other hand, at the University of Guanajuato, Dr. Yanmei Li and her team developed software called "Vision plant". This software uses precipitation, temperature and wind speed as input data and, using an algorithm, estimates evapotranspiration. In this sense, they do not use evapotranspiration databases; rather, they estimate it from data from weather stations. They use a network of agroclimatological stations that are installed in the government of the state of Guanajuato.

To mention some of the methods to estimate ET, the CEA Guanajuato uses the Coutagne and Turc methods implemented in a spreadsheet. They use these methods due to their ease and low availability of information, since the input data required by these methods are precipitation and temperature.

Finally, Dr. Juan Estrada from INIFAP Coahuila, commented that they use the Sentinel platform, Copernicus and also Google Engine. In the case of INIFAP, they mainly use two software to manage and monitoring water irrigation control: "IrriNet" and "CropWat".

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8.2.2 Aside from the satellite data, what types of ground-based inputs (weather station networks) are being used as inputs into those models?

In the estate of Baja California, it was commented that the Secretariat of Farming and Food Security (SADERBC) does use evapotranspiration data as input; although normally, they download satellite images to calculate indices and to be able to estimate evapotranspiration with the support of weather stations. According to Dr. Eliana Burgueño of the UABC, evapotranspiration data from measuring stations in the border area of Yuma in Arizona have been used, and within the Valley of Mexicali there is a weather station with evapotranspiration information.

In Chihuahua, meteorological stations are used, and they are stations managed by institutions such as Unifrut, or some network of CONAGUA and INIFAP. Although it was commented that the network of stations is probably outdated and generally emit the reference evapotranspiration, not the real one.

In Guanajuato, mention was made of the existence of a network of Davis-brand meteorological stations, administered by the National Water Commission, and which emit evapotranspiration data. In addition, a network of stations operated by INIFAP and which emits evapotranspiration data was also mentioned.

Engineer Gustavo Magaña commented that in Cauce Bajío Guanajuato, they use a network of 52 free access meteorological stations managed by the Guanajuato Produce Foundation, where evapotranspiration is reported in a timely and precise manner. On the other hand, the NUUP social enterprise has contracted 4 physical and 3 virtual stations with private companies, which issue already calculated evapotranspiration information.

On behalf of INIFAP, in Coahuila it was commented that in Mexico there is a deficiency of observed data, since the monitoring networks are far below those existing in the United States. There are networks of weather stations; For example, private networks whose installation method is not known, since the stations may be next to a property, a road, etc., which greatly limits the quality of the information available.

INIFAP has a network of meteorological stations that are managed directly in Aguascalientes, managed by Dr. Víctor Rodríguez, but locally there are other meteorological stations, for example, in Tamaulipas; where the citrus zone is, there is a network financed by climatic producers. On the other hand,

Chihuahua has some meteorological stations, Guanajuato also, and in the case of the lagoon, there is a network of stations and some other isolated station administered by INIFAP.

INIFAP is the institution that manages all the agricultural part essentially at the national level, and according to Dr. Juan Estrada from INIFAP Coahuila, he mentioned that they would be willing to participate with EDF by establishing a collaboration agreement.

8.2.3 How would scientific and technical experts within the community of ET modelers in Mexico characterize the quality and quantity of available weather data in our regions of interest?

The quality of the evapotranspiration estimates made on land is linked to the quality of the data from information sources such as that provided by weather stations.

The interviewees consider that a great opportunity offered by OpenET is that, unlike the methods to estimate evapotranspiration based on weather stations; and that are based on interpolating the information between stations, OpenET offers robust and more precise information, reducing possible errors due to the interpolation of the information from measurement stations.

On behalf of INIFAP in Coahuila, it was mentioned that OpenET is a very useful platform due to the speed it offers in accessing and consulting evapotranspiration information, as well as its resolution.

8.2.4 What kinds of ground-based estimates of ET are available for use in an accuracy assessment / intercomparison effort? (Could be eddy covariance stations / flux towers, or lysimeter data).

In general, Mexico has a wide network of weather stations that measure precipitation, temperature, and evaporation every 24 hours; however, these records are not updated in real time, and many of the stations are out of operation. In this sense, Mexico does not have a wide network of stations that allows the verification of evapotranspiration estimates. Some irrigation districts could have observed information; however, the availability of these data is restricted. For example, in the Colorado River irrigation district; In the central part of the Mexicali Valley, there is a meteorological observatory operated by the OCPBC Technical Directorate, however, a denser network of stations is required to verify ET forecasts or estimates.

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Dr. Eliana Burgueño from UABC reports that in the Valley of Mexicali they have a network of regional measurement stations, however, access to the data is limited and the data is in PDF format.

In the state of Chihuahua, although the types of measurement devices were not mentioned, it was commented that INIFAP has data at the parcel level that could provide an analysis of the precision of the ET estimates. The UACJ in the state of Chihuahua is carrying out a project to manage a network of low-cost soil moisture sensors, made with microcontrollers and that emit information in real time with the Internet of Things. For this, technology with Arduino and Raspberry is being used. Accordingly, the information collected could be used to verify satellite-based evapotranspiration estimates.

In Guanajuato it was mentioned that irrigation modules and districts can provide information on their crops, and information on weather stations, in order to calibrate the ET estimates. The CEA Guanajuato can collaborate with OpenET through data for the verification of satellite estimates. They manage a network of 29 automated weather stations that issue precipitation and temperature data; they also have the support of the Guanajuato Produce Foundation; from INIFAP, who also have 57 weather stations distributed throughout the state.

INIFAP in Coahuila mentioned that they have networks of agroclimatological stations in different fields in the country, but that they expect a collaboration agreement to be carried out in order to have their data available for the verification of evapotranspiration information.

8.2.5 Do technical / scientific experts think that the available ground-based ET estimates are of high quality? Are they aware of any efforts to close the energy balance at those locations, and/or any other efforts to compare satellite-based approaches for estimating ET to these ground-based measurements at specific locations?

According to TNC México, unlike the evapotranspiration data available for Mexico or on platforms such as Google Earth Engine, OpenET offers higher quality and support in its data, especially due to the coverage and resolution of the information.

INIFAP could provide plot-level data and previous, present, and future studies to verify satellite-based ET estimates.

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On behalf of the University of Guanajuato, they could provide data, such as temperatures, wind speed, etc.; as well as provide help in the use of data. Additionally, an exchange of ideas could be generated with the OpenET team, because the UGTO has the experience of knowing the farmers, and a good relationship with them.

In general, the experts and technicians commented that a wide network of meteorological stations is necessary, in order to calibrate the estimates of evapotranspiration derived from satellite information. On the other hand, they also commented that collaboration between institutions is necessary, in order to establish plans that allow information to be shared and to work on a common goal.

The director of Cauce Bajío in Guanajuato, Oscar Leal, commented that they could collaborate with OpenET by defining the sites where measurement stations can be placed or collecting data, as well as data analysis; however, they would need to contact the OpenET team.

In Coahuila, it was commented that in Mexico there is a deficiency of observed data, and the monitoring networks are far below what exists in the United States. In this sense, to validate the OpenET information, observed data is required and this is a major limitation in Mexico. Additionally, the station networks in Mexico have deficiencies, for example in the case of CONAGUA, not all its stations have the same quality in their data. It was also commented that the Federal Electricity Commission (CFE) has a network of stations, but they are very jealous and do not share the data.

8.3 Empathy map

The empathy analysis is presented graphically in the next Figure, where the perception of the people interviewed is shown.

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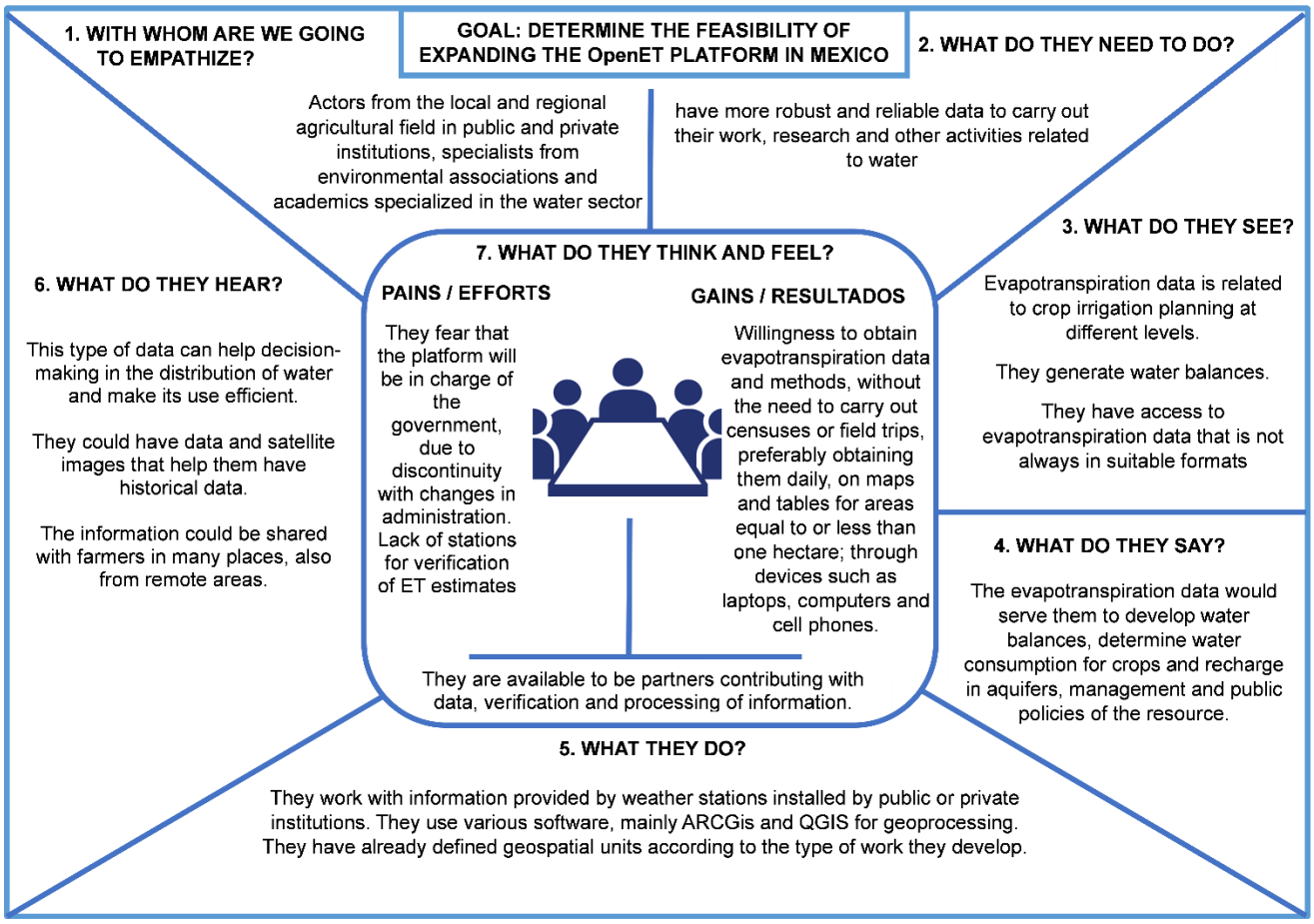

Figure 8.10 Empathy map with the interview of stakeholders.

8.4 Important framing and messaging considerations in order to establish trust in EDF and OpenET across various stakeholder groups

8.4.1 What kinds of concerns came up most in conversations about this?

Despite the good quality of the data and the free access to the information offered by the OpenET Platform, the interviewees believe that training is required for its use, since if the information is not

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interpreted correctly, it may lose its usefulness. For this reason, it is more important to know how to read and use the data than to make it free to the public.

It is important to mention that irrigation planning has not evolved, the same methodology is used year after year, with practices that are deeply rooted. Perhaps it would be necessary to reformulate the planning with the inclusion of new methodologies.

The concerns and recommendations issued by each of the regions of interest are summarized below:

Valley of Mexicali

According to the interviews, the stakeholders revealed the need to establish collaboration with and between the different institutions in the country in order to standardize processes and data.

A Comprehensive Training Plan is required for the Country's Irrigation Districts. Associated with the lack of Human Resources and trained Personnel, social and union conflicts are also added, and the continual change in staff. Irrigation districts in the country require rethinking, in order to implement better practices; since most farmers work based on experience for the decision of when to irrigate. Irrigation districts in Mexico have areas of operation, conservation, and administration, but they lack a technological development area.

Additionally, the interviewees revealed their concern about a necessary verification and calibration of the evapotranspiration data for the development of OpenET in Mexico, and they recognize that it is an arduous and necessary job for which there is not always the human resource available to carry it out. In this same context, there is a big difference in the infrastructure of measurement stations (weather) between the Mexican and US sides. The US side has a denser network of stations, and for this reason it is necessary to standardize the information from both sides; that is, having the same databases on both sides of the border. Having standardized information will allow modeling systems to be on the same page, considering cross-border aspects.

The concern of hosting or that the platform is under the control of a public institution in Mexico was mentioned, since these institutions are very vulnerable to changes in administrations. In addition, Mexican institutions lack the financial resources to develop or support OpenET-type projects.

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One of the problems is that the international treaty restricts the request for the volume of water, which is established 30 days in advance and cannot be modified by more than 20% per week. For these reasons, CONAGUA does not see much use in having the Platform.

On the other hand, there is not good communication between farmers and decision makers, and this impacts efficiency in terms of water and energy consumption, especially in times of drought.

Regarding being partners or collaborators in the development of the platform, the interviewees were somewhat reserved, because they mentioned that a collaboration with the EDF would be necessary. For example, the COLEF proposed that the OpenET team suggest coordination between the entities, in such a way that the COLEF, the Government and the research institutes can coordinate to contribute to the growth of the platform. For its part, CONAGUA also proposed an approach to restore CONAGUA's technical regulations before society, because one of the biggest problems is the lack of personnel.

In this sense, Mexican institutions are willing to collaborate as long as the initiative is given by the EDF. It was mentioned that transparency and diffusion of technology is required; and seek coordination at the Government level with the Secretariat of the Field, which is aimed at standardizing the systems and information related to the field, agriculture and water.

Finally, OCPBC commented that its way of supporting the growth of the Platform is to be the link with irrigation users (associations or farmers).

Chihuahua

On behalf of INIFAP Chihuahua, they discussed the importance and need to have free access to the data, but that said information is also accompanied by its interpretation, in order to be able to use it in efficient water management, public policies and a better awareness.

Another important point that was considered by INIFAP and CONAGUA in the state of Chihuahua is the offline operation of the platform; since in Mexico there are still places that do not have access to internet service.

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In Mexico there are communities with deep-rooted customs in terms of agricultural practices; In this sense, the researcher Jesús Ochoa from INIFAP commented that the platform could consider the uses and customs and agronomic practices that occur in communities within the state.

Finally, a recommendation from the UACJ was to increase efforts and synergies with universities or research centers to monitor and disseminate platforms such as OpenET, in such a way that local or regional universities can carry out the transfer of technology to the productive sector.

Guanajuato

From the University of Guanajuato, it was commented that OpenET team could approach the research institutes in the state, the State Water Commission and the international company C3, which provides projects in the development and implementation of technological and scientific solutions, and that ventures into information and communication technologies. The need for in situ measurements and work in the field was also discussed. Regarding this, Dr. Yanmei Li's students could support or include technical personnel.

The social enterprise Nuup mentioned that in the future, in terms of improvements that they consider for the OpenET platform, is making specific irrigation recommendations and verifying water savings. In this way, OpenET could become a public data platform, and users could verify irrigation management.

The director of Cauce Bajío; Oscar Leal commented that the platform can contribute to the regulation of the water issue; however, ordering the concessions of the irrigation units is an administrative matter, and is defined by CONAGUA. For this reason, OpenET may not be able to contribute to the issue of regulating concessions, but it does provide technical data on the volume of water required and when the crops must be irrigated.

According to Eng. Gustavo Magaña from Cauce Bajío, it would be very useful if the platform was capable of calculating irrigation needs. Regarding the collaboration of Cauce Bajío with OpenET, they were somewhat reserved and commented that a meeting with the secretary would be necessary; and that the possible collaboration in the short term could be with the technical assistance program that they currently manage. In this program they serve close to 2,000 hectares, where information is being collected in the field that may be useful to verify the OpenET estimates. Finally, Eng. Gustavo said that it would be very

useful if the OpenET platform allowed an exchange of information with other applications, for example MATRi (application used by Cauce Bajío), to determine the appropriate irrigation times.

At the State Water Commission (CEA), it was mentioned that they are currently carrying out a study on evapotranspiration in basins and aquifers in the state, and that it would be very useful for them to know more details about the methodology or new processes used to evaluate evapotranspiration. Due to this interest regarding the use of new methodologies, they request that the OpenET team share or publish their methodology used to estimate ET. Being able to know this information to users could build more confidence in the data. Finally, they also revealed their concern about the verification of ET estimates.

8.4.2 Which aspects of OpenET were most exciting for various stakeholders?

In general, the most relevant aspects for the majority of the stakeholders were being able to have free and accessible information for the entire public. Virtually none of the interviewees have a problem with the evaporation data being public, on the contrary, the majority believe that it is essential that the information be free. Having this information is a necessity for users; it is part of the governance over their resources and helps them understand how the resource they are administering and managing works.

An interesting opportunity is that several of the interviewees showed interest in the platform, especially in the arid areas of the country, where better water management is required. Most of the stakeholders agreed that public access to information can benefit traditional producers or peasants who do not have the possibility of paying specialists or accessing data from automatic stations.

On the other hand, the stakeholders indicated that OpenET platform would allow demonstrating how much water is being used for irrigation, and this in turn would help in a more efficient management of resources. Accurate evapotranspiration information could improve water management and be able to deliver the resource according to what is actually required. Unfortunately, it is unknown if the water volumes are overestimated or underestimated. This is where OpenET presents the best benefits, and could help adapt the hydro-agricultural infrastructure or create a new public policy related to water.

The most important benefits will be reflected in more efficient irrigation and harvest planning and its possible application in the modernization of irrigation and the development of technologies such as soil

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moisture sensors and intelligent irrigation systems. Having the data is a good opportunity to monitor irrigation and adjust water volumes in a timely manner

Regarding the visualization of the information, it was commented that having ET data in the form of a map is very useful and practical for consulting the information, as well as for monitoring irrigation. The most common practice in Mexico for irrigation planning is through empirical methods, however, having estimated and reliable data will allow better control; and on the other hand, train farmers.

The data could be used for projects such as green roofs and new methodologies to capture water

Valley of Mexicali

Mexicali is an area of high potential evapotranspiration, so this variable can be used as an impact for decisions related to water.

Free access to data is very important for Mexico, especially in terms of raising awareness among the population and farmers regarding the use and care of water. The evapotranspiration data is relevant, since a drought has persisted in the state for several years, so having evapotranspiration information is necessary to carry out pertinent actions.

Decision makers revealed their enthusiasm for free and public access to information throughout the year. On the other hand, having data coverage for the regions of interest in the Valley has other potential uses in addition to agriculture. Among these uses, mention was made of its application in the academic sector and research, on hydrological, climatic and ecological processes, consumptive use of water.

Another aspect that was of great interest was the possibility of having daily evapotranspiration data; especially the Valley of Mexicali, to make water balances. These balances at the level of detail would allow better decision-making and efficient management of water in agriculture.

For TNC Mexico, having ET information in the Colorado River polygons is of great help to make hydrological balances for specific events, with the objective of ecological restoration. TNC México has a particular interest in extending the development of OpenET Platform in the Valley of Mexicali, where the river corridor is located. Additionally, the platform could help to better identify agricultural areas in

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the Valley, as well as be a tool for the development and better restoration of ecosystems in the Colorado River delta.

It was mentioned that OpenET could help boost or promote projects that would definitely change the way things are currently carried out, such as irrigation planning, for example. In the Valley of Mexicali there is a continuous variation of the irrigated surfaces and change of crops, so having evapotranspiration information on a map provides a better overview of the updating of said changes over time. Having evapotranspiration data would help in the crop conversion process, and knowing if water efficiency in the short, medium and long term is a reality.

As for regulating water concessions in Mexicali, it was considered that the platform could be very useful, since, being an arid region, practically the evapotranspiration generated would not be due to rain, but almost exclusively by irrigating crops. CONAGUA were more closed on the issue of concessions, assuming that this cannot be changed, it is more complicated and that having evapotranspiration data would not serve to regulate the concessions.

Chihuahua

Regarding the exploitation of groundwater in the state of Chihuahua, the importance of having access to evapotranspiration information was commented, because it would allow a better quantification of hydrological behavior and anthropic activities (water extraction). Knowing this would lead to mitigation strategies or alternatives to stop the overexploitation of aquifers.

CONAGUA commented that the platform could help to better manage the uses of water, both from surface and underground sources, and this in turn could be applied to the implementation of regulations. Additionally, regarding the application of the platform in the irrigation districts in the state, it was commented that it would allow estimating more precise values of water consumption, analysis for the evaluation of water consumption and crop production, and monitoring of current and historical water use.

From the UACJ it was commented that the data would allow carrying out balances or programming in real time of the agricultural units, which they have already identified, as well as making projections of

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climate change at the basin scale. This would help to calculate almost perfectly what is the irrigated and planted area in the entire state of Chihuahua without resorting to censuses.

The potential uses of the platform in the irrigation districts in Chihuahua are to plan irrigation scheduling operationally by district and by module, and to use satellite data in a reliable way to optimize water in the plots. For irrigation districts, the opportunity that OpenET has is to influence the modernization of irrigation, as well as management, monitoring and support for producers.

Regarding water concessions, evapotranspiration could be used to create public policies on the use and management of water in irrigation units, which would allow the implementation of more efficient and sustainable agricultural schemes in the state.

Guanajuato

Regarding the potential uses of the OpenET platform in the state, the quantification of the use of water actually used for irrigation and determination of efficiencies in the systems used were mentioned; and the optimization of irrigation procedures, using water effectively.

According to Dr. Yanmei Li of the University of Guanajuato, the evapotranspiration data are relevant for the quantification of water consumption; above all because in the state of Guanajuato it is difficult to account for groundwater because there is no meter in many of the wells. According to Engineer Gustavo Magaña Sosa from Cauce Bajío, ET is used to determine the opportune time for irrigation. Generate awareness and culture of water. Regarding the potential uses, being able to determine the areas planted and that are being irrigated without the need to make field trips would be a very helpful tool to have a precise estimate of the consumption and volume of water used.

Both Dr. Yanmei Li and the Nuup social enterprise commented that evapotranspiration can help the selection of crops, and define which is the most efficient form of irrigation; by comparing the water used for irrigation and agricultural production, which in turn can be evidence to convince farmers that it is worth investing in new irrigation techniques. Additionally, it can also be used to convert crops.

On the other hand, Nuup is strengthening and developing a voluntary program for the compensation of the water footprint. At the moment they are giving technical assistance to producers and helping them spend or waste less water. At the moment it is only a pilot project for this type of voluntary program;

however, in order to scale this, they will eventually have to be able to not only measure the water savings but be able to verify those water savings, make it public and have anyone corroborate the information. So, one idea is that the OpenET evapotranspiration data helps to measure quickly and without field visits, water savings due to improved irrigation management.

NUUP company talked about how producers can have access to the OpenET platform in offline mode, which is robust enough but not so loaded with data, due to the intermittency of mobile data in the producers' work region. Having reliable information on evapotranspiration will allow for good programming and better use of water. The data could help regulate water concessions because it could be known where a concession is being overexploited

Nuup, CEA Guanajuato and UGTO were very enthusiastic about collaborating with OpenET and wants to follow up on this project. In the state of Guanajuato, Nuup is dealing with many allies in the sector, companies, producers, irrigation modules, government; to be able to change a little the situation of overexploitation of the state. Nuup is working with pilot projects that seek to strengthen methodologies and alliances. Nuup established their full openness to contribute to OpenET and they want to stay informed about the development of OpenET in Mexico, since they share the same concerns and desires to improve water security.

Finally, CEA Guanajuato commented on its interest in using evapotranspiration estimation methods with greater certainty and that can be fed from the available information.

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9 Conclusions

The main objective of this work was to carry out a feasibility study for the development of the OpenET evapotranspiration data platform. For the application of this work, 4 regions of interest were designated: the states of Chihuahua and Guanajuato, as well as the Valley of Mexicali in the state of Baja California and the Lagunera Region in the state of Coahuila. These regions were chosen because they correspond to some of the areas with the highest water stress in Mexico.

As main activities of this study, an investigation of the regions of interest was carried out, covering the description of their social, political, physical, hydrological and agricultural situation. Subsequently, field visits were made to each of the regions with the objective of presenting and disseminating the OpenET platform, in events and work meetings with decision makers and different actors in the water sector in Mexico. As a final result of this activity, it was possible to collect contact information from the stakeholders, which is presented from Table 7.1 to Table 7.4.

In accordance with the framework of this study, a questionnaire was developed, whose questions were designed in order to collect the necessary data on the requirements and needs of evaporation data in Mexico. Based on the questionnaire, interviews were conducted remotely to collect and transcribe the information provided by the stakeholders. The participants with whom we had contact during this study correspond to actors involved in the agricultural field, at the local and regional level in public and private institutions; specialists from environmental associations and academics specialized in water issues at surface and underground levels.

Once the data and perspectives of the interviewees were collected, an analysis of the information was carried out in order to find common points and ideas, as well as the level of enthusiasm on the part of the stakeholders in relation to the OpenET platform, as well as its concerns and recommendations.

Based on the collection and analysis of the responses of the participants from the 4 regions, an open position to the use of the data generated by the OpenET platform was observed.

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According to the stakeholders, ET is a very important variable for decision-making in irrigation management and planning, since it would allow them to estimate the water consumption required by crops. Likewise, these data would serve to carry out a better management of water resources, water balances, calculation of the water footprint and public policies related to water sector.

However, the use of satellite-based evapotranspiration data estimates is not a commonly used methodology in the regions of interest. The analysis of the interviews revealed that in Mexico, within the governmental scope with respect to water administration, it is not common to use evapotranspiration as a variable for the design, control and operation in the water sector; although technicians and specialists understand the importance of this variable for water management, they lack the human resources to apply new design methodologies, at least this is something that can be seen at the governmental level with the National Water Commission. CONAGUA is the agency that administers and regulates water concessions throughout the country; for this reason, they are responsible for quantifying the volumes of water necessary for irrigation; however, CONAGUA does not have a research area or technical area that works with models or estimates of meteorological variables, such as evapotranspiration. In this sense, the method most used in Mexico to quantify irrigation volumes is based on experience, which has been a practice for years and is deeply rooted in the country.

In addition, the participants do not mention using any specific model based on satellites, but most allude to the use of software that allows working with satellite images such as Google Earth, Google Earth Engine, Sentinel and Copernicus. In this case, some of the interviewees have their own sources of evapotranspiration data, derived from field studies or; in the case of research institutes, they use satellite information containing direct estimates of ET.

In addition to satellite data, the other type of inputs that are generally used are the networks of weather stations installed by government or private institutions. The interviewees did not talk about the quantity and quality of the data provided by these stations, however, in the interviews two positions can be inferred, the first, that the data with which they work is useful for the determinations that they make in a particular way, for example, the irrigation and evapotranspiration index, in addition, most of the interviewees mentioned that they could collaborate with OpenET platform by providing data. The second

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position is that in Mexico there is a deficiency of observed data and the quality of this information is limited.

Other methods to estimate ET in the regions of interest are the following: In UACJ Chihuahua, they currently have a project for low-cost soil moisture sensors with microcontrollers that provide information in real time. In Guanajuato, evapotranspiration data is compared with piezometric studies. In previous years, in the state of Mexicali, CONAGUA does not use evapotranspiration as a relevant parameter in its operations, but they do use a volumetric method to establish crop irrigation values.

The quality of the evapotranspiration estimates made on land is linked to the quality of the data from information sources such as that provided by weather stations, and as mentioned above, the majority, except one participant, considered them to be good, with good detail and very good level. No other satellite-based efforts for evapotranspiration estimation were mentioned.

At the moment, the actors and those in charge of managing evapotranspiration data use different software, among which geoprocessing software such as ArcGIS and QGIS predominate. Additionally, they are also supported by Google Earth, Google Earth Engine. While some research institutes have developed their own software, or use Python programming language.

Most of the actors that use ET data consider it very useful to have plot-level data, among others. In some cases, they consider it ideal to have the information in areas smaller than one hectare. In summary, stakeholders mentioned that the higher the resolution of the data, the better. Regarding the temporal resolution and latency of the information, most of the participants revealed the need to have daily ET data with a latency equal to or less than 15 days.

Farmers and operators and researchers are the actors that use evapotranspiration information the most. The current sources used by the participants in terms of evapotranspiration vary, but a constant use of weather station networks was mentioned to directly obtain evapotranspiration, or estimate it from meteorological parameters.

On the other hand, the general agreement is that the information is required throughout the year; however, they often mentioned that the most critical times when data is required are the spring-summer and autumn-winter seasons.

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The preferred ET information display option for users is maps, followed by tables and graphs as a last resort. In this section there was an interesting comment by Dr. Burgueño from the UABC, about the availability of ET data in the Mexicali Valley in PDF format, which made her work difficult, since processing the information in this way was not practical. Regarding the access and consultation of the data, the preferred devices were the laptop and the desktop computer at the same frequency. Additionally, the participants would like the evapotranspiration data to be summarized at the plot level.

In addition, most of the participants said they have well-defined work areas, and only 31% have sensitive information on them.

All participants agreed that the evapotranspiration data should be publicly accessible. They considered free access to data of the utmost importance to strengthen water governance and for the benefit of people involved in agriculture, such as producers

Stakeholders considered that the possibility of disposing of these data could contribute to improve irrigation, the calculation of water requirements according to the types of crops; the evaluation of water consumption in a given area and in the recharge of the aquifer, as well as for the environmental and hydrological research, water balances; conservation and restoration of ecosystems, the approach to the population to create ties that contribute to sensitization and awareness about the uses and other issues of water, such as making its use more efficient and the exchange of ideas to solve water security problems.

Speaking of concerns and inconveniences on the part of stakeholders, the importance and need for verification of OpenET estimates and forecasts against data observed on the ground, and the possibility of relating evapotranspiration data to groundwater were highlighted.

Other issues suggested to OpenET were to consider the online publication of both the data and the methodology used to estimate the data, as well as having access to historical data through images; examine alternatives such as a possible synergy with universities or research centers in order to correctly transfer this technology to producers; and the possibility of considering other agronomic uses and customs.

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The participants mentioned that the availability of OpenET data can contribute to a certain extent to the regulation of concessions, establishing the relationship of a certain area with its evapotranspiration data and the calculated water volume, to later compare it with the volume granted. The regulation of concessions would allow the creation or adaptation of public policies for the use of water in agriculture; however, it does not depend entirely on the availability of data, but rather on its current administration.

In order for the Platform to have a greater impact, it is necessary to approach or generate a strategy that allows the information generated by the platform to reach the direct actors, who are farmers and operators, since they are in charge of irrigation planning and They are the ones who are directly affected by the availability of water throughout the crop cycles.

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11 Annexes

11.1 Landscape of State of Chihuahua

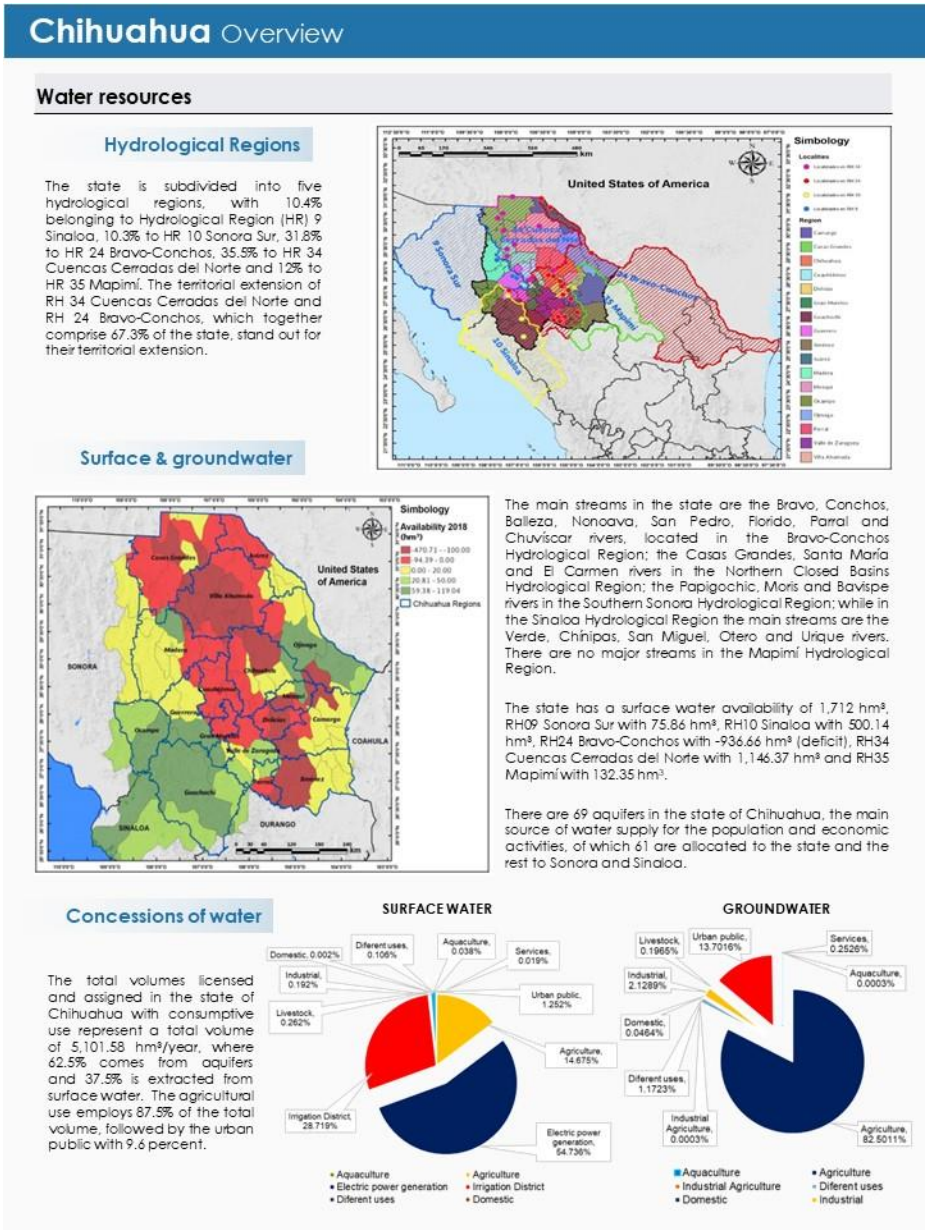


Figure 11.1 Landscape Chihuahua (1)

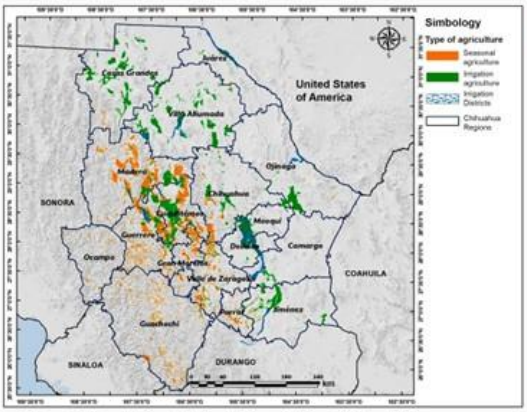
Chihuahua Overview

Water use in Irrigation Districts

The state of Chihuahua has historically been one of the most affected regions in the country by the effects of recurring droughts, mainly due to its geographic location, since it is located in the fringe of the largest deserts in the world and has faced the impacts of drought on several occasions, including economic losses and even loss of lives of livestock and people.

Name	# of users	Area [ha]	Irrigated Surface [ha]			Water volume [m3]		
			Surface water	Groun water	Total	Surface water	Groun water	Total
DR 005 Delicias	8 107	73 002.4	61 443.1	0	61 443.1	839.795	45.061	884.856
DR 009 Valle de Juárez	1 017	20 863.1	9 266.0	0	9 266.0	126.837	6.691	133.528
DR 042 Buenaventura	1 077	7 718.0	4 633.1	0	4 633.1	53.100	29.344	82.444
DR 083 Papigochic	635	7 651.6	4 376.0	0	4 376.0	30.747	0.000	30.747
DR 089 El Carmen	662	13 137.3	3 265.0	6 975	10 240.0	39.357	105.193	144.550
DR 090 Bajo Río	540	8 084.6	3 988.5	0	3 988.5	64.451	0.000	64.451
DR 103 Río Florido	1 392	8 219.3	4 670.0	0	4 670.0	69.880	0.000	69.880
DR 113 Alto Río Conchos	2 699	11 943.0	4 253.0	0	4 253.0	77.390	0.000	77.390
Total	16 129	150 619.3	95 894.7	6 975	102 869.7	1 301.556	186.289	1 487.846

Source: National Water Comission (CONAGUA), Management of Irrigation Districtsagricultural year 2015-1026



99.25%

Alfalfa, walnut and apple trees demand 99.25% of irrigation water for perennial crops.

TOTAL: 1 971.89 million m³

92%

Cotton, grain corn and green chili demand 92% of irrigation water for annual crops in the spring-summer cycle.

TOTAL: 1 774.16 million m³

95%

Grain wheat, green fodder oats and onions demand 95% of irrigation water for annual crops in the autumn-winter cycle.

TOTAL: 137.56 million m³

Main issues

Overexploitation

According to the State Water Plan, the recovery and regulation of overexploited aquifers in the basins of the State of Chihuahua is required.

Scarcity

The availability of volumes in the reservoirs is low due to the presence of recurrent droughts in the basins.

Diplomacy

The Conchos River basin is part of the Rio Bravo and year after year 450 million m3 must be contributed to the Rio Bravo reservoirs in order to comply with the 1940 Mexico-United States Binational Treaty. In recent years, this compliance in the payment caused conflicts with the federation, when the users took over the dams, forcing the Mexican State to use the Army to release the reservoirs.

Data

The agricultural statistics of almost 1 million hectares throughout the State is a problem; this is because the data from CONAGUA, the State Government and the Secretary of Agriculture do not coincide.

Water demand

The Irrigation Districts of the State of Chihuahua have exceeded the sowing of perennial crops such as Alfalfa and Walnut within their crop list, going from 10% to 50% in the last 20 years, causing an increase in the volume of water needed for irrigation and greater requirements for modernization and technification of land irrigation.

Technology

The gross lamina is high in relation to the national average of Irrigation Districts, this is due to the low application efficiencies mainly in perennial crops and walnut.

Figure 11.2 Landscape Chihuahua (2)

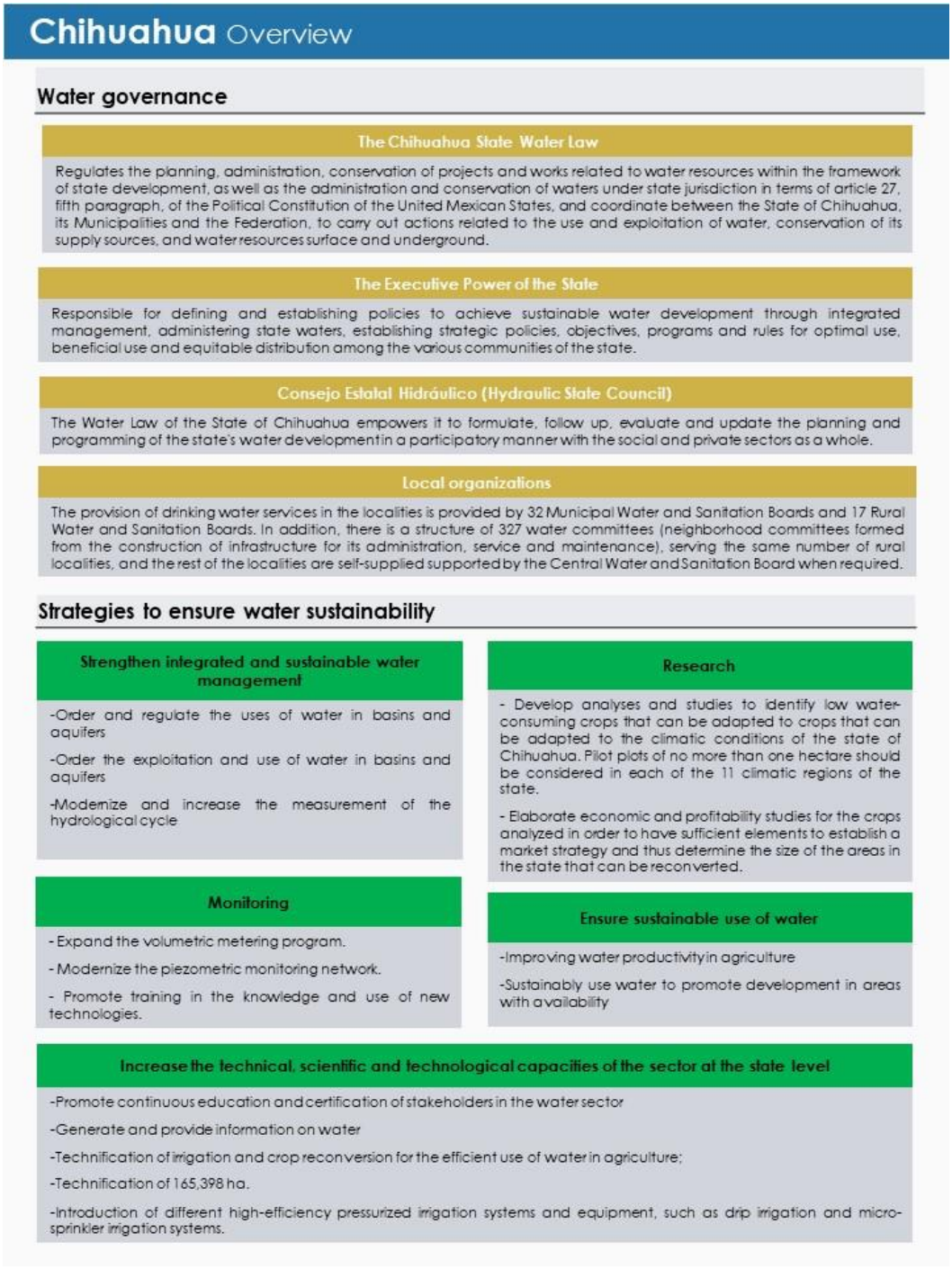


Figure 11.3 Landscape Chihuahua (3)

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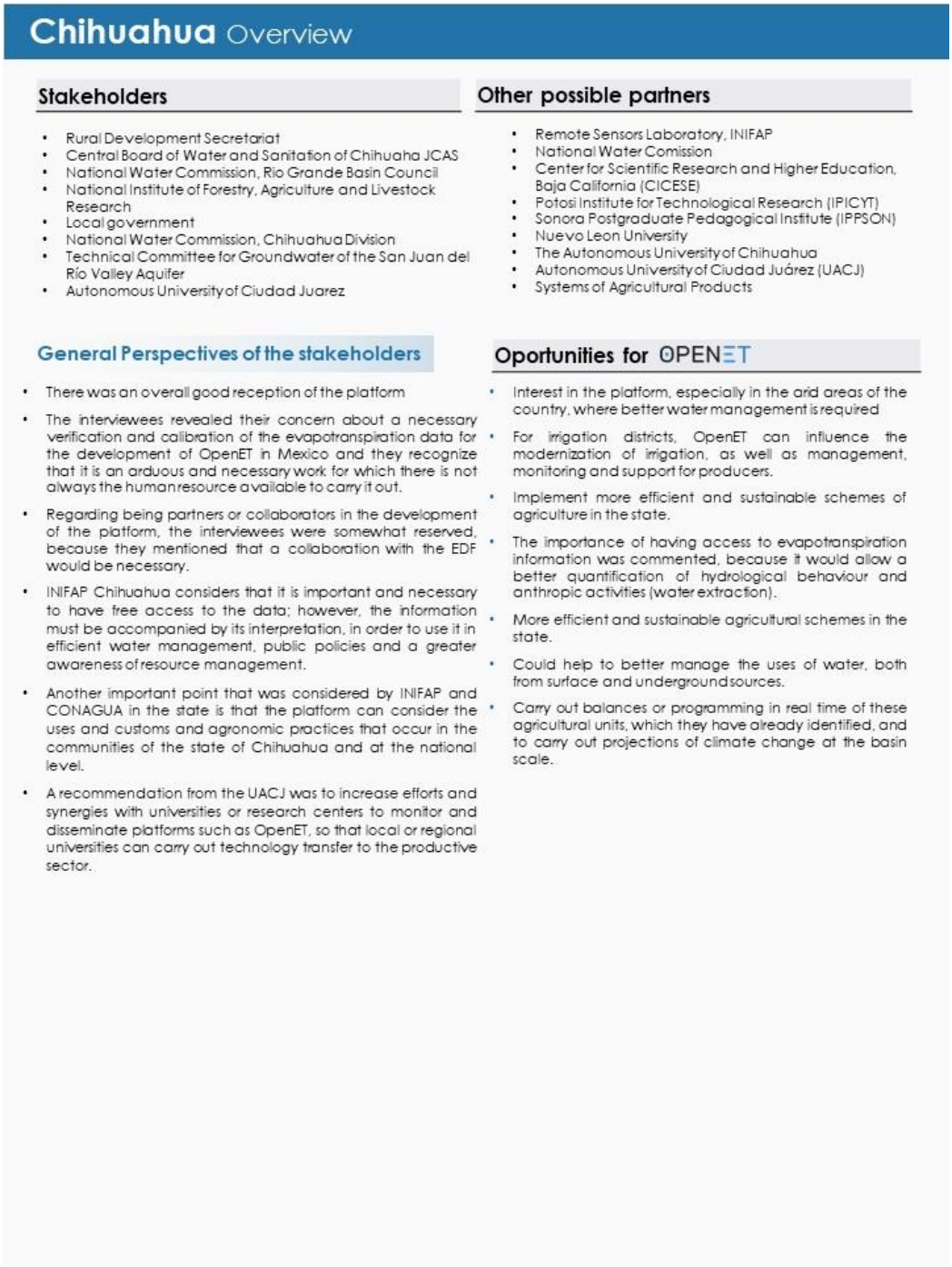

Figure 11.4 Landscape Chihuahua (4)

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11.2 Landscape of Valley of Mexicali

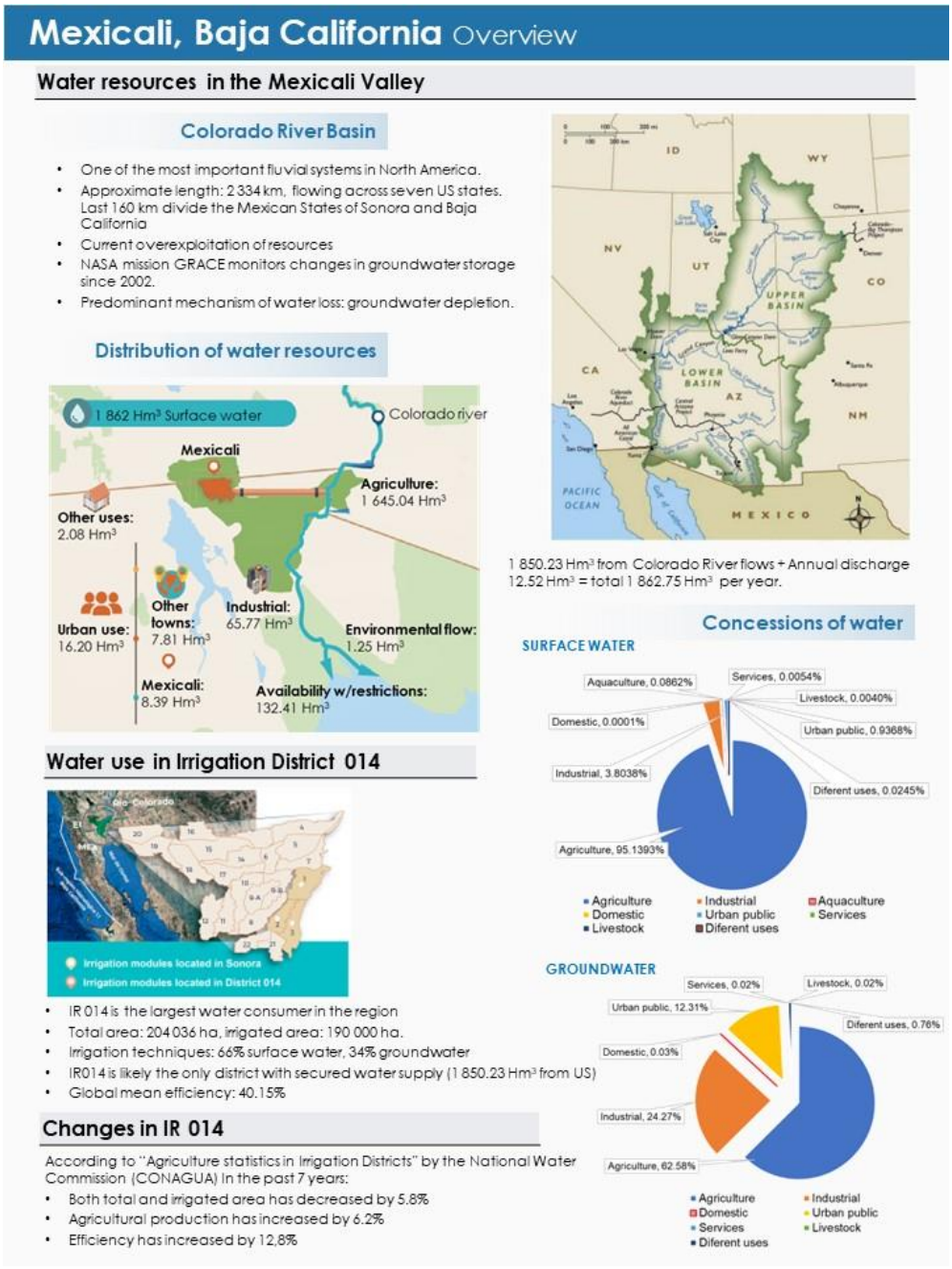

Figure 11.5 Landscape Valley of Mexicali (1)

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Mexicali, Baja California Overview

Crops in Irrigation District 014

Among the main crops are wheat grain and small onion (chives) in the fall-winter cycle; cotton and green fodder sorghum in the spring-summer cycle; alfalfa and bermudagrass, all year round. The six aforementioned crops together make up an average sown and harvested area of 164,003.55 ha, which represents 80.37 % of the total area of RD 014 (204,036 ha).

Crop	Water footprint (min) [m³/lt]	Water footprint (max) [m³/lt]
Wheat	269	785
Chives	108	345
Cotton	1 990	5 672
Green fodder sorghum	85	181
Alfalfa	166	955
Bermudagrass	80	250

Main issues

Main issue

- There is currently groundwater overexploitation. This problem was identified in 1925 by the U.S. Geological Survey, Eugene Clyde La Rue.
- Restricted use of water due to international treaties between Mexico and the United States of America
- Different water uses compete for the access to surface water resources

Water for irrigation

The planting of perennial crops such as alfalfa and fruit trees has increased from 10% to 40% in the last 20 years, causing an increase in the volume of water needed for irrigation and greater requirements for the modernization and technification of land irrigation.

Climate change vulnerability

Climate change in the Colorado River Basin has altered rainfall and temperature patterns, affecting water availability. Recent studies reported that the flow of the Colorado River has decreased by 9.3 percent for each degree Celsius increase in temperature.

Anthropogenic alteration of the water cycle.

The hydrology of the Colorado river is controlled by a series of dams and reservoirs that use the water for the economic development of cities inside and outside the basin, as well as the irrigation districts within the Mexicali Valley

Irrigation in context

The gross irrigation depth is high in relation to the national average of irrigation districts, this is due to low application efficiencies in perennial and fruit crops.

Agricultural wells

The rehabilitation and modernization of more than 200 agricultural wells that are concessioned to Distrito de Riego del Río Colorado S de RL de Ip de CV is required.

Water allocation

Water from the Mexicali Valley is received by annual allocation in accordance with the U.S.-Mexico Treaty. From the waters of the Colorado River, whatever its source, Mexico is allocated 1.5 million acre feet (1,850 Mm3) each calendar year. In cases of extraordinary drought or serious accident to the U.S. irrigation system, it will be reduced in the same proportion that consumption in the U.S. is reduced. Act 319 of the treaty provides for cutbacks for the U.S. and Mexico defined by the level of Lake Mead (Hoover Dam). In the current year 2022, a cutback of 86 million m3 is estimated

Strategies to ensure water sustainability

Rehabilitation of the potable water supply network

The volume of water granted for urban public use in the city of Mexicali guarantees the supply of approximately three times the current population of Mexicali, which points to the need to improve the operation of this system, reduce leaks in this infrastructure and consider its expansion.

Data transparency

Due to the high level of socio-water conflicts in the region, it is recommended that information on the concessions of the different users, transfers of water rights, as well as the corresponding discharges be made transparent.

Figure 11.6 Landscape Valley of Mexicali (2)

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Figure 11.7 Landscape Valley of Mexicali (3)

11.3 Landscape of Guanajuato

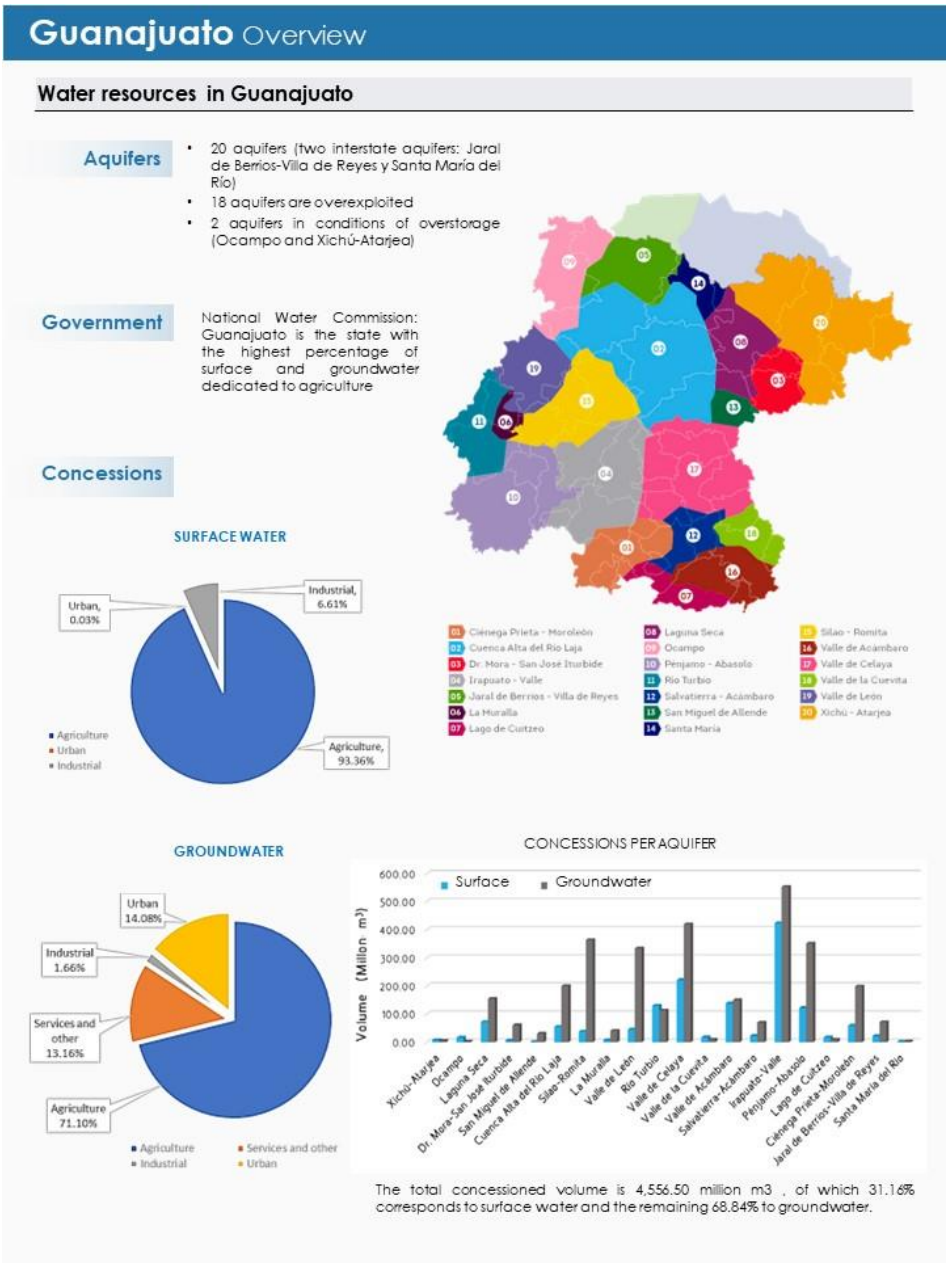
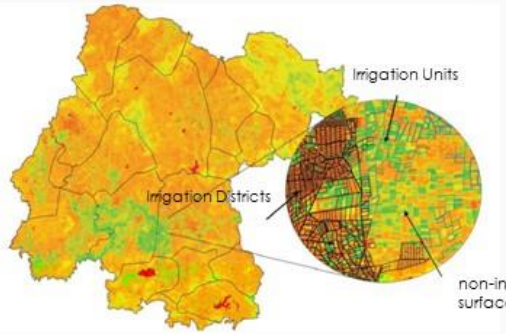


Figure 11.8 Landscape of Guanajuato (1)

Guanajuato Overview

Irrigation



The state has two Irrigation Districts, with a total Surface of 122 000 ha and 28,154 users

The NDVI was used to determine the actual cultivated area throughout the State of Guanajuato. The inventoried area is 62,352.29 hectares. Three aquifers, Irapuato-Valle, Silao-Romita and Pénjamo-Abasolo, have 53.24% of the non-inventoried surface.

Changes over the past 30 years The sown area is reduced, but productivity increases

Crops

In the case of the most important grains for the state (corn, sorghum, wheat, barley and beans), the area planted under irrigation conditions went from 388,000 to 342,000 hectares, with a 12% reduction. The area planted under rainfed conditions went from 388,000 to 342,000 hectares, a reduction of 12%, rainfed went from 565,000 to 450,000 hectares, a reduction of 20%, and overall, grains went from 953,000 to 792,000 hectares, representing a drop of 17%.

Grains

Grain production went from 2,770,000 to 3,324,000 tons, an increase of 20%. Grains increased by 36% under irrigation conditions, 50% under rainfed conditions and the average was 44%.

Main issues

Uncertainty

There is no tool to support the determination of the irrigated and sown surface by the more than 20,000 wells for agricultural use in the State of Guanajuato. The agricultural statistics of CONAGUA, the State Government and the Secretary of Agriculture are not precise and accurate.

Water availability

The availability of water in hydrological basins such as the Upper Lerma, in recent years has been greatly affected by recurrent droughts and due to the water distribution agreement of the Lerma Santiago Basin, volumes of water have to be transferred through the Ecological Expenditure to the Chapala Lagoon in the State of Jalisco.

Groundwater

The pumping of groundwater volumes has caused the existence of overexploited aquifers, generating problems of availability and quality of water for other uses, with some regional problems of scarcity and the need for rehabilitation and modernization of wells.

Agricultural use

Irrigated agriculture covers more than a fifth (21.34%) of the state surface, registering an average of 493 thousand hectares per year between 1997 and 2005. It is located mainly in the Lerma river basin, and in small areas in the flood of the Laja river. The greatest use of surface water for agriculture in the state occurs in the Lerma Chapala basin through the Irrigation Districts 011 Alto Lerma and 085 La Begoña.
The estimated theoretical demand for irrigation water in 2005 was 5,133 Hm³/year.

Livestock use

It is estimated that in the state there is a surface of one million 387 thousand 706 hectares dedicated to livestock activity, divided as follows: 22.3% of low deciduous forest; 37.0% grassland; 16.7% scrub and 24.2% forest. Livestock production in the state is concentrated in raising cattle, due to the advantages offered by the Bajo area in terms of forage availability and cost.
To obtain the demand for livestock use, CONAGUA has estimated the water allocations according to each type of livestock.
Based on the number of heads registered by type of livestock by municipality and with the endowment values, the total demand for livestock use is estimated at 42.35 Hm³/year.

Figure 11.9 Landscape of Guanajuato (2)

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Guanajuato Overview

Main issues (continuation)

Groundwater

The pumping of groundwater volumes has caused the existence of overexploited aquifers, generating problems of availability and quality of water for other uses, with some regional problems of scarcity and the need for rehabilitation and modernization of wells.

Industrial use

The industrial sector, as a user of water in Guanajuato, uses between 1 and 2% of the total volume according to REPDA data; while this sector generated 26.6% of GDP in 2003.
The results of the last economic census carried out by INEGI showed that a total of 731,350 people are employed in the entity in 22 sectors and 83 subsectors into which economic activity is divided. In the manufacturing industry, 223 thousand 352 people were employed, 30.5% of the total, and within this, the subsectors corresponding to food, textiles and leather products concentrated 55% of the employed personnel.

Urban and rural public use

The demand for domestic use depends fundamentally on three factors: the population (the number of users), the endowment (the net water requirement for each user) and physical losses (the percentage of water lost due to leaks). For a better approach to the real demands of this sector, the demands of rural areas (towns with less than 2,500 inhabitants), medium urban populations (2,500 to 19,999 inhabitants) and large cities (greater than 20,000) were considered separately. inhabitants), in order to take into account for the latter the number of users by size of the locality, the prevailing climate, as well as the socioeconomic composition in particular, as well as the percentage of physical and commercial losses that affect the level of service of the localities.

Strategies to ensure water sustainability

- Increase irrigation efficiency through modernization, rehabilitation and/or technification of irrigated land.
- Reuse of treated wastewater (Sectoral interchange)
- Crop Pattern Conversion
- Increased water supply (inflows) through construction of adequate recharge structures:
- Water harvesting through wells/tanks.
- Recharge dams on deep water table aquifers
- Promote the participation of the scientific-academic community in the state and at the national level; for the introduction of technological innovations regarding the use, handling and management of water resources.

COST PER PROPOSED ACTION

Improve the conditions for the use of water resources in the state of Guanajuato

Achieve a micro measurement coverage of 90.83% in water operator systems and maintain at 72.50% the commercial efficiency of water utility agencies:
-Develop a work program for drinking water, drainage, sanitation and reuse in rural and urban areas.
-Develop manuals for the Integral management of water systems.
-Develop guidelines, formats and stages to formalize the declaration of protection of recharging zones.

Strengthen the sustainable and balanced management of water in the state territory

Maintain the annual groundwater deficit below 978 hm3 and achieve that 20.20% of agricultural production units are trained or assisted in irrigation techniques:
-Keep groundwater and surface water balances updated.
-Monitor the hydrological cycle and water quality.
-Develop the state program of Water Culture by sectors
-Promote the modernization and modernization of state agricultural land.

Promote timely attention to extreme weather phenomena

Assist with water supply actions to 80% of the municipalities identified as vulnerable to drought:
-Issue forecasts and early hydrometeorological alerts.
-Implement a care program for hydrometeorological phenomena.

Figure 11.10 Landscape of Guanajuato (3)

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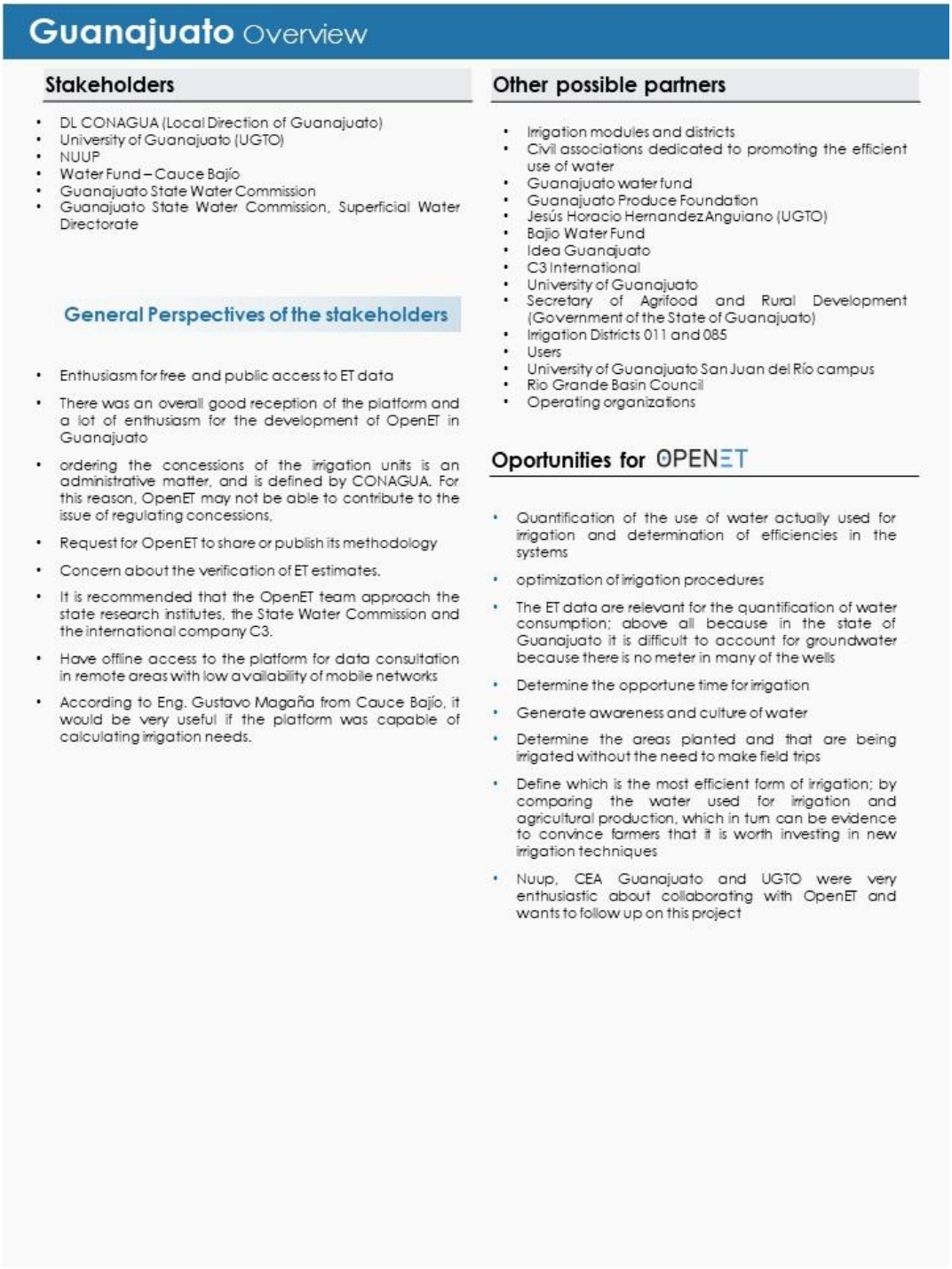

Figure 11.11 Landscape of Guanajuato (4)

11.1 Landscape of Lagunera Region

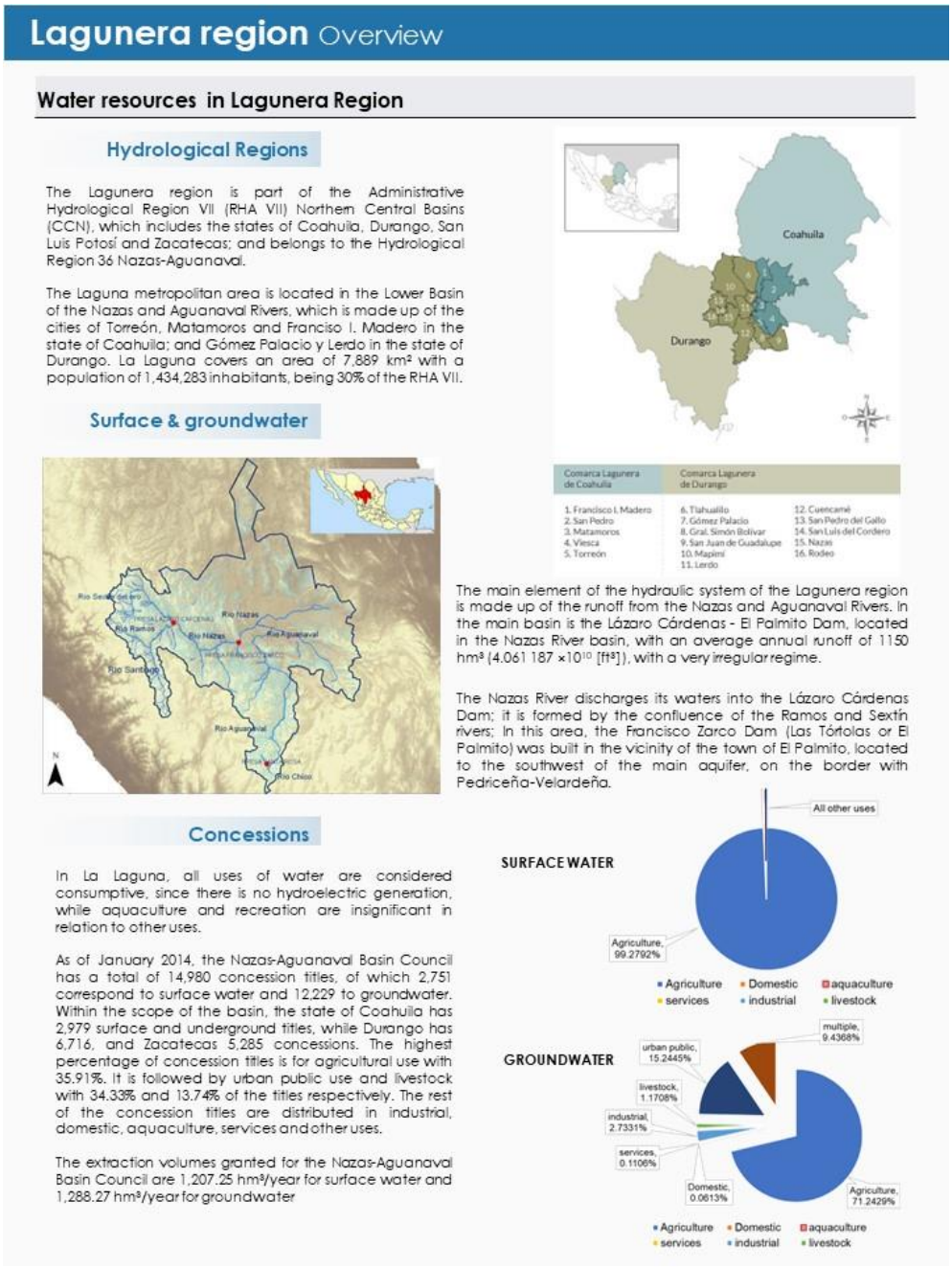

Figure 11.12 Landscape of Lagunera Region (1)

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Lagunera region Overview

Main issues

Overexploitation

The absence of rain has led to the overexploitation of groundwater, causing its overexploitation in the region; which has resulted in depletion effects and loss of water quality in the Principal-Lagunera Region.

The average annual availability of groundwater in the Principal-Lagunera Region aquifer, key 0523, is nil and presents a deficit of 149,045,850 cubic meters per year, therefore there is no available volume to grant concessions or assignments.

Water quality

In Mexico, in 1958, it was recognized that the Comarca Lagunera is an area with chronic hydroarsenicism, a time when the first effects on health became visible, which manifested as skin, liver, gallbladder, prostate, bladder and lung disease, as well as black foot disease, sterility, and miscarriages. The first epidemiological studies were carried out in the 70s and 80s, concluding that these were mainly due to the consumption of water with high arsenic content.

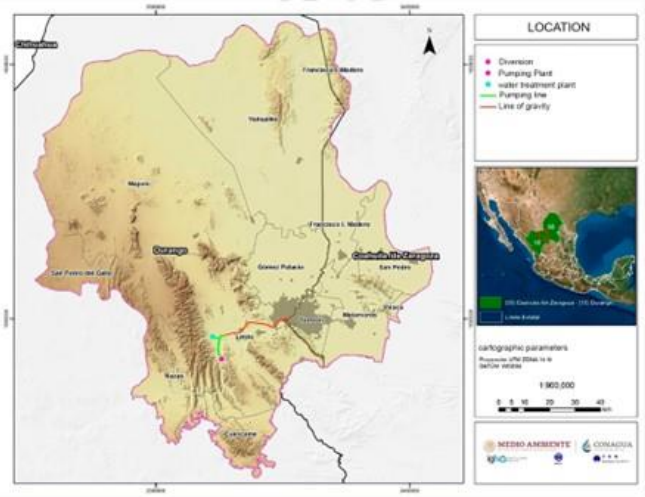
Scarcity

In the case of the Nazas-Aguanaval basin and particularly in the lower basin (Comarca Lagunera) the drought has worsened in three periods in the last 70 years: 1950-1953, 1994-2003 and 2011-2013.

Strategies to ensure water sustainability

The development of the Agua Saludable para la Laguna project

The purpose of the Agua Saludable para la Laguna project is compliance with article 4 of the Constitution of the United Mexican States, which establishes that every person has the right to access, disposal and sanitation of water for personal and domestic consumption in a sufficient, healthy, acceptable and affordable form. It is considered a work with relevance to meet basic needs by providing the resource for at least one million 600 thousand inhabitants.



Is the most viable and reliable alternative to provide drinking water to the population of the 9 main municipalities of the Comarca Lagunera, substituting the source of extraction of the resource from the Principal-Lagunera aquifer for water of the Nazas river. With this action, the over-exploitation that is currently exerted on this body of water, from which the water consumed by the population is mainly extracted, is reduced, in parallel, the resource continues to be provided without generating social discrepancies and ups and downs in economic activities, such as agriculture, livestock and the dairy sector, which is characteristic of the economy of the lagoon area.

Figure 11.13 Landscape of Lagunera Region (2)

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Figure 11.14 Landscape of Lagunera Region (3)

11.1 Stakeholder map

The final version of the Stakeholder Map can be found at:

https://miro.com/app/board/uXjVOfP7yw0=/

Figure 11.15 Identification of potential stakeholder

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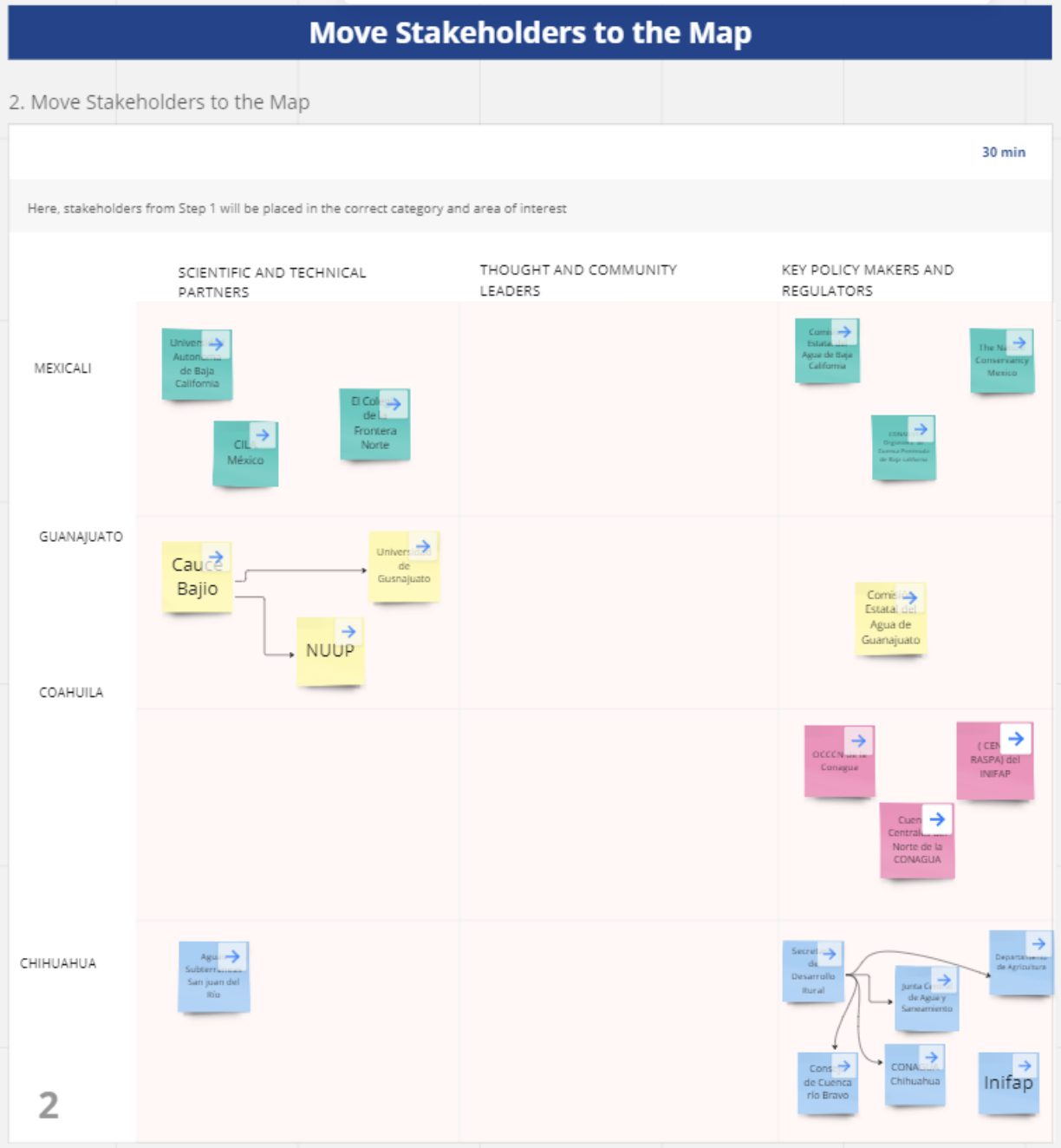

Figure 11.16 Stakeholder classification

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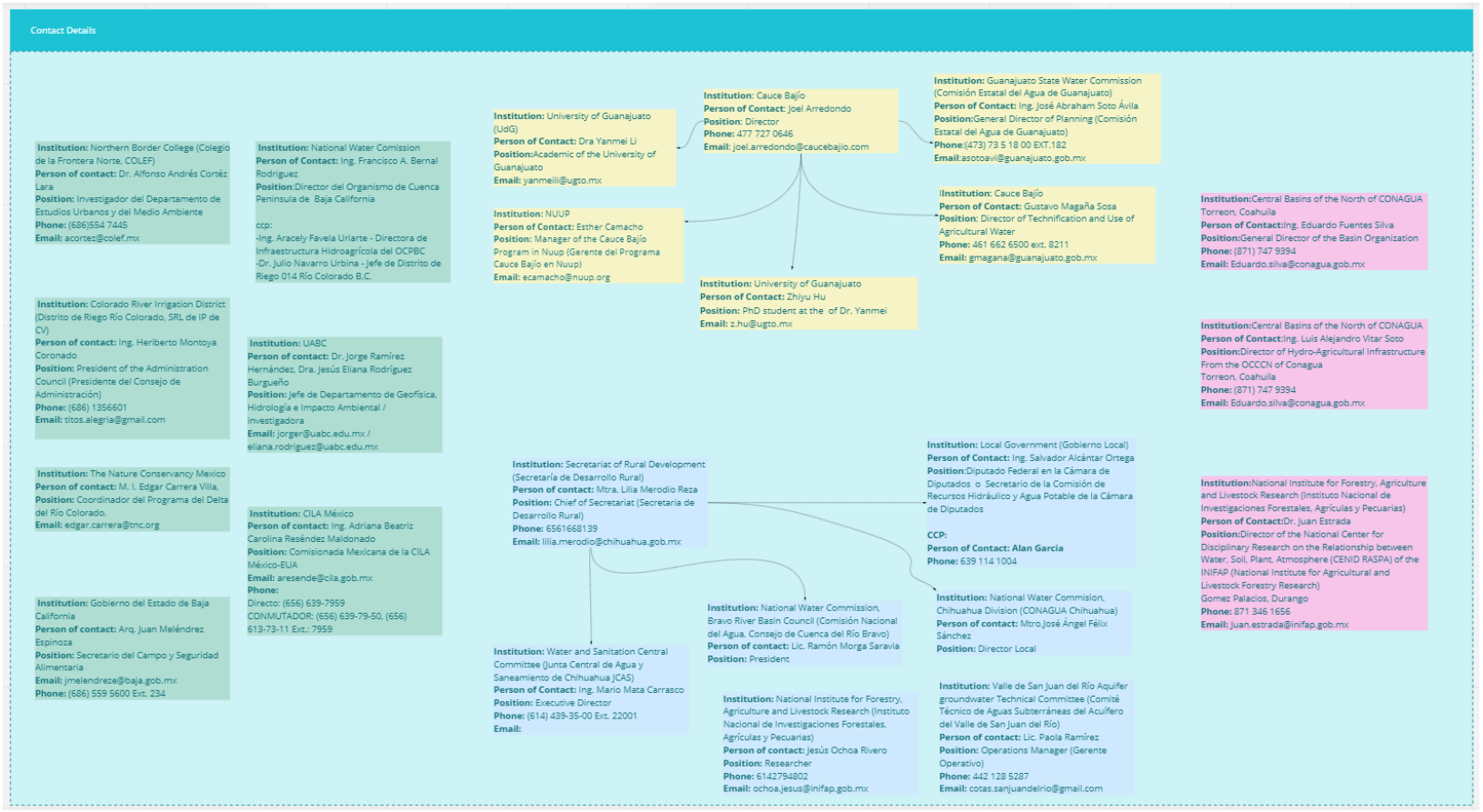

Figure 11.17 Contact detail

11.2 Transcript of interviews from the Valley of Mexicali

11.2.1 COLEF: Doctor Alfonso Andrés Cortez Lara

Contact information

Full Name: Dr. Alfonso Andrés Cortéz Lara
Researcher at the Department of Urban and Environmental Studies (Investigador del Departamento de Estudios Urbanos y Medio Ambiente)
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General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

> I have no concern, on the contrary, transparency and diffusion of technology are required. On the other hand, it is important to seek coordination at the Government level with the Rural Secretariat, which is aimed at standardizing systems and information related to rural, agriculture and water.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

> There are many potential benefits, it is important to have the availability of the variable, especially in Mexicali, which is an area of high potential evapotranspiration. This parameter is essential and should be accessible to irrigation users and farmers. Evapotranspiration is an important variable to carry out studies and for decision makers, so that this variable is used as an impact for decisions related to water.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

> I am a professor of Hydrological Measurement in Monterrey. We have a master's degree in Water Management. As I mentioned in the presentation given by Dr. Iskra, there is a big difference in the infrastructure of (climatological) measurement stations between the Mexican and US sides. The US side has a denser network of stations, and for this reason it is necessary to standardize the information from both sides; In other words, the same databases can be found on both sides of the border, because here we speak binationally, we even share the same water sources. Having standardized information will allow modeling systems to be on the same page, considering cross-border aspects.

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[x] Yes [ ] No

Additional comments:

I propose that the OpenET team suggest coordination between the entities, for example, how the COLEF, the Government and the research institutes can coordinate to contribute to the growth of the platform.

18. Do you have suggestions for other partners?

[x] Yes [ ] No

Additional comments:

The COLEF is a hybrid research institution that covers social and environmental issues, in this case, there are some other centers such as the INIFAP of Mexicali and the Institute of Agricultural Sciences of the UABC (Autonomous University of Baja California).

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11.2.2 The Nature Conservancy Mexico: Edgar Carrera Villa and Roberto Real Rangel

Contact information

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Email: edgar.carrera@tnc.org

About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

No, well, definitely at the regional level for agriculture it is an important part, right?

Currently in our neighbor to the north, in the United States, the OpenET platform and others are being used for this part of evapotranspiration. In the case of Mexico here, we know that we have the availability that INIFAP has something similar without having all the robustness or support that OPENET has in the United States, right?

Now, at the State level, the Secretary of Field and Food Security or SADER or SEDAGRA used to be called, it uses this data, yes? It just uses it as an input but they normally use the method of images and satellites, they try to calculate and indices and then they estimate it, right? This is how they do it, with data from the weather station, meteorological here.

In this sense, I think that, for example, what decisions are influenced by evapotranspiration information? Mainly I would say it: the global planning of irrigation, of irrigation in agriculture. And I say global because, for example; Who uses these more, I was telling you, the Rural Secretariat, INIFAP and CONAGUA previously used it, but it no longer has that capacity to measure evapotranspiration throughout the year, and then calculate with that, well, this is what is evapotranspired, how much is infiltrated and how much is the need for water of the plant itself and with that determine irrigation sheets by type of crop and then with that put together your annual plans, right?

2. What types of stakeholders use evapotranspiration information in your organization?

	Farmers and operators		Area directors
	Researches		Other:
X	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

INIFAP uses a platform that is in Google Earth Engine, they have this transpiration on a map, you can see that, in OpenET, you go in and it has the evapotranspiration of everything in general, all the land cover and you can draw a polygon in anywhere and from there obtain the historical record, the daily monthly transpiration historical record, etc., no, I think it is monthly, the scale is monthly, right? in the OpenT.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

Well, yes, definitely all year round, there are crops all year round, but really irrigation planning, just to emphasize that, let's say that it is the sector that uses these data the most, right, the agricultural sector, the planning of Watering is done once a year, right? it's not done... it's not that adaptive. There is an annual planning and normally the irrigation modules have to enter their global irrigation plans around the end, beginning of September and then CONAGUA collects all this here locally in Mexico, collects all this like in September and has to present to the International Boundary and Water Commission (CILA), who is also managing the dam in September, and they, in turn, do this planning in September with the United States government to program the volumes of water, how they will be delivered monthly. So, I would say that there is a critical stage because it should be around June... August... that the information for at least the previous year was available to use that information from INPUT... to say... last year so much evaporated, we know How much is this plant, so that would be like a critical moment, but in reality, since irrigation plans continue to be made, it's very... I'm going to say like... they're very bohemian, they just continue what they've always done, they never change.

5. What is the most useful data visualization format?

- [X] Map
- [X] Table
- [ ] Graphic
- [ ] Written report
- [ ] Other:

6. From what device do you think you and/or your colleagues will access the information?

- [ ] Cellphone
- [ ] Tablet
- [X] Desktop computer
- [X] Laptop
- [ ] Other:

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About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

Around 50 hectares, because first… the plots are 20 hectares and the wetlands with which we work here on the Colorado River, many of them are less than 5 thousand hectares.

The ideal would be 10 x 10 meters

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

Yes, the resolution I would say daily and in terms of availability at least every 10 days, for example; In the case of the irrigation plans, they are every 10 days, the irrigation plans are updated every 10 days, so... if you want to schedule an irrigation, you have to schedule it in the ten days before the day you want to have the water so that on that ten days your irrigation is included in the programming, so... if at some point this information could be used to feed those irrigation plans, then at least the information would have to be available like this every 10 days so that the farmer can see the stage in the one where your crop is, then look at evapotranspiration, try to project something like that forward and say well… I'm going to use a certain amount of water.

9. How do you find it useful to have ET data summarized?

- [x] By plot
- [ ] By irrigation module
- [ ] By irrigation district
- [ ] By specific unit of area (specify)
- [ ] Other:

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

- [x] Yes
- [ ] No

Additional comments:

We have polygons in a database, in a geographic information system (GIS), of the polygons of the sites where we do restoration and of the wetlands in which we work and for us at that level it would be fine.

Now, that is like in the conservation sector, we even have the polygons of the entire River in which we work, divided by sectors and that would also be useful for us, a summary of the evapotranspiration by sections of the River, because then we use it to make hydrological balances of events in which we restore environmental flows, we want to know how much is evapotranspired, how much is

infiltrated... which we currently do, but we do it by event, we download the images, we do calculations, etc. And... always have it, it would be very useful for us because we can compare... we can have, for example; years in which we do not have water and use them as a reference for our ecological restoration objectives

And now, at the district level here... 014 of the Colorado River, at least the state of Baja California has a record of the area cultivated in polygons of plots, it has it on a basis... in a chalk, which they have not wanted to share with us but I don't doubt that maybe with IMTA yes, and it's interesting because they've been doing this census since 2009 I think, they do their surveys, their flights with drones, they use an NDVI and then out there... I don't know if is it a supervised procedure or not... they demarcate the polygons, right? and they have that, the interesting thing is that year after year there are some plots that change, right? Sometimes it is 20 hectares, sometimes it is 15 hectares because an area was not planted or sometimes it becomes 20 or 40 because they rented from the neighbor, so the polygons are changing there but they already have them and so that information is there.

11. Do the polygons in Question 10 contain private or sensitive information?

[ ] Yes [x] No

Additional comments:

Notice that... those of us who have, have no problem sharing them, in fact, as part of the work, it is financed with federal funds from the United States by the Law of... the Transparency Act I don't know what, that is... all this information has to be public, but in the case of the polygons that we are talking about from the Baja California Country Department of this census that they do, well, one of the reasons why they never wanted to give us those polygons is because they just have private information, right? ? In other words... we are talking about plots of individual people and that on some occasions the census differs a little from the registry that CONAGUA has of the cultivated forest, right?, for example; It can be found that a user has a plot of 30, 40 hectares of alfalfa and then you go and see... you cross it with the record of the crop cell that CONAGUA has and it says: have... here it says that you only have a permit to plant 20 hectares and the other 10 or the other 20 from where, right? If you don't have permission,
At the end of the day, the record of the CONAGUA crop cell, they want to know how many surfaces are going to be planted for each crop and see if the water it has..., the available water is going to be enough to grow this crop No? On the other hand, if you lie to them... if that data is tampered with, then you ruin their plans, but rather what you do is that you generate that there has to be more informal water market, right? and apart you pay more, for example; there are different payments by type of crop, for example; grains pay an amount for rights, because they also use a certain amount of water, but vegetables pay more because they use more water, because they use more irrigation, they go more frequently, etc., and apart from that, since they are more profitable, then... they pay more, just like alfalfa… it is a fodder; therefore, this information and the authorized REPDA never want to share it with you.

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14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

I believe that… agriculture and the academic research part, the conservation part, are the ones that have already… been undisputed.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

It's that... if the OPENET platform is going to work the way it works in the United States, that is... it's global, it covers everything, it makes no distinction, you look at the map and everything, every centimeter is mapped, right? I don't think that's the case.

Now, for this, what should be considered? I think that what this should be considered is that... it would be nice to have this type of thing because it is going to be used, not only in the private sector, but also in the academic sector, but consider that if the platform is hosted on some public institution, public institutions in Mexico as they are very vulnerable to changes in administrations, is an example; INECC, right? We're talking about INECC almost disappearing, good thing it wasn't, but then we had another space, such as the CONABIO server and it hasn't been updated anymore; So, consider that, if this is housed within a public institution that is vulnerable to changes in administration and/or that is considered one that has a little more autonomy, right? I don't know... INEGI... that's a thing, and the other thing for development is... I don't know, I can't think of anything else.

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

☐ Yes ☐ No

Additional comments:

If you remember… when we were here in the workshop someone from the session asked: What was needed? No? And the IMTA technicians told us that... I think there was an associated cost of... I don't remember how many dollars per hectare, for the server and analysis, etc., right?

Now, I would say that on our part as an organization, there is a willingness, we have a particular interest, that is... to have this extended platform that covers at least the part of the Valley of Mexicali where the river is, for us it would be... let's say anyway, we do it every time we need it, right? Having it always would be very good.

Now, in addition to what Roberto mentions, which is the part of the capacity that we have, well... to finish quickly, this is something from EDF and... you are not here to know it and I am not here to tell you about it, but then the coordination between organizations of this size It is complicated, there are many things... because then each organization takes care of its interests and the focus

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that its work receives, right? So... normally, as our philosophy, at least in this region, is, we are always willing to collaborate, right? but we also avoid getting involved in anything that can be perceived as competition, so... on our side there may be willingness but we would have to see first if EDF wants this collaboration, it wants that partner, you know?

They are not political issues, they are issues... I would say collaboration, here it is not a political issue because we are not political organizations, neither TNC nor EDF, even though we have components, even though we may have programs or people dedicated to doing some management in policy issues but we're not organizations, that's definitely not our focus, the focus of TNC globally is always the issue of science-based conservation. In the case of the Environmental Defense Fund, I think it has a somewhat similar profile, also very scientific, but the issue is partnerships and collaborations, right?! but we have to go looking... I don't think it's convenient.

18. Do you have suggestions for other partners?

[x] Yes [ ] No

Additional comments:

In the workshop they did here I did not see the participation of, for example; the Secretariat of the Field and Food Security of the State of Baja California or SEDAGRA, that is an interesting one, and I tell you, they have that census of crops that can easily be crossed with this and do something at the plot level, right? because they already have the polygons; the other is INIFAP, that is... I know that the technician who came from IMTA at the end gave an example of the IrriModel platform system that was just developed between IMTA and INIFAP but in the workshop and as a partner I don't know if it is INIFAP but... Well, INIFAP is a partner that could be interested in this.

The International Maize and Wheat Improvement Center (CIMMYT), I also think that... in the case that they can use this to make their water balances, it could be the State Water Commission here in Baja California and, thinking about it, for example in this region Specifically, I think I would put the Bureau of Reclamation of the United States, and there is an organization called... (these data that I am giving you are the good ones, you are lucky) this organization is called... it is basically a Bank that does not have the name of Bank because then the government of the United States would require other types of things, but it is basically a fund that was created with private funds, which seeks to pay for projects that somehow make the use of water more efficient in the Southwest of the United States and the Northwest of Mexico, and they have money, they are a canning group... BLUESHIFT, and if that's exactly what it says here, its mission is to promote the incubation of projects that seek to address critical issues or critical problems of water and natural resources in the Western United States and Northwestern Mexico, so I think that more than from a technical point of view or whatever, they have money and here what we were talking about on that occasion is that the authorities that they were there, nobody said about the Mexican organizations; oh! we have money to invest, everyone said: no, well we don't have money.

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Organization or dependency: The Nature Conservancy
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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

I believe that here in the state, the most relevant thing is the agricultural part, right? I don't know how much this is currently being taken into account for the evapotranspiration variable in the field at present, but I think it would be the main use that could be around here to quantify water consumption, right? in the agriculture.

2. What types of stakeholders use evapotranspiration information in your organization?

	Farmers and operators		Area directors
	Researches		Other:
x	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

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4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

I would think that throughout the year, right Edgar? Because there are crops in both seasons, I don't know what you think.

I would think that it is a value of the information, the statistical part, right? In order to plan for next year, statistics are reviewed and thinking that this will be the case or with a certain margin of error, this... is planned, but I imagine that this also has the potential to be used, I don't know what the delay is of the timing of the publication of information, but it has the potential to be used operationally, right? Like… let's say… in quasi-real time?

Thinking of projects that could be promoted, that is... things that would definitely change the way things are currently carried out, right? which means that there is a guarantee, that it will be well adapted by the users, but considering that this can inform irrigation times throughout the year, um… there should always be this irrigation throughout the year, right? I mean... there are two

ways: one, to use the information as a way and the other as an operational way, right? I don't know if that's feasible at the moment but maybe it's something you could like... imagine, right? and see if it can be implemented.

5. What is the most useful data visualization format?

x	Map		Written report
x	Table		Other:
	Graphic		

6. From what device do you think you and/or your colleagues will access the information?

	Cellphone	X	Laptop
	Tablet		Other:
	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

But it says... spatial resolution... 30 or 50 hectares is a lot, right? We would rather be talking about 900 square meters, something like... 30 x 30 meter.

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

Temporal latency refers to the time it takes for today's information to be published, right? From a statistical perspective, latency almost doesn't matter, it's very unimportant but operative like this in almost real time, I think it would require no more than... both resolution and latency, I think no more than a week, I suppose... that is, a time in which, if you go too far, the information is of no use to you. I don't know Edgar what would you think

9. How do you find it useful to have ET data summarized?

x	By plot		By specific unit of area (specify)
	By irrigation module		Other:
	By irrigation district		

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10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

[x] Yes [ ] No

Additional comments:

Now, what Edgar mentions caught my focus, I don't know if within the areas that OpenET already has defined as agricultural plots, surely the river corridor is not there, right? because strictly speaking it is not for agricultural use, however; Right now, due to Edgar's comment, there are actually restoration sites within the river corridor, which are users of the water from the irrigation district, that is... although it is not agricultural production but rather for environmental use, if water is received from the district, then... or I mean... it seems to me that it would be a good excuse if the entire corridor could be included, what Edgar was saying, we have these polygons into which the entire corridor of the River is divided, which would be of interest from the perspective of restoration, environmental conservation . Yes, perhaps with the pretext that they are users of the irrigation district, these sites that are restoration, that are well defined within the corridor, it would be very good to include them within what is already by default in OpenET because they are water users of the district, repeating what Edgar said, those polygons already exist, they are already out there, the shape files.

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

In a way... let's say formally, you have ARCGIS PRO, I think it's called, right?... it's ArcGIS but I think ARCGIS PRO is the current Full name, but actually, I personally use QGIS but I think formal is the ARCGIS.

General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

Well, I think the important thing is that the information is available to anyone, right? but I don't know, I can't think of any concerns that it's available.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

There is an important environmental, hydrological, ornithological research sector here in the region and I think that one of the potential benefits is to improve conditions or let's say… support or be a tool for development and the best restoration of ecosystems here in the delta.

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16. What other applications do you think the evapotranspiration data could have?

The utility for water balances would be the most important.

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[x] Yes [ ] No

Additional comments:

What is the work that is required for the development of this here, that is... it is nothing more to say, well... widen the coverage area, otherwise I imagine that calibration work must be done, right? I suppose, what happens It is that our organization is physically few people here in the region, so we would have to think very carefully, exactly what activities and the commitment that would be acquired, right? and see terms and everything, right? Because the time that we actually have available due to the number of people we are is limited, then also see what is required, exactly what we are talking about with the development of OpenET, in the state right?

18. Do you have suggestions for other partners?

[x] Yes [ ] No

Additional comments:

I would think that, in all the organizations of the Colorado River, individuals who are here in the region working with restoration, they would be the ones that come to mind, right? "Let's restore the Colorado", "Sonora Institute" "Pronatura Noroeste", there are the others, but they are not physically here doing restoration work, they are the ones that occur to me.

Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area throughout the Valley of Mexicali and in the cities of northern Baja California?

Well, I don't know how the platform can do it, I mean... definitely, if it is an evapotranspiration index, surely the irrigated and planted surface will have greater evapotranspiration and it will be possible to do some delimitation of areas, right? But in the case of this region here, as it is very arid, in fact, where there is evapotranspiration, it will almost be directly an agricultural area because you will not see forests or something like that, right? An area with evapotranspiration will be almost cultivation, or I mean... I think that those that are not from agriculture will be easily identifiable, right? It's not like it's in the middle of the woods and we'll have to see how it's done to calibrate and differentiate one from the other, so well... that's all I can think of, right?

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20. How can the OpenET platform serve as support to the producers of the Irrigation District 014 Río Colorado in their processes of programming, monitoring, operation, design and evaluation of their irrigation systems?

Edgar already talked about this, right? Edgar has much more experience than me in how things are handled with planning, that is... in the Irrigation District, what I understand is that: volumes are handled at the beginning, I think they are like general principles, right? Total volume is handled at the beginning and as the year goes by, it defines what will be delivered the following month, but all respecting the volume that was handled at the beginning, but this is as well as a very general and very broad understanding of what actually happens, I think that ultimately if you have that statistical information, with that you can think about planning for the following year, based on the fact that next year the conditions with respect to the historical do not vary, right?

21. What do you think would be the most important potential applications of OpenET in the Valley of Mexicali, since it is installed in the neighboring Valle Imperial District (IID)?

In other words... that it doesn't exist in Mexicali but what if it were operating in the Imperial Valley? this is in the case in which... well, in Mexico nothing was done, here we have nothing but here the only thing is that if we do, well it seems to me that... simply that you have information that you assume that you could use that information, assume for what is so similar climate and conditions, soil, etc., you could think that this information is valid for this region too, right? evapotranspiration? I am not sure but it is already done, there is more information here with the neighbors, and since it is so close, it is considered valid, with their reservations but valid for this area, we are close here.

22. How do you think the OpenET platform will be useful to regulate and order the concessions of the existing Irrigation Units throughout the Valley of Mexicali?

Well, it ends up being an audit, right? Because regardless of what can be reported on paper, having well calibrated evapotranspiration information, you can have estimates of how much surface area and an estimate of how much volume of water is being used, right? in which places right? and even though you are reporting that your land is in rest, if you have high degrees of evapotranspiration, in fact, I think that he told us about cases like this... I am taking it from examples that Dr. Mario Montiel gave us, he told us about cases in which that they were even discovering... I'm sure it wasn't with OpenET I think there's another platform that they're developing, right? Maybe it's even the other IMTA platform that Edgar was talking about, I don't remember anymore... but in Sinaloa they were already handling it, no I know what… that they have even discovered sites, right? where... that they are reported as being on rest and that they do not have crops and therefore I think they do not pay;

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the “canaleros[19]” do not send them water, no one is sending them water but they steal it by themselves, let's say... and they discovered that there is evapotranspiration, that there is development of agriculture, well, in those parts where it has not been reported on paper, right? and in that region they have the facility, returning that it is an arid part, that the source for an agricultural field is not going to be the rain, well... that you say: it is evapotranspiring but because of the rain, that is, not... the source of water is canals , it's irrigation, so... Yes, becomes a source of information for auditing and I think that from that perspective it can help to make technical regulation, let's say, right? Administratively and all that, who knows, right? But I think so, this information would be an argument, right? because even though they are arguments... imagine that you achieved tremendous precision, you had the perfect picture of what you are actually doing, the other is that it is legally accepted and that users accept it, that is... that they believe you, obviously they are going to question the results of such a tool, right? but as a source of information to control water use, especially in this arid region, I think it can be useful

[19] The canal operator has some operational activities (such as maintaining the tension of the channel that has direct intakes from the river) and performs tours in order to make a report of the standing crops. Said report is the basis for the collection of the irrigation service fee.

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11.2.3 OCPBC CONAGUA: Ing. Aracely Favela Uriarte, Doctor Julio Navarro Urbina, Ing. Víctor Maldonado

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Dr. Navarro: The questionnaire was considered too academic and technical for what the irrigation districts handle, that is why it was not answered, because what I am going to know, just the head of operations and a very small number of people will know. In addition, we saw that there was no point answering a questionnaire as if I was a student, so the authorities of the irrigation district decided that.

Ing. Maldonado: The issue of evapotranspiration is still a concept that is not handled in a practical way here in the district, as my boss comments here, this parameter is very important, but we have not yet managed to apply the concept of transpiration in what is the district because it deals with monitoring in a particular way some areas by their types of climate, by their type of soil, by their types of crops to be able to contemplate that variable of evapotranspiration in what is the management, the application of irrigation, for the farmer this is still too scientific. Sometimes, training has been given once a year, but it remains as a topic that is too elevated or too scientific that we know exists, but to put it into practice we still lack, and need a lot of personnel, a lot of resources, a lot of intention, to see the benefits of the monitoring of evapotranspiration to crops for what is the management and planning of water, that is what we saw...**About the evapotranspiration information**

1. What decisions are impacted or informed by evapotranspiration information?

Dr. Navarro: Based on what Engineer Víctor Maldonado says, it is clear to me that evapotranspiration is the water necessary for the development of a crop, it depends on climatic factors and the soil factor. At the time, the irrigation district used the volumetric method, to establish the irrigation values of the crops, these irrigation tests were carried out many years ago and irrigation calendars were determined, which obviously with the climate change that accuses the world, have varied. but we do not have measuring devices in the field to calculate it, if we base ourselves on the calendars of the indexes of those years of the few irrigation districts in the country where irrigation tests were carried out, irrigation intervals were calculated for the crops for different textures, different slopes and as it is done currently, through irrigation plans, which is what irrigation plans do, they use factors to relate water consumption between the surface that is being irrigated, factors called Irrigation indices, irrigation coefficients, and based on that, the previous year is replicated, what happened in the previous year, and now those irrigation indices are taken and multiplied again by the areas that are intended to be planted, from after the successes and

errors that were committed in the previous year when obtaining that irrigation index, since it is affected by the new planning, that is why it is important to determine the evapotranspiration in real time to define the irrigation calendars since they are modified and they are affected by not having that real-time climate information, and we also don't have the necessary personnel to be doing those calculations. In addition, a comprehensive training plan is required in the irrigation district and in all the irrigation districts of the country to be able to train district personnel who are very heterogeneous, sometimes the personnel assigned to the technical areas do not also meet the profiles. of irrigation for them to make those decisions and that is what affects the most, is the human factor and the lack of information to have in real time or to calculate it in an accumulated way, the consumption of water, the crops, this function of climatic variation.

We have received talks from different institutions, mainly from IMTA to use GeoGraphic Information Systems, satellite images and all that information to make the calculations, we also work with the World Bank, with which we had a project 3 years ago, an interdisciplinary group of several areas but failure with the start of COVID, here the intentions unfortunately go from more to less, the number of trained personnel we have, the union issues that we are here addressing as an irrigation district, since we have 3 or 4 engineers and the replacements of the personnel that we have in the district, and I am not misogynistic, but there are a lot of female personnel that it is difficult to send them to the field to do this type of work, because they are at risk, the personnel is put at risk, we have a great labor problem , not just technical. The staff is either very young and is learning and there are very few of them, or they are on the way out. It would be necessary to reinvent the design of the irrigation districts of the country so that they are more normative and with an experience in the quality of the service that they are providing to the limited liability companies and the irrigation modules themselves.
I can say that evapotranspiration is used indirectly, because that is what user associations carry out to do agricultural planning, since it is obtaining statistical information on past events, water consumption is related to the surfaces of irrigation, and irrigation indices or coefficients are obtained and these are the ones that are applied to redo the planning of the following agricultural year in question or the month in question.

2. What types of stakeholders use evapotranspiration information in your organization?

[ ]	Farmers and operators	[ ]	Area directors
[ ]	Researches	[X]	Other: Módulos de riego
[ ]	IT specialists		

Karla: Do you as an organization, independently of the farmers, use evapotranspiration data?

Dr. Navarro: No, we do not have information, we have previous data, previous information, we do not have adapted weather stations and personnel who are precisely processing all of this information. We handle the water through an international treaty that has serious restrictions on your requests, the water

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request is requested two months in advance, 30 days in advance, sorry, the volume of water for the following month is requested, 30 days. And then, there are restrictions for weekly volume changes as well, you cannot request a change of more than 20% weekly, which binds us, which cannot be changed by that international treaty. It is a rather strong padlock that prevents us. So we plan the water 2 months in advance, and we concentrate the information, we purify the irrigation modules, we review their certificates, we purify them, we review the famous irrigation indices and we recalculate what it says to see if it is good or bad, We also have to review the market situations, because sometimes we are scheduled for various production lines and crops that later do not occur because they did not have credit, make adjustments that are more of an economic nature, see the situation of the seeds, fertilizer, if there were or there was not, and all this also interferes with the question of the calculations that we do not have in real time of evapotranspiration either.

An advantage that we have in this irrigation district is that there is a certain capacity for integrated water management, that is, to combine the operation of the aquifer with the waters of the Colorado River in different proportions and in different places, each one with very special situations, but as I told you, the management of water in this irrigation district is very complex.

Karla: In the event that they could have access to this type of data, they identify:

3. If available, what are the current sources of evapotranspiration information?

We have a meteorological observatory in the central part of the Valley of Mexicali, which is operated by the Technical Directorate of Basin Organizations. In that place, a lot of climatic information is processed with which we could refine some data, but it would also be necessary to know how large the area of the influence of your information, and I understand that the intention of working based on evapotranspiration calculations, is that weather stations are required in the plots and with a higher density in order to have a better forecast.

Karla: In the event that they could have this information, identify:

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

Well, of course, in times of maximum demand where we have the junctions of winter and summer crops, the winter crops are in their last irrigation and the summer crops are about to start, as this is where the maximum driving capacities are requested. of the channels and that would also help us, in the winter season (October, November, December). I also want to comment that they confine us that since we deal with an international treaty, we make the annual request, we make an order for a fiscal year, that is, from January to December of the year in question, while the agricultural years begin in October and they end in September of the following year, so there are three months, which are October, November and December, in which we have to leave them insured for the endowment of the agricultural year as is done at the country level, but as it is an international treaty, we have to play with these two situations, because even though it is an international treaty

and we can ask for water that we had reserved for December, we could ask for it in July or August if we had a problem, but then we pull the blanket and uncover the coming agricultural year, then we have we have to take care of the fiscal year and the agricultural year also to have the endowments for October, November, December, we are going to say, like the checkbook starts again for the farmers, but for our country, for the irrigation district, we are in fiscal year process.

The fiscal year and the agricultural year, of course, make water planning difficult, and we can no longer defer the water for the following year, I cannot send the December water for January because I don't have a dam, I already programmed it, so I stay with her, and they are situations, aspects of improvement that must be resolved with the American authorities, through the international water commissions that are also involved in this situation.

Karla: ¿Which one:

5. What is the most useful data visualization format?

X	Map		Written report
X	Table		Other:
	Graphic		

6. From what device do you think you and/or your colleagues will access the information?

X	Cellphone		Laptop
	Tablet		Other:
X	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

Ing. Maldonado: As a CONAGUA dependency, we meet the needs of the users or of the irrigation modules to request water from the United States, so it would be interesting in some areas, it may help us with areas of 5,000 ha, which are almost what a module covers and there may be interested producer users, so there would be 50 ha. For micro monitoring and for macro monitoring, which with 5,000 ha is already almost a complete module.

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8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

Ing. Maldonado: It can be daily to finally have the monthly accumulated and based on that, to be able to make a comparison of how evapotranspiration is behaving or monitoring crops or water delivery.
The historical information would only help us to see how efficient we were in the supply for the irrigation service, but in order to have the request for the orders for the users we have to start two months before, so if we have delayed information, it would not help a lot, maybe simply to evaluate perhaps a previous agricultural year, what its behavior was, but at this moment, the current agricultural year would not help us because we are ahead of schedule with the water request.

Dr. Navarro: The irrigation district has 92 irrigation sections, approximately 5,000 ha, it is variable, there are 22 irrigation modules and the zones are about 25 irrigation zones, it is also variable sizes, to integrate the demand from all these associations, the meetings take about 15 days, to put together all the modules and make adjustments for the demand in which we can decide for the following month, but we have to prepare it one month in advance, so there are 2 months, which is what Víctor says, and how much it would vary at the district level, it could be one meter or 4 m^3/s that we would be modifying, the projection for that month can vary, from one meter to 5 m^3/s, speaking in volume It is already considerable because we are talking about 2.5 million to 10 million in a month that we would be deferring for another month or advancing it too, failing that, but that is the capacity that we have for the integration of information, I wish we could predict, the detail is that we need the information to come from the irrigation modules, the user associations, because we authorize them a volume and they are the ones who distribute it and if the volume that we authorized is not there, then we would already enter into a conflict , and the truth is that there is a battle with the human team, because it is the one that requires the most training and also, well, confronting its authorities, since each module is an autonomous authority, since they have presidents and associations and all that, and not all of them love each other Incorporating it into the technological processes requires much more, about 15 days.

9. How do you find it useful to have ET data summarized?

X	By plot		By specific unit of area (specify)
X	By irrigation module		Other:
	By irrigation district		

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10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

[ ] Yes [ ] No

Additional comments:

We only have geographic information, the plans in Autocad, we have tried other software to have digital information but we use it little because we do not have the necessary personnel dedicated to a development area, I talk to the irrigation modules when I invite them, at least me, because CONAGUA does not invite me, it is that the irrigation districts in the country have operation, conservation and administration, they do not have a technological development area, CONAGUA does not have, of development, the society of limited liability, which is analogous to what we do, it does not have a telemetry, control, or research development area, there is none, the irrigation modules do not have it either, so that is what makes these processes of how to do it if we don't have the staff and we don't have development and technical support areas, we work fast track, something urgent arrives, something else urgent arrives, we leave the other and go for the other, it's a disciplinary body, that's what we are currently facing. But if we have a Geographic Information System where all the irrigation modules are, georeferenced information to be able to set up any information system, there is basic information that we could use at any given time to implement measures.

11. Do the polygons in Question 10 contain private or sensitive information?

[ ] Yes [X] No

Additional comments:

Dr. Navarro: I remember that IMTA helped us develop these Information Systems years ago. Of course, when this situation of georeferencing and all that was born, it began to oversell, everyone came selling and we had the same thing many times, but they are IMTA bases. That's where it started, we use Autocad to carry the volumetric monitoring information of the concession titles basically, we don't go any further.

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

Ing. Maldonado: The polygons that we have are in KMZ, it is not software like that.
Dr. Navarro: Autocad for our construction projects and all that, and Google Earth, where we set up the same thing, sometimes comes out of date due to the nature of the scales, but we basically try to solve it.

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General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

No, it is better that they have them, there is no problem for that.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

Sometimes they generate problems, when we face other user sectors, outside of irrigation, if they are users of urban public use or those of ecological use, basically they are other large consumers, because they start to observe the data of the district and they will always be saying that we are inefficient, which is what is customary in Mexico, by always pointing out that the irrigation districts in the country are inefficient, that there is a lot of waste of water, that their overall efficiency is quite low, although here we presume that we are the higher, but this is how this type of situation is generated, not because they want to join in helping to develop it, but simply because in our case there is quite strong competition with the waters of the district for the management of the coastal zone of Baja California outside the Colorado River basin, so that situation is always going to be kept in mind, that it is managed efficiently and inefficiently and all that, but after all, I am in charge here of the district of irrigation, I see and know many things that can be done, only we do not develop them for economic reasons, lack of personnel, but we have to continue and learn to live with the other users of the irrigation district and the public sector as well, we have to learn to live together and that they also know the importance of the irrigation district for the society of Baja California, that the only water available is that of the Colorado River and the farmers have it under concession..

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

Dr. Navarro: Basically, turn first to CONAGUA and find a way to compensate and establish CONAGUA's technical regulations before society because we lack personnel. It was talked about before, for example, from the 70's, 53 years ago, they went ahead with a program called "PLAMEPA" (Programa de Mejoramiento Parcelario) where all the efforts that you are telling me about right now when mentioning evapotranspiration were being made. All these efforts were made 50 years ago, there was enormous financing, there was enormous training, an enormous hiring of technical specialists in water management to make it more efficient, but that was when the water boom existed, at least in this district. there were surpluses of irrigation, more water came from the Colorado River, right now is when we are occupying it, I believe that the country should turn towards CONAGUA, the various sectors that are established. Water has already been established as a priority and they say that it is essential for survival and all that type of situation,

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but we do take care of personnel to be able to face all those challenges that the current world is imposing on us and that Mexico has in all regions.

16. What other applications do you think the evapotranspiration data could have?

Dr. Navarro: There are many methodologies, there are many routes to reach the same thing, it would be a matter of evaluating what other methodologies there are to be able to compare them. It is like when we talk about, to say something, the decision of a hydraulic structure, there are many types of hydraulic structures and they all do the same thing in water when we talk about evapotranspiration, it can be done with gravimetric methods, or it can also be done with images of satellite, which is more practical, perhaps it is more practical to handle satellite images for large surfaces, but at the plot level, I believe that the gravimetric method will take them locally, only that it would be necessary to do and think about a combination, same calibration, could that be true.

Ing. Maldonado: For us it would be what water management is, but the concept of evapotranspiration is tangible in what is the agronomic issue at the producer level, because if you have a better efficiency in the application of irrigation, you will save water, and that is what benefits us, it will be more efficient in water management but, also in its productive activity, by applying irrigation in a better timely manner, it will also be reflected in what is the production of his crop, and the crop that the farmer is managing will also be more profitable. Those would be the issues, from the water issue and from the production issue or application of inputs to the plot, we see management at the macro level and the management of what is plot or micro, well, it would be up to what is the farmer or producer.

Dr. Navarro: To close, in this context the need stands out, I say again, in CONAGUA, in Limited Liability Companies, to strengthen what it previously had in the irrigation districts, the Irrigation and Drainage Engineering Area, We no longer have the Irrigation and Drainage Engineering office, which was not only in charge of monitoring irrigation, but also advising on the different lines, but also on the issue of drainage of agricultural land, and we are no longer doing specialized studies on salinity, on the concentration of salts, etc., we are no longer doing these types of studies and they are hindering or impoverishing agricultural land and irrigation districts, and we do not have that information, that is also important. I believe that the basis for these developments is to strengthen the irrigation and drainage offices in all the irrigation districts of the country. The area of operation is dedicated to opening and closing keys and gates, the area of conservation to attending to the conservation of the infrastructure, etc., but the thinking being, the philosopher, the one who solves things of talent, of development, is the Irrigation and Drainage Engineering office, and we no longer have this office with the necessary personnel, so we have to turn to see those Irrigation and Drainage offices, that is why we have insisted a lot, but curiously, the person we had here was fired when there was a personnel cut, then it is necessary to retake them.

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17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

We have no problem, we have to assess what support we would have because if it is with our staff that we have, I think we could not, we would have to have a special project in which technicians are assigned to support us, and we will also gladly support or participate in that way, but if we occupy the assignment of specialists also for this activity.

Collaborate: The best way is that we are the bridge or the link between the irrigation associations, call it associations or farmers, we are the link, if we don't provide the facilities ourselves, no one can say it would be difficult, no one can come to work like this, in an association in some module without the users themselves coming to ask us "hey, let's get in, we don't get in, how does it help us, are they convinced", we also follow up on it, but it's required to question economics, is very important in this.

18. Do you have suggestions for other partners?

[ ] Yes [ ] No

Additional comments:

Of course it is the civil associations of users that can approach them, but as I tell you, a reflection, I think it applies to everything, to farmers, to irrigation modules, they do not like to pay for training, they like to be paid by the government, and I do it with due reflection because we have seen it on many occasions that we have tried, they start them and then they abort them because they say, well, that the state government supports me, well that the CONAGUA, and we follow him, but if the government does not finance this noble action, I believe that the results that could be obtained would be very modest..

Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area throughout the Valley of Mexicali and in the cities of northern Baja California?

All this is a result, see, observe, the determination of irrigated and planted areas in the Valley of Mexicali, of course it helps us, the systems we have for the issuance of unique planting permits, by regulations, what we authorize , we authorize a single planting permit for a certain area and another area is actually planted because the plots are not adjusted to what the government defined as what they have registered in the register, and here we have a larger irrigated area than the one registered, and there is a contradiction here, the unique permissions, hopefully you can explain it to me. The sole planting permit is given by area, but it turns out that the government manages volumes, manages concession titles that are volumetric, so of course the tool will be

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able to help us understand the difference, or know the difference of how far there is each irrigation module, each user association, what is the difference between the authorized volumes and those that are actually irrigating, so if it would help you, but not for coercive aspects but for planning purposes, why, why, I'm going to enter a bit in details. In the statistics that we manage, that error also occurs. In the irrigation index, in the irrigation coefficient that is used, the error goes if the irrigation area is exceeded, it also goes there, then it alters that information, so, of course, a platform of this type can help to have much better information for planning

20. How can the OpenET platform serve as support to the producers of the Irrigation District 014 Río Colorado in their processes of programming, monitoring, operation, design and evaluation of their irrigation systems?

I think I answered it right now with the previous point, it is 19 and 20.

21. What do you think would be the most important potential applications of OpenET in the Valley of Mexicali, since it is installed in the neighboring Valle Imperial District (IID)?

The Imperial Valley is managed in a very different way. I told you a while ago, if you see in Google Earth the color of the Imperial Valley against the image of the irrigation district with the green that you see there and the green that you see here, it's a brownish green here, it looks like the blood of the who has diabetes and there a clean blood. They irrigate in an open furrow or open beds, the length of the furrow pours a drain, instead here there is a stopper at the end, so from there it is already different, they are allowed and they are not fined, to drain 30% of what that they receive in the intake, and it is allowed to do this soil washing, those practices that we do not do, so they cannot compare us. Proudly, I believe that we have more infrastructure than Valle Imperial, I believe that our efficiency is greater, but as I told you, irrigation is taking place in the same way that Valle Imperial is over-irrigated. I don't think Imperial Valley serves as an example. This irrigation district is more heterogeneous due to textures, heavy, medium, light soils, etc., and Imperial Valley has lower quality soils than this irrigation district.

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22. How do you think the OpenET platform will be useful to regulate and order the concessions of the existing Irrigation Units throughout the Valley of Mexicali?

No, I think that there is nothing to do with it because the concessions are regulated by the user registers, and the user registers are well determined in each user association. Maybe if we said that there are exceeded areas somewhere, but they are not exceeded areas, it is the intensity index, the repetition index that is used in the irrigation district is different in the associations, and suddenly their types of ground, but I think not at this point, the regulation and ordering of the concession is of a different order.

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11.2.4 UABC: Dra. Jesús Eliana Rodríguez Burgueño

Contact information

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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

Mainly I think it is the management of water resources, this is because evapotranspiration is part of the balance, so these outputs from the system that in agricultural areas such as here in the Valley of Mexicali, apart from the climate in which we are in a semi-desert area, since the uses and requirements of water are also affected by the information that we can obtain from evapotranspiration for the balances both at the plot scale and at the regional scale of the Valley area.

2. What types of stakeholders use evapotranspiration information in your organization?

	Farmers and operators		Area directors
X	Researches	X	Other: The students, they also make use of the information with their postgraduate training process.
	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

There are some regional stations here in the Valley of Mexicali area, however, for the information you have to make an account and they are in PDF format so it is not very easy to enter. There is also the evapotranspiration data from stations in the border area of Yuma and also here in California, and we also have a station in the Valley of Mexicali, which is where we have evapotranspiration information.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

For the agricultural cycle, considering whether it is necessary to carry out a precise balance with the information that can be obtained there, if it would be monthly, however, if we want to say that there is a specific temporality in which, well, we do not have all the resources, within that importance would be in the areas where there are more crops and another where there is less cultivation to make reference balances that could be from May to June and another from August to September.

5. What is the most useful data visualization format?

X	Map		Written report
X	Table		Other:
X	Graphic		

6. From what device do you think you and/or your colleagues will access the information?

	Cellphone	X	Laptop
	Tablet		Other:
X	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

The ideal would be 1 m x 1 m, when they tell you what you would expect the most, however, I think that within these is the question of use, since for the analysis of evapotranspiration in zones, we have noticed that, for example, a resolution of 15 m x 15 m gives us something adequate, it is enough, also because the terrain conditions here are very flat so the variations are few, due to the conditions of the study area, about 15 x 15 m. The better the resolution, the better one sees the condition of the plants at a higher resolution. As a matter of plots, up to 1 m x 1 m is a lot because if there are conditions where the types of soil, the concentrations of salts do reduce the condition of the plants.

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8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

Ideally, they would be there the same day, but we understand that the processing of this information is not fast and the review, the data quality protocols and others take time. Being a week late I think there is no problem, just 15 days to make the monthly balance. The ideal would be daily data, this depends on the objective, we have worked with daily data because we also have the measurement of the other variables of the balance daily, even on schedule, and we have already carried out the estimation of these daily variables, but there will be some other projects that work with larger temporal resolutions, weeks. But the ideal or reasonable would be to have them daily.

9. How do you find it useful to have ET data summarized?

X	By plot		By specific unit of area (specify)
	By irrigation module		Other:
	By irrigation district		

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

X	Yes		No

Additional comments:

We have some. We are also interested in the general part of the Valley of Mexicali, which is the entire irrigation district 014, the riparian Corridor of the Colorado River delta, for example, within the Corridor there are more specific sites that are already restoration sites, which is where they are made. issues there of monthly balances for the water requirement, so it depends on the objective of the investigation, but if we already have specific polygons.

11. Do the polygons in Question 10 contain private or sensitive information?

X	Yes		No

Additional comments:

Some, yes, are derived from concessions so it is not their own information, but rather it is derived from a binational group, perhaps there you just have to check with the group if they can be delivered or viewed freely, or published.

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12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

We use several, it's QGIS, Arc GIS from time to time too, Earth Explorer, I think those are the 3 main ones.

General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

No not at all.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

I think it is important to bring the population closer to raising awareness about the uses and issues of water. An important part is evapotranspiration creating this link with the public and also because of the utility it has for the farmer to say this is my real water requirement, coupled with land washing, perhaps I do not use this amount of water, being efficient with the use of water, especially now that we are in a drought of twenty-odd years, we already require this type of information to take pertinent actions, I think it is very important.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

I think that when we were seeing the presentation, we only had doubts related to the methodology and the data in situ to make the calibrations, but from then on, another additional consideration, no, I can't see it right now. Marco: That is, were you a little concerned about the verification of these forecasts, with respect to the observed data? Yes.

16. What other applications do you think the evapotranspiration data could have?

There are several, depending on the users, but for us it is focused on research. Some time ago we finished a thesis that is related to the use of water in restoration sites and there we use evapotranspiration data which is important to see the sustainability of the sites in terms of water requirements, so they are highly variable depending on the user. Farmers for the water requirements of their plants, decision makers for local, regional management of the use of both

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surface water and groundwater, water balance. Mainly the balance and management and a good integration of this information for use in the governance of the resource.

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

Yeah

Marco: how could you collaborate?

We have data, also if support is required here, on the location of some stations, set up sessions with users, we could also be able to call the population, information integrators, etc. Those are the ones that come to mind quickly, but those are mostly data.

18. Do you have suggestions for other partners?

[X] Yes [ ] No

Additional comments:

There are other universities, for example, we don't have stations, but the University of Sonora does, maybe the team could have a collaboration between IMTA and them because they could install stations here.

Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area throughout the Valley of Mexicali and in the cities of northern Baja California?

Well, it would be very interesting to have the information because also, here the changes or rest of plots are used and changes of crops are made, then suddenly in one or two years, a change is made from wheat to alfalfa or cotton, which are crops that require of a lot of water. In this area, what is being discussed right now, I think they have an experimental plot where the conversion of crops that have greater uses, efficiency in the use of water and greater economic value is being carried out.

This is also important because the surfaces as such are not updated over time, but we are talking about the district as a whole and as if everything is planted and we know that this does not happen, or that it grows and we don't realize it until we see an image satellite, that we already see areas that were not planted before and that now are. This kind of information would be very interesting. And above all, also the changes that are now being made, the opening of making this conversion of crops from a before and after, to see if it is really an efficiency of water in the short, medium, long term.

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20. How can the OpenET platform serve as support to the producers of the Irrigation District 014 Río Colorado in their processes of programming, monitoring, operation, design and evaluation of their irrigation systems?

It is interesting, because many times there is a communication cut between the farmers and the decision-makers when they say, well, we are in a drought, we have to be efficient, the light or water goes down but they stay there, so we have to demonstrate how much water is actually being used, maybe it can be more efficient, with infrastructure, take advantage of the fact that right now there is support for infrastructure in agriculture, this decision-making based on measured information is essential, we are not going blindly and actually, we are monitoring these farmers and with data we are showing them once the farmer can be trained, he himself will make the decision of how much water he is going to use for his crop during the year.

21. What do you think would be the most important potential applications of OpenET in the Valley of Mexicali, since it is installed in the neighboring Valle Imperial District (IID)?

Well, we can share experiences, that is an important issue that we are always with the lessons learned from our neighbors because they have other tools that they are using, other infrastructure, other technology, so having and counting on their own information can give us or we can standardize the conditions, at least in terms of data and seeing, we have this similarity of conditions, which is what we can implement according to the lessons learned from the neighboring country.

22. How do you think the OpenET platform will be useful to regulate and order the concessions of the existing Irrigation Units throughout the Valley of Mexicali?

It would be to deliver the water according to what is actually needed. We see concessions that we do not know if they are overestimated or underestimated in terms of the water needs of each farmer and later, these concessions become the market, because it does not exist as such formally, but we know that there is a market in the concessions for sale or change of use.

Having this monitoring also helps to make the balances, that the balances are in accordance with the information, the usefulness of these data, in addition to the balances, once we already have all the volumes that are required or that change with the year, well we actually see the water needs of the district and if it can be observed in which areas more water is required, of what type, perhaps an adaptation can be made to the hydro-agricultural infrastructure that already exists, many things can help, It will not necessarily come out of the platform, but with the use of the data from the platform with the management, with the sessions between users and the analysis of that information, it is possible to create a new one or adapt the current public policy in relation to water.

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It is quite delicate. It is walking, it is a process, little by little.

Thank you very much, excellent work and excellent initiative and we hope to see it work here.

11.2.5 CILA: Ing. Daniel Adrián Galindo Peña

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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

1) Determination of the amount of water necessary to irrigate crops, considering the ET, irrigation must be programmed and applied seeking efficiency and effectiveness in the use of water. 2) Calculation of the volume of water available in a hydrographic basin, and with this plan the allocation of water for different uses (agricultural, public-urban, etc.). 3) Estimation of the number of green areas, seeking a balance between urbanization and vegetation zones.

2. What types of stakeholders use evapotranspiration information in your organization?

	Farmers and operators		Area directors
	Researches	X	Other: SubArea directors y specialized technicians.
	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

It is estimated considering the evaporation data collected at measurement stations, and considering the areas exposed by sections of the river, interpolating with tables resulting from a field study on ET.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

Weekly.

5. What is the most useful data visualization format?

X	Map		Written report
X	Table		Other:
	Graphic		

6. From what device do you think you and/or your colleagues will access the information?

	Cellphone	X	Laptop
	Tablet		Other:
X	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

Spatial resolution: 1 Ha. Spatial extension: Irrigation District and/or Hydrographic Sub-basin.

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

Temporal resolution: Daily. Temporary Latency: as close as possible to real time.

9. How do you find it useful to have ET data summarized?

X	By plot		By specific unit of area (specify)
X	By irrigation module		Other:
	By irrigation district		

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

X	Yes		No

Additional comments:

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11. Do the polygons in Question 10 contain private or sensitive information?

[X] Yes [ ] No

Additional comments:

In some cases, due consultations with authorities and authors of the polygons would have to be carried out.

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

ArcMap, Google-Earth

General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

No

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

1) Help water users to perceive the amount of water available in a river basin.
2) Planning irrigation and harvesting more effectively, which can result in higher yields and less water use.
3) Development of technologies, such as soil moisture sensors and smart irrigation systems.
4) To trigger research on hydrological, climatic and ecological processes.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

Yes, presentation of a timely and concise summary so that any user of the platform can read the information (e.g., Based on these results, it is estimated that X% of the Y zone is oversaturated, while Y% of the zone X, is under water stress.)

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16. What other applications do you think the evapotranspiration data could have?

1) To expand the information on drought conditions in different regions, which can be useful for the management of water resources.
2) In crop planning to determine how much water is needed for a specific crop in a given area.
3) As a component in some hydrological models to predict the flow of water in different regions.

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

Yes, as collaborators in the search for financing for the implementation of automatic ET meters that allow to help in the monitoring of the demands and use of water, and the planning and design of more efficient irrigation systems.

18. Do you have suggestions for other partners?

[X] Yes [ ] No

Additional comments:

CONAGUA, IRRIGATION DISTRICTS AND IRRIGATION MODULES.

Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area throughout the Valley of Mexicali and in the cities of northern Baja California?

1) Evaluating the efficiency of irrigation in different areas and crops, helping with this to identify opportunities for improvement in the use of water.
2) Identifying areas where the amount of water used in agriculture is high compared to the amount of water available for this use.

20. How can the OpenET platform serve as support to the producers of the Irrigation District 014 Río Colorado in their processes of programming, monitoring, operation, design and evaluation of their irrigation systems?

1) In scheduling irrigation more effectively, using accurate data on evapotranspiration and weather conditions and crop water demand.
2) As it helps growers to monitor irrigation in real time and adjust irrigation in a timely manner.
3) As a tool for the design and installation of more efficient irrigation systems, taking into account the amount of water required by crops and the climatic conditions in the region.

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21. What do you think would be the most important potential applications of OpenET in the Valley of Mexicali, since it is installed in the neighboring Valle Imperial District (IID)?

It is estimated that it would allow joint monitoring of the amount of water used in both regions for the same types of crops, which would make it possible to optimize irrigation practices and systems.

22. How do you think the OpenET platform will be useful to regulate and order the concessions of the existing Irrigation Units throughout the Valley of Mexicali?

The platform would be one of the support tools in this regard, since the regulation and ordering of concessions and use of water in the Valley of Mexicali are very complex and multifaceted issues that also require the application of various measures with broad approaches. and collaborative that involve all interested parties, including producers and local communities.

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11.1 Transcript of interviews from Chihuahua

11.1.1 INIFAP: Jesús Manuel Ochoa Rivero

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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

Well, to begin with, the question of water balances is something fundamental, not knowing the evapotranspiration for that balance, since it generates an information gap, so for decision-making in the management of water resources it is essential to know this variable, the evapotranspiration and apply it to agronomic, ecological and natural resource management issues.

2. What types of stakeholders use evapotranspiration information in your organization?

X	Farmers and operators	X	Area directors
X	Researches		Other:
	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

As such, it is free access to sources such as the FAO, such as the program we have been talking about, the Open one, some satellite images or remote sensing data, mainly.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

If we speak in the case of agriculture, the highest points of the cycle, that is, during the development of the crop is where we would be giving punctual monitoring to this parameter, I put the case of corn when it is being born, when it enters into development and in the cob formation is when we would be using this variable the most. However, it must be considered during all cycles, speaking of the agronomic issue, speaking of water resource management, during all seasons this factor becomes important, and especially in arid zones.

5. What is the most useful data visualization format?

X	Map		Written report
X	Table		Other:
X	Graphic		

6. From what device do you think you and/or your colleagues will access the information?

X	Cellphone	X	Laptop
	Tablet		Other:
	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares)

The higher the resolution, the better the result, everything will depend on the study area and the crop being worked on, so we could start from places with one hectare to places with 50, 5000, this information will vary depending on the spatial and temporal conditions that exist, in the case of us in Chihuahua, the surfaces are wide, so we would be interested in having a wide margin, however, something very focal, something very punctual, to be able to determine water balances at the level parcel.

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

We would go for constant monitoring with data that is as fluid as possible, the shorter that temporal resolution is, the more it would make it easier for us, right now we know that there are technologies that are happening daily and that are giving information, so that type of data would come to us very good for our work, to have much more precise information than to open it in a wide range.

We could talk about a period of 2 or 5 days. Latency, we could talk about 3 weeks, a month to keep that latency current.

9. How do you find it useful to have ET data summarized?

X	By plot		By specific unit of area (specify)
	By irrigation module		Other:
X	By irrigation district		

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10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

[X] Yes [ ] No

Additional comments:

These are study areas that we already have focused here in the state of Chihuahua, mainly in the region of District 05, in the Cuauhtémoc region and the Ojinaga region.

11. Do the polygons in Question 10 contain private or sensitive information?

[ ] Yes [X] No

Additional comments:

Because we work with cooperating producers.

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

We use from Q GIS, Arc GIS, Google Earth Engine, programming languages such as Python, such as R, we work with images such as Landsat, Sentinel, open platforms such as the Planet, information from INEGI as well, and from official Mexican sources, and data that we also generate with drone flights.

General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

No, the idea is that the information to flow.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

Having access to information and not just having access to information, but having the interpretation of that information, so that tomorrow it becomes efficient water management, it becomes the generation of public policy and about all in raising awareness about the management of the resource.

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15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

It would be access to this type of media such as the internet, because there are still places in Mexico that do not have accessibility, the other is to consider the issues of uses and customs that are held in the areas to have that consideration and above all to know the agronomic practices that occur in agriculture, agronomic practices that occur in some distant communities. More inclusive and generate a wider network or range to have more accurate information in places where the availability of access to is limited.

16. What other applications do you think the evapotranspiration data could have?

Well, as we mentioned just now, to know the consumptive uses of water, in the case of agriculture, to know the productive water versus the non-productive water, that is, the water that the plant uses to generate biomass and the one available through infiltration, evaporation and runoff, in the case of cities, knowing it would help me in the matter of urban ecology, dasometric management, knowing the balances that I will have for drinking water, so it has endless applications that we could start listing.

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

With all security, we could participate and collaborate with you in whatever we may require. The institution to which I belong is throughout the national territory, and we focus on Chihuahua, as far as Chihuahua is concerned, we are fully available to collaborate on this platform. Providing information at the foot of the plot, and from previous studies that are available, studies that are currently present and, in the future, then we could begin to feed that information either by cartography or with database management, access to properties, etc., it is in what we could collaborate with.

18. Do you have suggestions for other partners?

[X] Yes [ ] No

Additional comments:

I don't know what range is already identified right now, but it could be considered within INIFAP, consider the Remote Sensing Laboratory, which is located in the Pabellón Aguascalientes experimental field, with Dr. Víctor Moreno, they have the network of stations institute

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meteorologists, they are the ones who handle that information, that laboratory could be a good ally. I can think of agencies like CONAGUA right now, which I imagine is already immersed here, CONACYT centers such as CICESE*, such as IPICYT**, northern academic institutions such as IPPSON, Nuevo León University, the Autonomous University of Chihuahua and the UACJ***

*CICESE: Centro de Investigación Científica y de Educación Superior, Baja California

**IPICYT: Instituto Potosino de Investigación Tecnológica

** IPPSON

****UACJ: Universidad Autónoma de Ciudad Juárez.

Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area throughout the Chihuahua State?

This is going to help us to what we said right now, to quantify for the state of Chihuahua, what is the productive area used by the plants and what is the non-productive water, that is what we, for the state of Chihuahua, begin to determine balances at a level of detail that allows us to make decisions for the efficient use and management of water in agriculture.

20. How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basins of the State of Chihuahua as established in the State Water Plan?

To a large extent because we know that agriculture consumes over 70% of the water that is allocated globally, so having access to this variable that is evapotranspiration allows us to give ourselves a more accurate idea of how this hydrological cycle is behaving. and anthropic activities and therefore begin to mitigate and seek alternatives to stop these depletions that are taking place in the region with the aquifers that are currently in the states and in the basins00.

21. What do you think would be the most important potential applications of OpenET in Irrigation Districts: 005 Delicias, 090 Ojinaga, 009 Valle de Juárez, 090 Buenaventura, 089 El Carmen, 103 Río Florido, 113 Camargo, in their programming, monitoring, operation, design and evaluation processes of their irrigation systems?

Here, above all, it would be to migrate to a more effective technology with this and those who are already technical, to make a good management of the irrigation systems by knowing this variable in a more open, more precise, more concise way. So, I think that would be to follow up on the process of modernization and once it has been technically developed and with those that are already technically advanced, implement management, monitoring and support for the producer in those areas.

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22. How do you think the OpenET platform will be useful to regulate and order the concessions of existing Irrigation Units throughout the State of Chihuahua?

As I said in previous questions, it would be one more input that would add up for decision makers in the generation of public policy on the use and management of water for irrigation units, then, it would mainly be that, to provide one more input than thus allow the search for more efficient and sustainable schemes of agriculture in the state.

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11.1.2 CONAGUA: José Ángel Félix Sánchez, Lauro Fernández Carrasco

Contact information

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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

Planning of Irrigation Plans

2. What types of stakeholders use evapotranspiration information in your organization?

X	Farmers and operators	X	Area directors
X	Researches		Other:
	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

Conventional and automatic weather station

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

All year, but very important in the months of September and October

5. What is the most useful data visualization format?

X	Map		Written report
X	Table		Other:
	Graphic		

6. From what device do you think you and/or your colleagues will access the information?

	Cellphone	X	Laptop
x	Tablet		Other:
x	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

50 ha

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

5 years

9. How do you find it useful to have ET data summarized?

X	By plot		By specific unit of area (specify)
x	By irrigation module		Other:
X	By irrigation district		

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

	Yes		No

Additional comments:

No comment

11. Do the polygons in Question 10 contain private or sensitive information?

	Yes		No

Additional comments:

No comment

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

SIG, ARC VIEW, Google Earth

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General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

No

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

Assist in decision-making, improve irrigation practices, application of inputs or activities

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

Improve accessibility to information in remote areas

16. What other applications do you think the evapotranspiration data could have?

Improve the management of information on the use of surface or underground water Improve irrigation water application Monitoring of current and historical water use

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

as collaborators

18. Do you have suggestions for other partners?

[ ] Yes [x] No

Additional comments:

No comment

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Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area throughout the Chihuahua State?

For indirect estimation of water consumption

20. How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basins of the State of Chihuahua as established in the State Water Plan?

By making summaries and reports based on accurate and reliable data. Based on the above, to be able to implement regulations or regulations

21. What do you think would be the most important potential applications of OpenET in Irrigation Districts: 005 Delicias, 090 Ojinaga, 009 Valle de Juárez, 090 Buenaventura, 089 El Carmen, 103 Río Florido, 113 Camargo, in their programming, monitoring, operation, design and evaluation processes of their irrigation systems?

Estimation of more accurate water consumption values Measurement of the timeliest water application Evaluation of water consumption and crop production Establish a platform as a Water Bank

22. How do you think the OpenET platform will be useful to regulate and order the concessions of existing Irrigation Units throughout the State of Chihuahua?

No comment

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11.1.3 UACJ: Dr. Victor Salas

Contact information

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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

Here I believe that the decisions are based on water policies. In Chihuahua, public policy issues related to the water sector are affected, I believe that very specifically, since agriculture is the area that consumes the most water, above all, for example, with regard to the plan.

2. What types of stakeholders use evapotranspiration information in your organization?

X	Farmers and operators	X	Area directors
X	Researches		Other:
	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

They are generally weather stations, there is a network from some institution, for example, Unifrut, or some network from CONAGUA and INIFAP that could be outdated but generally they are giving you the reference evapotranspiration, not the real one.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

I believe that it would be required for the entire year, however, in matters of the agricultural period, here in the state it goes from March to September, I believe that it would be the most critical period to be able to use or require this evapotranspiration information.

5. What is the most useful data visualization format?

X	Map		Written report
	Table		Other:
X	Graphic		

6. From what device do you think you and/or your colleagues will access the information?

X	Cellphone	X	Laptop
	Tablet		Other:
	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

An ideal resolution would be 5,000 hectares to be able to work a little on large areas, either irrigation modules or other irrigation units that can be easily mapped with these tools.

The spatial resolution I believe that for issues of extensive use should be between 5 and 10 m, enough to be able to recreate, especially when we go to the hectare level, since more representative data, 1 m would already be an excess of information.

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

I believe that the temporary resolution should be daily, because there are some meteorological phenomena that affect you from one day to the next. The latency I think is a maximum of three days so that the data can be updated.

9. How do you find it useful to have ET data summarized?

X	By plot		By specific unit of area (specify)
	By irrigation module		Other:
	By irrigation district		

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

X	Yes		No

Additional comments:

In fact, we already have well-defined cultivation areas, for example, in my region, apple tree areas, corn areas, bean areas, which practically do not change from one year to the next because producers always try to sow the same for culture, and making these balances or real-time programming of these agricultural units would be excellent, for which we already have this information.

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11. Do the polygons in Question 10 contain private or sensitive information?

[ ] Yes [X] No

Additional comments:

It is completely public information, scientific articles have been made with this type of information, so there is no problem.

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

Google Earth Engine, Python, QGIS and ARCGIS above all are what we use.

General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

No, on the contrary, I would like these data to be public to empower users to make decisions with their own data.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

I believe that improving decision-making basically for the use of water in some regions.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

I think they should work in synergy with local universities or research centers so that they are following up on this type of platform, and local or regional universities transfer technology correctly to the producer, otherwise large-scale projects remain that they can't really make decisions based on this information and take it bit by bit with a local technology transfer.

The research must be more in synergy with the local universities to give us follow-up and feed information to you, to be hand in hand, then.

16. What other applications do you think the evapotranspiration data could have?

I believe that they can have applications in the question of modeling forest fires, the question of carrying out water balances at the basin scale, highlighting climate change projections also at the basin scale.

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17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

Of course, as I mentioned, we are also programmers in the water area, whatever we can help with would be excellent.

Right now, we are bringing a project to manage a network of low-cost soil moisture sensors made by us with microcontrollers and that are giving us information in real time with this internet of things thing, with Arduino, Raspberry, so that really the costly project comes out, prepared by us and easily implemented by anyone and we collect the data in real time through internet platforms and with that calibrate the models, there we could have information.

18. Do you have suggestions for other partners?

[X] Yes [ ] No

Additional comments:

I believe that agricultural product systems may be very interested, for example, the Chihuahua Corn Product System, Apple Product System, Walnut Product System, Alfalfa Product System, and well, all crops have a Product System and I believe that they can visualize this information and also help them make decisions.

Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area throughout the Chihuahua State?

Well, what I understand with the platform would allow us to see, almost in real time, the areas with the highest evapotranspiration in agricultural areas that are already established, and therefore it would be possible to calculate almost perfectly what is the irrigated and planted area in the entire world. state of Chihuahua without resorting to censuses, but already a practically realistic photograph of how the irrigated and planted surfaces are found throughout Chihuahua

20. How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basins of the State of Chihuahua as established in the State Water Plan?

In terms of recovery, well, if irrigation is programmed based on the evapotranspiration in your area, the efficient use of water can be improved, that is a matter of recovery. In watering, the most precise or ideal way for each crop in the area.

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Regarding the regulation issue, it has a lot to do with the other question, because we, with this type of satellite platform, can see spatially, where and when they are irrigating based on the color situation and the evapotranspiration data and where they are not. In a matter of a region telling you that it is not irrigating; with this type of data or images, you can really realize that they are doing it.

21. What do you think would be the most important potential applications of OpenET in Irrigation Districts: 005 Delicias, 090 Ojinaga, 009 Valle de Juárez, 090 Buenaventura, 089 El Carmen, 103 Río Florido, 113 Camargo, in their programming, monitoring, operation, design and evaluation processes of their irrigation systems?

I think it is for them to plan irrigation scheduling already operationally by district and by module and to try to see that they can really use satellite data reliably and help them optimize the water in their plots.

22. How do you think the OpenET platform will be useful to regulate and order the concessions of existing Irrigation Units throughout the State of Chihuahua?

I believe that in order to obtain historical information about evapotranspiration in any type of crop, it can give us an idea of what cubic meters would have to be irrigated for each zone, in each crop and especially in each area, that is, , the volumes can be ordered so that in certain areas a certain volume is needed, so it can be delivered and try not to waste this resource so much.

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11.2 Transcripts of interviews from Guanajuato

11.2.1 COTAS: Lic. Paola Ramírez

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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

Especially the issue in the agricultural sector and also, for example, there in the San Juan del Río aquifer there are two very important dams that are used for irrigation. When it is not irrigated with wells, it is irrigated with dams, so if there is a high rate of evapotranspiration in the area, well, we are going to have less water availability in the surface area, so we are going to have to put the wells to work, for example. for longer, and that implies that we are going to have an overexploitation of the aquifer.

2. What types of stakeholders use evapotranspiration information in your organization?

X	Farmers and operators		Area directors
X	Researches	X	Other: Tomadores de decisiones
	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

The SEAG automated stations and also the dams have their own stations where the data is automatically acquired, a report is made and that is the information with which we work on the modeling.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

For example, for me it is very valuable because I compare it with the data highlighted by the piezometric, so I do two piezometries, one in the dry season and one after the rains, so it is to make a comparison of how the surface waters behave and underground at these temporary moments. The dry season is before the rain begins, normally it is January, February, March, before the rains arrive,

the piezometry has to be done between March and April to have the results in dry season, and to have them in rain It does in October and November, when the rainy periods have ended, more or less the strong periods.

5. What is the most useful data visualization format?

	Map		Written report
X	Table		Other:
	Graphic		

6. From what device do you think you and/or your colleagues will access the information?

	Cellphone		Laptop
	Tablet		Other:
X	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

Well, clearly depending on the objective, for example, for farmers the ideal is 5 ha or, in reality, parcels, but it is the smallest unit you have; 50 ha sounds good for a sectorization and already very general, well, 500. I think that with 50 ha it would be good, if it implies a great work but it is actionable information. 5 ha is already a very small unit that would be much more difficult to process, I think that this is already for specific cases where we need something specific and clearly data like (inaudible) are useful to me, I don't know if you as an institution have the ability to do it, if they had, it will always be ideal to have something detailed.

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

I think that is what I was answering a moment ago, for example, April-May, October-November. We do it every year, twice a year we use this information, the dry season and after the rains the data processing is done, not just evapotranspiration, precipitation, and correlations are sought. We, from the automated stations, use the evapotranspiration data, we take out the daily evapotranspiration data to end the annual study, it does not end with the 365 days because, first, sometimes there are many gaps in the information and certain stations have to be discarded or it is also shortened to availability, clearly the more data there is, the better estimates, better forecasts, better models.

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9. How do you find it useful to have ET data summarized?

[X] By plot
[X] By irrigation module
[ ] By irrigation district
[ ] By specific unit of area (specify)
[ ] Other:

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

[X] Yes [ ] No

Additional comments:

We have reforested areas and also users who have specific needs; so we have updated the agricultural vector of the San Juan del Río valley aquifer a bit. So, we do have specialized where the information would be required specifically.

11. Do the polygons in Question 10 contain private or sensitive information?

[ ] Yes [X] No

Additional comments:

In fact, it is public information.

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

QGIS, ArcGIS, and Google Earth

General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

I think they have to be public because users need to know each other, to know that it is part of the governance of their resources, it is part of understanding how what they are managing works, I think it is important, but above all training, any data we have is nothing if you don't know how to interpret it, then there may be a lot of public information available, but if you don't know how to interpret it, who guides you, who helps you interpret it, because it's of little use, more than the public, is the reading of that data.

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14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

I'm like imagining the users of independent irrigation units, because for example, the irrigation modules and districts have very specific information, they even have specialists in the area. There are also independent producers that belong to the industrial sector and they wouldn't use them either, perhaps because they also have specialized personnel who take that data or have stations, right now that there is all this issue of greenhouses. Right now, I think it is important that it be public because the people who would be accessing them or at least who could be the end user are users who do not have the capacity to pay specialists, they are users, many of them traditional peasants and who you know of information that will give them better management of their plots.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

I have not had the opportunity to review the platform in depth, but I know that evapotranspiration, well, depending a lot on the method used to calculate evapotranspiration, but I will understand that for what we are working on, one of the areas of opportunity for evapotranspiration calculations , is that obviously by interpolating you lose a lot because we are talking about making assumptions that the area will have a certain crop, it will have, I don't know, a certain productive activity, and sometimes it is not like that, so I think that the generalization always it will mark us a margin of error.

16. What other applications do you think the evapotranspiration data could have?

I am in the water sector, so out of the sector, because it is in the basics, which is agriculture and the monitoring of surface waters that serve livestock and agriculture, but I also imagine that for projects like these for industrial roofs, capture of mists, for all these since evapotranspiration is basic, the execution of these new ways of collecting water.

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

The function of the COTAs is precisely to collaborate with all organizations, whether public or private, to precisely develop this knowledge that strengthens the information on, in this case, the aquifer. Also, it is a very important variable, so no problem.

I don't know how they collect data, we are requesting some automated stations precisely to be able to protect them, there are several points where they already have drivers and it would be good to implement, in addition, an automated question or some monitoring that occurs on board, not all boards within the aquifer within San Juan del Río they bring stations, or well, smaller dams, so there would

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be important points where they could be acquired, or also, it is that the data that we use, is actually that data that are already public, we would also like to have the ability to generate or have that data with stations. We are going to request three stations, so we are going to see if this part is achieved, well, without problem, these data can be uploaded.

18. Do you have suggestions for other partners?

[X] Yes [ ] No

Additional comments:

Well, I imagine that they already did it with the modules of the San Juan del Río Irrigation District, if not, then they are a good area of opportunity, there are three modules. I think the users, because clearly, the Irrigation District is in charge of CONAGUA, but the modules, which are the users, which are as an association, I think it would be good within the aquifer, and also with the universities, there It is in San Juan del Río, the Autonomous University, the UAG San Juan del Río campus and that would be good. Regarding my study area, there are clearly more study areas.

Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area in the State of Guanajuato?

Well, we know that evapotranspiration directly influences when irrigated, even drip irrigation tries to prevent water loss from occurring a lot, what we want to do is make irrigation more efficient and have fewer losses, and that's why we talk about irrigation by dripping that will contribute to reducing so much evapotranspiration, because in general, evapotranspiration is not something desirable in cultivated areas or in bodies of water, it decreases the water. There are other areas where evapotranspiration must clearly exist for the hydrogeological cycle to continue, such as areas with dense vegetation, so I don't know exactly in Guanajuato, but I could see the case of the agricultural area of San Juan del Río, so well, it is useful for that, to know how much water is being lost, so how can we make it more efficient so that this loss of water does not occur, putting I don't know, even membranes that cover the bodies of water. A lot depends on your budget.

20. How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basins of the State of Guanajuato?

In general, and not specifically in Guanajuato, evapotranspiration is ultimately an important variable for the hydrogeological balance of an aquifer, so having this information will allow us to have more accurate models of how much water is actually available. .

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21. What do you think would be the most important potential applications of the OpenET platform to support the producers of Irrigation District 011 Alto Lerma and DR 087 Rosario Mezquite in their programming, monitoring, operation, design and evaluation processes of irrigation systems?

I think these questions are very similar, especially for those of us who are not from the region, I don't know what the dynamics of the area are, so I think I would give the same answer as the previous one and it is not my area of study.

22. How do you think the OpenET platform will be useful to regulate and order the concessions of existing Irrigation Units throughout the State of Guanajuato?

It is also an issue, what you mentioned above. The subject of the overexploitation of the aquifers, I would summarize everything in the hydrogeological balance, and I suggest that you not make it so specific because I believe that we are from different places, so that sort of closes the answers that one can give them a little, but because the hydrogeological balance goes hand in hand with a regulation or an administration that will derive in the concessions. At the end of the day, if there is high evapotranspiration, they are going to look to take more care of the resource, or they should look to take more care of the resource, especially on the surface to avoid overexploitation of an aquifer and also to know, you know that most of your superficial concessions, I don't know, you have 300 without considering evapotranspiration, well clearly it's not going to be 300, you can give 50 one and 50 until you reach 300, but if you didn't consider evapotranspiration, those people will never be able to exploit 50 or whatever you're giving him, which is why it's so important that you consider it in the case of superficial concessions.

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11.2.2 UGTO: Yanmei Li

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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

It is that, for example, with evapotranspiration, with what I know I can say the production and demand of water for irrigation, for exploitation here, the majority are from groundwater, so we can evaluate and estimate the use of water, the decision also for see if in the end the harvest changes or not, for the economic and water security. It is for the decision on the use of water, such as water demand, this is very important because here it is difficult to take into account the water that we are exploiting because there is no meter in many wells.

2. What types of stakeholders use evapotranspiration information in your organization?

X	Farmers and operators	X	Area directors
X	Researches		Other:
	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

We have software called "Vision plant", in this software there is input of precipitation, temperature, wind speed, we send these data as inputs and thus we can calculate evapotranspiration.

I do not use direct evapotranspiration databases; we calculate it from the weather station.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

The whole year is important, but for me it seems that spring-summer is more important, here in Guanajuato it is the harvest season and it is also the dry season, it is more irrigated and has more evapotranspiration.

5. What is the most useful data visualization format?

X	Map		Written report
X	Table		Other:
X	Graphic		

6. From what device do you think you and/or your colleagues will access the information

X	Cellphone	X	Laptop
X	Tablet		Other:
X	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares)

The more precise, the better, but I know that OpenET of evapotranspiration is very difficult to have much more detail because the satellite has its precision, but when we do groundwater work, we use Arc GIS and we use 500x500 m², but the data that we you put here, 50 hectares is like the more precise, the better. At the level that can be fine.

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

We want groundwater, if it were for half a year it would work for us because we don't have more data on the water level, we use data from CEAG, what they have is for periods of 2 times a year, for us it is mainly Twice a year and that's fine, but if we want to include water security for agriculture, then if it were daily, but at least weekly, I think it's necessary. The delay maybe a week could be. The daily delay is almost impossible, I don't know if I could get there.

9. How do you find it useful to have ET data summarized?

X	By plot		By specific unit of area (specify)
X	By irrigation module		Other:
	By irrigation district		

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

X	Yes		No

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Additional comments:

For us, the use is perhaps due to the aquifers when we take stock, but in the aquifers, it can be divided into mountainous areas, recharge areas and discharge areas, how best to divide them, if not, by aquifer.

11. Do the polygons in Question 10 contain private or sensitive information?

☐ Yes ☒ No

Additional comments:

There are wells that we do have the levels but when we use that data, we need to ask for permission but there are not many, most are from CEAG.

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

Here we use Arc GIS and also MATLAB, others as a "hurry" that is already from our own software that we made when we were in Spain.

General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

For me, if everything is public there is no problem, if all my studies can be made public in the end, it seems very good to me.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

For me it is crossing ideas and that is from each researcher or user, they have their own intention of use, if in the end the ideas cross and it could generate new ideas to solve water security problems.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

The truth is that I don't know very well what they are doing now, I don't know very well, but at UG we have a group of Researchers, geospatial professors, if we have colleagues from that area.

The idea in Guanajuato, wants to make it like a theater of decisions, here we have a group of international C3, they make programs to make platforms, there is a part of the Researches and programming, also decision making.

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In the state of Guanajuato, between the government of different units, the districts and the institutes, everyone has good communication, CEAG also has very good data, so it seems to me that OpenET is evapotranspiration, if it can be related to the groundwater thing is going to be very good for progress in the future.

16. What other applications do you think the evapotranspiration data could have?

To recharge the aquifer, agricultural production and water demand.

It is to finally have the balance.

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

With great pleasure.

how could you collaborate, with data or in what way could you help us or contribute?

We have other sources of data, my husband is also from this area, he found a lot of data from other sources as well, such as temperatures, wind speed, etc., and there we can help as a data source and another is to help how we use these data, such as our studies, for example, we tell you, we want us to see the demand for water from there, see if we can recharge the aquifer, with what data, precision, periods we need, here we can exchange ideas for when you have we will to do so and for us it seems very useful, perhaps some parts or something that some jobs are perhaps more important than others.

In general, we can offer some ideas, because we also have the experience of knowing the farmers, a good relationship with them.

18. Do you have suggestions for other partners?

[X] Yes [ ] No

Additional comments:

For example, my husband here, he knows more about geospatial than I do, Jesús Horacio Hernández Anguiano, he is also a professor at UG and here at the Bajío Water Fund, I don't know if they know more people from different areas and also from Idea Guanajuato, they were supporting us, perhaps they would also be interested in supporting some of this project and those of C3 Internacional are collaborating as groundwater level visualization, they do a lot of programming and platforms.

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Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area in the State of Guanajuato?

With my experience, although I never made these calculations, but if I knew that between evapotranspiration and the growth of plants and crops and the production between them, I think that if they have a correlation, then from there I should be able to have a relationship between the data that OpenET can offer with the irrigated and planted surfaces, but I think that if it is necessary to go and verify in situ, it is necessary to work in the field. Now I think that if we want to install OpenET, maybe in that part my students and collaborators here can help or we include a technician, we have to go around to verify some things.

20. How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basins of the State of Guanajuato?

It is the data to estimate and determine the evolution of water demand, it is very important.

21. What do you think would be the most important potential applications of the OpenET platform to support the producers of Irrigation District 011 Alto Lerma and DR 087 Rosario Mezquite in their programming, monitoring, operation, design and evaluation processes of irrigation systems? irrigation?

It seems to me that it can help the selection of crops, such as what type of crops is best for this area, also the time of irrigation, when it is more, when it is less, also the most efficient way of irrigation, although we do know, there are many types like drip, if it is more efficient, if it is not reporting and we perhaps like OpenET at the end, having this area is irrigated very little as it has very little evapotranspiration but it has very high production and we are going to see that they are using drip irrigation there, it is enough to have evidence to convince the farmers or the bosses who say if it is worth the investment of these new irrigation technicians.

Also, in exchange for crops, they told me that in some places they are changing crops, instead of corn or sorghum they are changing to agave, which needs less water, also economically.

22. How do you think the OpenET platform will be useful to regulate and order the concessions of existing Irrigation Units throughout the State of Guanajuato?

It seems to me that it depends a lot on the frequency and accuracy of taking the data and updating the data, also the price. We need a technician who does not depend on people, when once we already do surveys, it always depends on the person, what they want us to know. We need a technician. This type of OpenET is safe, we need it so that we can estimate the use of water without conflicting with people. This facility, I'm talking about price, I could look for many types of sources of resources, but there are many that can support the project.

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Nuup: Esther Camacho, Braulio Torrés Beltrán, Humberto Vergara González

Contact information

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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

Humberto: Basically, the evapotranspiration data is helping us to calculate the water needs of the crops and, based on that situation, we define how much water is really being used, we make some measurements and compare how much the crop occupied against what was is actually applying to know the efficiency of water application.

Braulio: And perhaps, and I say perhaps because part of what we are doing in upsets, I also wanted to discuss this to hear your opinion and to have us on the radar, we are strengthening and developing a voluntary program for the compensation of the water footprint. As you know, global companies make commitments to save water, they say, to produce what I produce, I spend 100 thousand or 1 million, whatever it is in cubic meters, I need to compensate that footprint. We are offsetting that footprint by providing technical assistance to producers and helping them spend or waste less water. Right now, this is still a laboratory for this type of voluntary program, in order to scale this we will eventually have to be able not only to measure the water savings but to be able to verify those water savings, that is public and that anyone can say ah These from XXX saved 7,000 cubic meters of water and here 2,000 cubic meters, let it be real. So, one idea that we are not completely landing on is that these evapotranspiration data help us to quickly measure, without so much field measurement, water savings due to improved irrigation management. Eventually we would like to use it for that if we are methodologically capable of developing that.

2. What types of stakeholders use evapotranspiration information in your organization? **Humberto y Bráulio:**

X	Farmers and operators		Area directors
	Researches	X	Other: We as advisers, it is not research as such, but it is the direct application.
X	IT specialists		As such farmers for irrigation management.

3. If available, what are the current sources of evapotranspiration information?

Humberto: We are making use of the agroclimatological stations that are installed in the specific case here in the government of the state of Guanajuato, through Guanajuato it produces, it has installed and open access 52 stations of which we are already estimating evapotranspiration, among other stations Also, by Nuup that they have contracted with private companies there are fewer, there are 4 physical stations and 3 virtual ones, but we also make use of that, which are providing us with the information already calculated.

Braulio: Commercial tools are exactly what you are proposing, satellite images to see evapotranspiration in crops. And for the calculations that we want to make of water savings, obviously they are working on it, Humberto knows more about it, the reference tables, the theoretical references for evapotranspiration by crop to know whether or not we are saving water and are used for the recommendations of irrigation issue.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

Humberto: We are basically monitoring these values throughout the year because it is important, well, we are trying to bring the irrigation as close to real time as possible to really know the needs of the crop, so, like say a specific date of great relevance, probably It could be at the beginning, before the beginning of the crop cycles, main, autumn-winter, spring-summer, probably there it could be. But in general, it is the whole year, all the time you have to have that daily updated information available.

5. What is the most useful data visualization format? **Humberto:**

X	Map		Written report
X	Table		Other:
	Graphic		

6. From what device do you think you and/or your colleagues will access the information? **Humberto:**

X	Cellphone	X	Laptop
X	Tablet	X	Other: **Bráulio:** For the producers it has to be in offline mode, which is sufficiently robust but not so loaded with data because the intermittence of data where these producers are, sometimes the signal goes away. Consider the intermittence of data.
X	Desktop computer		

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About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

Braulio: The units we use are in square meters, because to manage irrigation it is necessary to be as small as possible. For water saving measurements in this context, the voluntary water footprint compensation program, I think a little more would be enough. The short answer is that the more resolution the better because it can be used for more things.

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

Humberto: Daily, as it is open field, daily is enough. It is not greenhouse production so that we have that data every hour or perhaps a shorter interval. In the open field it is fine every day.

If it could be as short as possible, maybe, if we have had that delay time of 2 or 3 days, even with satellite images we work with MANA, well we are already talking about brands, um, there were occasions when it did depend on satellite images and sometimes it would take up to 5 days, but if we talk about the possibility of reducing the waiting time, every day is enough.

9. How do you find it useful to have ET data summarized? **Humberto:**

X	By plot	X	By specific unit of area (specify) We can have certain plots defined, but if suddenly I want to select a smaller area or some other from that plot, I can also make the corresponding calculation.
	By irrigation module		Other:
	By irrigation district		

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized? **Humberto:**

[X] Yes [ ] No

Additional comments:

We have defined areas with which we work for each cycle. And we have those areas identified

11. Do the polygons in Question 10 contain private or sensitive information? **Bráulio:**

[X] Yes [X] No

Additional comments:

Yes and no. We already have the information with sensitive data of the producer such as name, location, but much of the analysis we do, we separate an identification name or code, we separate the sensitive data with the georeferencing information of their cultivation polygons.

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

Humberto: Currently we use Google Earth, Global Mapper, ArcGIS very little, but well, we are also considering it.

General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

Bráulio: No, we like the idea.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

Esther: Above all, I would support the producers there because it is difficult, although many have access to this information.

Braulio: Just in the voluntary program of water upsets, make the information public so that it can be verified, so that it is not what a third party can see the data.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

Bráulio: In the future, what this information will help us with is making specific irrigation recommendations and verifying water savings. If you, as a third party, were able to verify the water savings, that would help us a lot because it is precisely a way to bring more resources from these voluntary upsets of water savings, that is, if you yourself became a public data platform and the others an irrigation management verifier, and you could use this data to say that a lot of water is being wasted here or that it is being irrigated here , in a very cheap, scalable way with satellite imagery, could go a long way.

16. What other applications do you think the evapotranspiration data could have?

Marco: It could even be used for water balance; I don't know if it would also be the case for you.

Humberto: That's right.

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17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region? **Esther:**

[X] Yes [ ] No

Additional comments:

Because of the work we are doing in Guanajuato, if we are interested in collaborating for this to develop and what Braulio was telling you, what we want in the future is to do something much more robust with this information so that the companies that are investing, well, putting resources for this issue of water balance, be more transparent, more reliable, the information can be more at hand and this can progress much faster.

18. Do you have suggestions for other partners?

[X] Yes [ ] No

Additional comments:

Esther: Humberto, I think of the irrigation modules, for example, of the irrigation district, I suppose they would also have a lot of interest in this.

Humberto: Yes, without a doubt, the irrigation modules and districts would contribute a lot, but well, here in the end I understand that it would be the collaboration, it would be for development as such and they would be providing information on their crops, and well, they also have some weather stations, so maybe all of this helps to calibrate, I don't really know how the issue is going to be, but I think that they should also be considered.

Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area in the State of Guanajuato?

Braulio: I think that calculations can be made at the territorial unit level, state for example, how much water is being irrigated, precisely with those satellite images and know if they are well above what they should be according to the loads of the dams, that is, if it could be know at the national level, this state is irrigating more than it should or less than it should, if that can be done by satellite, it would be spectacular.

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20. How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basins of the State of Guanajuato?

Esther: In having reliable information, as Braulio was commenting just now, the government has a tool there that is information to be able to focus, that we are already in red, and precisely for this reason, having these more exact measurements, more within everyone's reach, this goes a long way and above all this for the government.

21. What do you think would be the most important potential applications of the OpenET platform to support the producers of Irrigation District 011 Alto Lerma and DR 087 Rosario Mezquite in their programming, monitoring, operation, design and evaluation processes of irrigation systems? irrigation?

Esther: Well, as I was saying, I believe that having this information very close at hand, allows precisely this, to make a good schedule, I think that right now the entire irrigation district 11, it is not the word to prohibit but, he suggested not to take crops right now from autumn-winter, precisely because of the scarcity of water, and this affects in many ways and in many ways, so having this information it is possible to have a good programming and better use of water. For example, within the producers that belong to a module and having it throughout the district, I believe that having this information would help a lot to be able to plan and make better use of water and distribute it better and, as we said in the previous question, that the government can have that information and then that its laws can be adapted to the real information.

Braulio: Related to the water demands of plants with climate change, obviously it would help us a lot, and any farmer, to know how much plants are transpiring. Beyond that of how to measure climate change, surely you have ideas.

22. How do you think the OpenET platform will be useful to regulate and order the concessions of existing Irrigation Units throughout the State of Guanajuato?

Braulio: I would tell you yes, ideally we would know where it is being irrigated and where it is being over-irrigated, but part of the challenge is that many farmers have 8 hectares and only irrigate 2, or they have 6 hectares but have water concessioned for 4, so that, I think, and Humberto has the clearest answer, it can really complicate knowing how much a concession is being overexploited.

Esther: I feel that since the information is not so close at hand, so accurate, what do I know, I think that right now, for example, this issue of concessions, of permits, for me is a little out of reality and therefore almost nobody complies with it, so it's like a farce, let's put it that way, that they put a number but that number is not real. I think that no producer, or almost no producer even in a cycle, not in the whole year, in a cycle, reaches the levels that the government is allowing to use water. I think that of course, having information at hand, information is a super powerful tool for anything, so, having this information at hand, you can regulate the rules a bit and then they can be applied well, and then we can be in another situation and or like now that everyone does not really carry the law as it is established, but because I believe that it is not so real, it is not possible to carry it.

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Put it in a more realistic way, because the truth is that right now the truth is not at all realistic to the situation in the country.

Esther: We would like to follow up on this, the work in the Bajío, specifically in the state of Guanajuato, we are trying and working with many allies in the sector, companies, producers, irrigation modules, government, to be able to change a little this situation that is so worrying and that there is no more time, not only in Guanajuato, but focusing on Guanajuato, there is no more time, we are already in red everywhere we look, so we all have to act and thus collaborate with each other, because everyone for its part, it may move a little bit but it does not really impact, so we who are in the nucleus, right now that is, with some pilots we are strengthening methodologies, alliances, but the goal is to scale this, because only by scaling will we be able to have an impact on the issue of water in Guanajuato. The more allies we have, the more joint work we do, it will be much faster, the better progress will be made. Tell them that they count on us for anything, just as they keep us informed of how this is progressing and we are in the same sector and with the same concerns.

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11.2.3 Guanajuato-Cauce Bajío Water Fund: Oscar Leal

Contact information
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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

Basically, it would be several things, it influences, for example, the availability of water in the dams, it also influences how they basically establish all the irrigation needs.

2. What types of stakeholders use evapotranspiration information in your organization?

[ ]	Farmers and operators	[X]	Area directors
[ ]	Researches	[ ]	Other:
[ ]	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

I could not tell you. I suppose that the one that is available is CONAGUA for open data, but it has a lot that I don't consult, I couldn't tell you that directly.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

In my case it is irrelevant. It can be any time of the year.

5. What is the most useful data visualization format?

[X]	Map	[ ]	Written report
[X]	Table	[ ]	Other:
[ ]	Graphic		

6. From what device do you think you and/or your colleagues will access the information?

[ ]	Cellphone	[X]	Laptop

[ ] Tablet
[X] Desktop computer
[ ] Other:

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

It depends on what you want to do, if you want to work at the plot level it would have to be 50 hectares, if you already want to work at the irrigation district level, 5 thousand hectares is fine, but if you want to work at the state level it would be 500 thousand hectares I mean, I don't restrict any of them, I think all three are useful, the only thing is that if there is a very detailed spatial scale, the problem is that you will have to deal with a lot of data that you will hardly be able to work on a computer normal staff, but it depends on each user and also depends on what you want to do.

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

The temporary resolution would have to be the one that is available monthly minimum. Latency, the sooner the better, having data practically in real time would be ideal, it depends on the structure of who is organizing it, it can be a month, every two months, in particular it would be very interesting for me if we had a tool in real time, which could be practically a week or two days out of phase, and I am going to tell you why, because in the field you can go and measure any situation and at any moment you could have how evapotranspiration is affecting and not arrive later and look for the data, could be very interesting, rather I think it depends on the analysis capacity and the technical and administrative capacity of the institution that is going to generate them.

9. How do you find it useful to have ET data summarized?

[ ] By plot
[X] By irrigation module
[ ] By irrigation district
[ ] By specific unit of area (specify)
[ ] Other:

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

[X] Yes
[ ] No

Additional comments:

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By irrigation district and we also work on some plots with producers and for me, for example, it would be great to have that information by plot.

11. Do the polygons in Question 10 contain private or sensitive information?

[X] Yes [ ] No

Additional comments:

The names of the owners

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

QGIS

General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

No, I think it's information that should be available to everyone.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

Well, analyzes can be generated that can later be used for measurements.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

I don't know.

16. What other applications do you think the evapotranspiration data could have?

No, I don't know, beyond what I already mentioned, I have no other type of knowledge.

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

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Well, I don't know, there we would have to see, for example, the needs or what the organization is open to collaborating with, because we can collaborate from defining the places where the stations can be placed or we could collaborate with the data collection or with the analysis, no I know, there we would rather have to get in direct contact.

18. Do you have suggestions for other partners?

[X] Yes [ ] No

Additional comments:

From here in the region, the University of Guanajuato could be, the irrigation districts, the Rio Grande Basin Council, the National Water Commission, the operating agencies, basically.

Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area in the State of Guanajuato?

Well, basically it has a lot to do with irrigation planning, so it is an important element to know when the plant has to be watered and a lot depends on it, for example, water management, not only by the irrigation districts, also by CONAGUA and the producers, so I think it is a very sensitive tool for that.

20. How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basins of the State of Guanajuato?

If, based on the evapotranspiration information, it is possible to determine when to irrigate, when not, what water to use, then the more information we have on how the hydrological cycle behaves, we will make better decisions.

21. What do you think would be the most important potential applications of the OpenET platform to support the producers of Irrigation District 011 Alto Lerma and DR 087 Rosario Mezquite in their programming, monitoring, operation, design and evaluation processes of irrigation systems? irrigation?

It would be used to carry out the programming, monitoring, design and evaluation of how irrigation is carried out at the unit level and also at the plot level.

22. How do you think the OpenET platform will be useful to regulate and order the concessions of existing Irrigation Units throughout the State of Guanajuato|?

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I think it is related to the fact that it gives us information on how much water is evaporating from the plant and when it is most necessary to irrigate, so that contributes to the regulation of the issue of water, now, how to order the concessions of the irrigation units, here already We are talking about something different, which is an administrative matter, and this matter is already defined by CONAGUA, which can take the data into account, it is true, but it also takes into account other needs and I don't know how much it can contribute to the issue of regulation of the concessions but it does provide the technical data of how much and when it has to be sent to the crops.

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11.2.4 Comisión Estatal de Aguas de Guanajuato: Ing. José Abraham Soto Ávila; Ing. J. Cruz Ángeles Gómez

Contact information

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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

In carrying out surface water balances, the evapotranspiration data plays an important role in this matter, since it is considered as a loss when evaluating rainfall and runoff. In addition, said variable is considered when determining irrigation sheets in crops.
We are currently doing a study on evapotranspiration in basins and aquifers here in the state, so the part that would help us is to learn more about the methodology or new processes to evaluate this data. We know that it is also used for agricultural matters, for consumptive uses, but specifically we would use it in this sense.
In general, what we have as a goal and task is to evaluate the hydrological behavior of each year, so it is a variable that we are interested in having each year, it is a variable that we are interested in having more or less correct to establish those balances in a more accurate.

2. What types of stakeholders use evapotranspiration information in your organization?

X	Farmers and operators	X	Area directors
	Researches		Other:
	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

Automated weather stations
Estimation with the Coutagne and Turc methods
There is a network of stations that CONAGUA has installed, which are of the Davis brand, and also among their reports they generate evapotranspiration data. In addition, there are other networks, with stations of other brands that INIFAP operates, and they also generate this data, that is the information we have. And the ones that Fundación Guanajuato produces, which is sponsored by INIFAP and the calculations that we do for balances, we use formulas, the

Coutagne method and the Turc method, we do the formulas in Excel. We use rain and temperature, if you notice, they are the formulas that have less information requirements, there are others that use radiation information or something else, so we use these because they require less information, but we are interested in those methods that can have more certainty and that we can feed with available information.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

All year. To make the balances we do them annually, so we require the information at the beginning of the year to have the complete information of the previous year, this is for the balances. But obviously when it is required or the users who have to do crop analysis, it would be another temporality, so we also require data on an annual basis, but without ruling out another temporality. The lowest time step would be daily. It would take care of it depending on the analyzes that we make of the daily data.

5. What is the most useful data visualization format?

x	Map		Written report
x	Table		Other:
	Graphic		

6. From what device do you think you and/or your colleagues will access the information?

x	Cellphone	x	Laptop
x	Tablet		Other:
x	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

In the case of agricultural activities, every 50 ha, for spatial analysis by basin, 5,000 ha. We really put them because they are for example, but we can adapt to the information that exists. Since we do the analysis throughout the state, with the division of basins and aquifers, we really do not require great detail in the case of balances. When we have the requirement or the researchers do the work on consumptive uses for irrigation or agricultural activities, it would have to be a smaller resolution. Finally, if you are going to generate results by raster image, I suppose they are going to be pixels. It would depend on the optimal resolution achievable; it is the condition level. I think it depends on the needs of each user, but if we are going to define the uses or evapotranspiration from uses, for example, here in the state, we have standards in certain

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modules where tenure is less than one hectare, then there can be diversity of crops, so the more detail the resolution has, the better.

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

Monthly and yearly. Due to the issue that we mentioned about the balance, if it is monthly and annual, but obviously if we have the monthly, we have the annual. From there on down, I don't know if we have much demand. For agricultural resources I don't know if daily. I don't know if it could be more often. latency. Resuming the balance that we do the whole year to make information. It would be ending the year, in January. But for users more dedicated to agricultural issues, the monthly case would be fine. As of the end of the month, maybe at most two weeks from the end of the month.

9. How do you find it useful to have ET data summarized?

x	By plot		By specific unit of area (specify)
x	By irrigation module	x	Other: Cuenca
	By irrigation district		

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized

x	Yes		No

Additional comments:

Analysis on basins and aquifers. Initially, yes, because practically everything we report here at the state water level is at the basin and aquifer level, perhaps other plaintiffs had another type of distribution or some other type of polygonal, either by module, by ejido, not I know, but at least for what we are dealing with right now, if it would be at that level.

11. Do the polygons in Question 10 contain private or sensitive information?

	Yes	x	No

Additional comments:

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

QGIS, ArcGIS

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General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

No The information that is generated here in the public sector, precisely comes from public resources, so there is no impediment for it to be published, the only restriction could be that the source be given, but there is no concern about it.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

General knowledge and practical use of information. When this information is generated, it is intended to make spatial publications of the values, we do this for information on rainfall, temperature, for information on relative rainfall and other variables, so that new variable could also be very important to make it known. We carry out balance studies of rainfall information, what runs off, what infiltrates, and what evapotranspires as one of the balance variables, so this would be a practical result of that analysis. Even the data itself is already practical data for a certain type of public, so it would be that way in how we are visualizing it.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

Publication of results and methodology online. Comparison of results with satellite images, for verification purposes. The methodology that you would use to determine this variable and that any user who wants to know that data knows the source, knows how that data was obtained, knows how that result was reached and that it can be disseminated. I think it is important that we can verify the data that you obtain, with some specific interpretation of a satellite image and that would help to continue with the analysis, that your results serve to verify satellite images from other dates, and to have an idea whenever.

16. What other applications do you think the evapotranspiration data could have?

Estimation of losses in reservoirs, water consumption in agricultural plots. In principle these would be the most important.

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17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

It is in our interest to participate as providers of information and verification of results, given that we manage a network of 29 automated weather stations that generate such information, in addition to the support of the Fundación Guanajuato Produce, from INIFAP, who also have 57 stations climatological, distributed throughout the entity.
As we mentioned, we have a network of stations throughout the state that generate information on rainfall and temperature that would be used as an input to determine evapotranspiration, so we believe that this could be useful for the generation of results for your project. If you consider it, we would make available to you this information that is throughout the state. Obviously, it would also help us to verify the information generated by the stations themselves in terms of evapotranspiration data that we understand is calculated by some procedure.

18. Do you have suggestions for other partners?

[x] Yes [ ] No

Additional comments:

Guanajuato Produce Foundation (INIFAP), University of Guanajuato, Ministry of Agri-Food and Rural Development (Government of the State of Guanajuato), Irrigation Districts 011 and 085

Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area in the State of Guanajuato?

Quantification of the use of water actually used for irrigation and determination of efficiencies in the systems used.
I think that depending on how we get to know the tool itself or the way in which they carry out their own analyses, the same and then we could provide feedback.

20. How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basins of the State of Guanajuato?

For the quantification of water actually used in irrigation, from surface and underground extraction sources.
You talk about the regulation of overexploited aquifers and we have doubts about what your idea would be like to regulate the use of water from the aquifer with this tool or with this information, if you could tell us a little more about this.

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I would think about it a little the other way around, because depending on the variables that they have after this, it may still work. Definitely, in the state of Guanajuato, practically all the aquifers are overexploited and have more or less certain levels of annual drawdown, all of them. So, if there is an interest in establishing regulation mechanisms in the extractions and obviously the short temporary steps or the shorter they are, the better, even according to the drought monitor that the National Water Commission itself is giving us, then I think that If we see in some processing, that you can give when theoretically, there is no, for example, allocation of surface volumes to the districts, but later you send, for example, that there is in the crops or a magnitude of crops that are not consistent to what we should be, so then we could take actions or develop criteria, guidelines, formulas, algorithms, whatever you want, to reach that regulation, which is of great interest here in the state, but right now We only have it as a project or idea, but we need inputs to get there. Of the 20 aquifers that we have, easy 10 would already have the urgency of establishing a control mechanism. The data would definitely be useful, depending on the regulation mechanisms that are designed or the control mechanisms that are identified, they could be good, any data would be good.

21. What do you think would be the most important potential applications of the OpenET platform to support the producers of Irrigation District 011 Alto Lerma and DR 087 Rosario Mezquite in their programming, monitoring, operation, design and evaluation processes of irrigation systems?

Optimize your irrigation procedures, using really effective sheets. Include in the analysis the producers of the Irrigation District 085.

22. How do you think the OpenET platform will be useful to regulate and order the concessions of existing Irrigation Units throughout the State of Guanajuato?

Verification of irrigation sheet used against official concessions. If we can match uses or exploitations depending, for example, on the phenological stages of the crops, etc., well, it is more or less we are realizing if more or less they are going well or if they have already gone from extractions.

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11.2.5 Cauce Bajío: Gustavo Magaña Sosa

Contact information

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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

I believe that evapotranspiration, since they do not inform, or help us or serve us to determine the opportune time of irrigation, is the use that we normally give it and well, another of the uses that it serves us is to estimate the water consumption of the crops and in the same way determine the volume of water that is used in agriculture, be it a plot, in a section, in a module, in a district.

2. What types of stakeholders use evapotranspiration information in your organization?

X	Farmers and operators		Area directors
	Researches	X	Other: Producers. The agents of change, we have a training program and technical assistance in irrigation, which is where producers are trained on when and how to irrigate, and well, the technical agents of change are other important agents.
	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

Well, here in Guanajuato, we are particularly using the meteorological network stations that the Guanajuato Foundation produces, they inform us in a timely and precise manner about the evapotranspiration that is generated in each of the stations that they have in the different parts of the state of Guanajuato, and that is the information we normally use.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

Normally we require the information when the crop is in the development stage, it is normally dealt with in the autumn-winter and spring-summer cycles, from the moment the seed germinates and is sown, from the first irrigation until the application of the last watering.

5. What is the most useful data visualization format?

X	Map		Written report
X	Table		Other:
X	Graphic		

The Guanajuato Foundation produces, delivers or makes this information available; you can download it in Excel, in Tables, and from there we give it the format that we consider convenient, but it would be very interesting to have that information on maps and graphs.

6. From what device do you think you and/or your colleagues will access the information?

X	Cellphone	X	Laptop
	Tablet		Other:
X	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

Normally we would require the information at the plot level, of 1 or 2 hectares, a resolution of that magnitude, when it comes to managing the irrigation time. But when it comes to determining volumes of use, it is also useful for us at the plot level, but also at that level we require a minimum of every 20 hectares for the irrigation unit level.

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

The ideal would be on a daily basis and as for the delay, I think that even with a delay of 2 or 3 days they would still be useful. If it is already to determine the water consumption on a monthly level, it is fine.

9. How do you find it useful to have ET data summarized?

X	By plot		By specific unit of area (specify)

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[X] By irrigation module
[ ] By irrigation district
[ ] Other:

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

[X] Yes [ ] No

Additional comments:

As I was telling you, we have the Irrigation Training and Assistance program and all the plots that are being attended to have polygons in KML and we visualize it in a software that we have visualized ourselves and we also have to visualize them in Google Earth in any geographic information system.

11. Do the polygons in Question 10 contain private or sensitive information?

[X] Yes [ ] No

Additional comments:

The polygons that we generate have information from the producer and also, I think, from their CURP and I think that this is sensitive information.

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

We normally use Google Earth and we also use software that we design and use ourselves. In this case we use "MATRi" and "Riego tech", which are systems that were generated here at the Secretariat for our use and that we can visualize all this information in geographic information systems in very good detail, very good level and very good information, makes summaries and all that.

General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

I think there would be no problem as long as that information is not shown, for example, name and all that, there would be no problem.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

I believe that the importance would be that they know how water is used in Guanajuato, how much

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water is used by plot, per hectare, etc., etc., and through this to generate awareness and a culture of water, I think that would be the utility that can be given to that public information.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

Well, maybe what would be useful there would be to calculate the need for irrigation.

16. What other applications do you think the evapotranspiration data could have?

Determining water consumption in an area could be used to determine irrigation needs, basically.

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

Look, this is a government agency and it would be necessary to negotiate or talk with the secretary so that they could collaborate with this type of project. Personally, I find it very, very interesting and I think that you should collaborate and participate in this, it is information that is undoubtedly of great benefit to the state, but it would be necessary to see it with the secretary.

Marco: how could you collaborate, with data or something?

If we could collaborate in the short term, it would be with the technicians we currently have in the Technical Assistance program. Right now, they are attending around 2,000 hectares with technical assistance and they would be a good pilot test to determine the feasibility and effectiveness of This type of projects, they carry information at a very good level, they carry information at the plot level, at the producer level, and if you work in these pilot areas, it can be a way of collaborating and it would be to validate the information provided by the OpenET.

18. Do you have suggestions for other partners?

[X] Yes [ ] No

Additional comments:

The civil associations that are dedicated to promoting the efficient use of water, in this case in Guanajuato there is the Guanajuato Water Fund that has had a good participation in the development of information to know how water is used in the state, I believe that Institutions or associations like them can participate actively. I don't know, maybe they already have contact with them but it occurs to me that it would be good to work with them, with Fundación Guanajuato produces that they also have very complete weather stations in the state, maybe with them.

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Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area in the State of Guanajuato?

It would be useful and it would be important for it to be ready and available to be able to use it, I think that would be the way we can determine it.

20. How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basins of the State of Guanajuato?

The utility in this topic would be that it would allow us to determine more precisely what is the consumption of water in agriculture or the volumes of water that are used in agriculture and having determined that type of volumes or that type of consumption by geographical areas or specific areas, I think that would be very useful, it would be very helpful for this purpose that you mention. An accurate water balance.

21. What do you think would be the most important potential applications of the OpenET platform to support the producers of Irrigation District 011 Alto Lerma and DR 087 Rosario Mezquite in their programming, monitoring, operation, design and evaluation processes of irrigation systems?

This type of platform would help a lot in terms of water management. I think it would help a lot to determine the areas that are planted, the areas that are irrigated, without the need to go around doing field trips, censuses and all that kind of thing. It would also be useful to determine the water consumption of their crops and compare it with the statistics they have, I think it would be a good reference. It would also be very useful if an application were available, for example, so that the data generated by OpenET could be connected and used, for example, we with the "Matri" that we have if we can pull the information in real time and how We have a very complete, very precise and well-defined database, we can automatically determine the appropriate irrigation times for producers, so, since there is an exchange of information between OpenET and the applications that we have, I think it would be cool, that would be pretty cool.

22. How do you think the OpenET platform will be useful to regulate and order the concessions of existing Irrigation Units throughout the State of Guanajuato?

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It would be as we discussed a while ago, if we can determine, for example, for a well we have the area of influence, the area that is authorized to plant crops, if you have this area with this type of platform, tools can determine how much is the water that is consuming that irrigation unit that has, for example, that well, then from correlating that information that is obtained with this platform, you can define if the producers are really using the water that was granted to them or are using a larger volume . It would be very useful to have a precise estimate of the consumption and volume of water used. I think that would be good in that sense.

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11.3 Transcripts of interviews from Coahuila

11.3.1 CENID RASPA: Dr. Juan Estrada

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About the evapotranspiration information

1. What decisions are impacted or informed by evapotranspiration information?

Look, it depends on who makes the decision, if it's a government decision, if it's a producer's decision, etc. So, I don't know what you mean by which decisions impact, that is, from whose point of view. Well, evapotranspiration is a variable, it is only an irrigation variable, the other data, the important data that cannot be determined is how much water is applied, but in fact, with the evapotranspiration data, you can already see how much water is consumed the crop, which, by the way, roughly, we already have knowledge of the evapotranspiration consumption of crops in the region.

2. What types of stakeholders use evapotranspiration information in your organization?

X	Farmers and operators	X	Area directors
X	Researches		Other: Técnicos, asesores de los productores
	IT specialists		

3. If available, what are the current sources of evapotranspiration information?

There are several, in the case of INIFAP we have an application called "IrriNet" and well, the other one that is also used is "CropWat", essentially those two.

4. At what time of the year is evapotranspiration information required? That is, are there seasons or situations when the information is more crucial than others?

Basically all year round, in the case of the Laguna region we have 3 cycles, the spring cycle that begins in the month of February-March, right now we are already seeing the first irrigations, that

spring cycle begins at the beginning of March with the irrigations, the dam is about to open right now, the irrigation district dam, the Lázaro Cárdenas and Francisco Zarco dams, this cycle ends towards the end of July more or less, and later there is a second cycle that we are going to say is the summer cycle that it starts on those dates, the end of June, the beginning of July, and there are three months essentially for production, three and a half months essentially for fodder corn and later comes the winter cycle, which is some winter fodder, we are talking about citrus, etc. Those are the 3 cycles that we have, and we have perennial crops that are alfalfa and walnut, in those periods it is necessary to know the evapotranspiration.

5. What is the most useful data visualization format?

X	Map		Written report
	Table		Other:
	Graphic		

6. From what device do you think you and/or your colleagues will access the information?

	Cellphone		Laptop
	Tablet		Other:
X	Desktop computer		

About the technical requirements

7. For your team or organization, what is the ideal spatial resolution of evapotranspiration information and what is the spatial extent of the data needed to support your work? (for example, 50 hectares, 5,000 hectares, 500,000 hectares).

These scales are completely out of any possibility, because 50 ha, the farms here in the region, we are going to say that the farms are between 150-200 ha, but they have different shapes, so if you talk to me about a pixel of 50 ha, that is, a square of 50 ha, you are going to have cross information, let me explain, the irrigation that you give, irrigation is given by tables, those tables or by beds, and you can irrigate perhaps 4-5 ha in one day, so let's imagine a 100 ha plot, it takes you 20 days to irrigate all 20 ha and you will have evapotranspiration data, if it is daily, you will have evapotranspiration data in sites that have just been irrigated and in sites that need time to irrigate, So you're going to have an average and you're not going to have precision, so definitely the pixel. I think that the right one for the sizes of property that we have here in the region should be around one pixel of one hectare, and it seems strange to me. that they say 50, 5000 or 500 thousand ha, I'm not sure, Marco, yes, is it 500 thousand ha? 500,000 hectares, I don't know if any irrigation district has it, perhaps in Sonora, some irrigation districts have that area, but it is difficult to have a pixel of 500,000 hectares. I think it refers to how much information you would like to have, for example, I would be interested in, in my case, 5,000 ha, I would like to have information on at least 5,000 ha. Those 5,000 ha

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represent an irrigation module for me, the irrigation modules are going to be between 3,000-5,000 ha, so give me the information of a complete irrigation module with a zoom of one hectare, it is that is, the pixel of a hectare. That way, because yes, the question is a bit ambiguous.

8. For your team or organization, what is the ideal temporal resolution and temporal latency of evapotranspiration data?

The detail is as follows, the key question of this information. The information on evapotranspiration is very important in the case of irrigation planning, that is, if I have a balance of how much water is being evapotranspiration, I can say, I am going to replace that evapotranspiration 20-30 days after irrigation, but there is a piece of information that is missing and that is how much water you are applying, that is, how much water is in the soil reserve. What do I mean by this, that the evapotranspiration data can be of use to me, if it is for irrigation, because it would be with a temporal resolution of 5 days in the case of Sentinel, 5 days would be enough, with that it would help me to plan irrigation, with a temporal spacing of 5 days, if it is for another type of analysis For example, in the case of the irrigation modules, the progress of irrigation, you know that the irrigation modules, when they release the water, have to distribute it throughout the entire module, so to see progress, there if data is required daily, it would be ideal, but there is another objective, it does not have an irrigation planning objective, it is a water distribution objective, that is, how you are distributing the water with your users. Now if it is for water balances, with the one from Sentinel it could be, with a temporal spacing of 5-10 days, in the case of water balance, but in this case that I am telling you about, it is an account that you have, I will give you a real example, in the case of an irrigation module that has 4,000 ha and that irrigation module is granted 50 million cubic meters that are distributed by one flood irrigation and three aid irrigation, then the one for flooding is going to say that there are 14 million cubic meters, you have to distribute those 14 million cubic meters over 14 ha, it would be very useful to see the daily balance of that distribution in the first irrigation, when there is bare soil but later, it gets complicated because You already have vegetation cover, but at least in that first instance, it would be very useful to have an analysis of how you are distributing those 14 million cubic meters, how you distribute them in the 4,000 hectares, that is basically an area distribution.
Latency I think that current equipment does not give you more than one or two days, so being one or two days late would not be a problem.

9. How do you find it useful to have ET data summarized?

X	By plot		By specific unit of area (specify)
	By irrigation module		Other:
	By irrigation district		

10. Do you have a set of well-defined individual field polygons or geospatial units over which you would like evapotranspiration data summarized?

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[X] Yes [ ] No

Additional comments:

We have practically everything at the parcel or district level.

11. Do the polygons in Question 10 contain private or sensitive information?

[ ] Yes [X] No

Additional comments:

It is public information, it is not associated with having it, that is, public information is what we handle, we do not handle any private information about the properties, in fact, that information is not available.

12. Which geospatial software tools (or Geographic Information Systems) does your organization use?

In the case of images, it is GRASS GIS and QGIS, but essentially the one we manage now is QGIS and well, there are also the satellite platforms, we manage the Sentinel platform, Copernicus and also everything that is Google Engine, which is what we currently have. it is being used more by everyone.

General considerations

13. Do you have any concerns in making the evapotranspiration data publicly available to other users, regardless of their sector?

No, worry, no. What happens is that in the INIFAP case we use all the information for purposes of efficient water use, that is, for issues of increasing water productivity, to make efficient use of water, to be more productive, eventually that information in other people's hands, it could be misused.

14. What do you see as potential benefits in making the evapotranspiration data publicly available to other users, regardless of their sector?

I believe that nothing is wrong, it is a need that we as a society have to make efficient use of water, increase productivity and therefore face the challenges that we have in the short and medium term to produce more food with the same water and soil resources that we have.

15. Is there anything else you think the OpenET team should consider for the development of the data in Mexico?

One of the limitations of OpenET and any other similar platform is the availability of data from

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weather stations, in Mexico we have a deficiency of observed data and it is well below what they have in the United States, so in a large part of the adjustments that has OpenET in the case of evapotranspiration is based on observed data and it is the limitation that we have in Mexico we have different networks, stations and within those same networks, there are deficiencies and differences In the case of CONAGUA, you know, not all stations have the same quality, etc., in the case of the INIFAP network we have some stations but not all, in the case of the Federal Commission network, they are very jealous, they do not share information and that is the main problem, and I can mention others. There are networks of weather stations, the private ones that are also available there but you don't know how they are installed, if they are on the side of a property, a road, etc., then the quality of the information is what limits.

16. What other applications do you think the evapotranspiration data could have?

I can tell you that for water balances, not only at the parcel level but also at the basin level, environmental studies, I can think of evapotranspiration at the basin level to make balances at the basin level, essentially for these aspects.

17. Would you/your organization be willing to be a partner or collaborator in developing OpenET for your state/region?

[X] Yes [ ] No

Additional comments:

Talking about the region by INIFAP would be very useful, in the case of INIFAP I told you that there are different networks of weather stations, INIFAP has a network of weather stations that are managed directly in Aguascalientes, Dr. Víctor Rodríguez manages it , but locally there are other weather stations, for example, from Tamaulipas, there where the citrus area is, there is a network financed by climate producers that is much more precise, I'm also talking about here in Sinaloa, Sonora, where INIFAP has a lot to see in that part, Chihuahua has some weather stations, Guanajuato too, and in the case of the lagoon, we have some network stations and some other stations of ours, that would help, what I mean by this is that INIFAP is the institution that manages all the agricultural part essentially at the national level, we have fields in all the states and I think it would be very useful and I think it would be true, we would be willing to see what kind of collaboration we could establish, some collaboration agreement, etc., and focused essentially on some irrigation districts, not necessarily at the national level but the main irrigation districts as in these cases that I have just mentioned, and also emphasizing that part of the water balance at the basin level.

18. Do you have suggestions for other partners?

[X] Yes [ ] No

Additional comments:

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Essentially the producers themselves, the producer associations, I believe that they would be willing to participate and I believe that they are the main ones, they are quite interested in making their production systems more efficient and I believe that they would be very receptive in this aspect and proactive.

Particular considerations

19. How can the OpenET platform serve as a support tool in determining the irrigated and planted area, calculation of savings and distribution of volumes within the "Healthy Water for the Lagoon" program?

I am frank, OpenET determines evapotranspiration but that is a variable of everything that irrigation implies, you are only knowing one of the variables, the other is how much water you are applying and that can only be known by being at the plot level, There is also another aspect that is management, that is, what I was trying to say right now about the distribution of water that is done at the module level, that distribution also has a lot to do with it, it has a lot to do with the planning part and the operation of everything that is the distribution of water, the efficiency of conduction, the management part of the irrigation systems, training in irrigation management systems, modernization of irrigation systems, so realistically it is not a tool that it will solve you but it is a tool that contributes to solving one of the variables that you have in the case of the efficient use of water. And of course, welcome everything that is trying to contribute to the efficient use of water, essentially for the "Healthy Water for the Lagoon" program, which is what it is about, to make water more efficient and recover volumes of water that we are losing, recover them to be able to dedicate them to healthy water, to drinking water in the case of the population.

20. How can the OpenET platform serve as support for the recovery and regulation of overexploited aquifers in the Basin Organization "Cuencas Centrales del Norte"?

Essentially what I just mentioned is through balances, but you know only one variable of the balance, the balance is inputs and outputs, you only know the outputs, but you don't know exactly the input or the percolation input.

21. What do you think would be the most important potential applications of the OpenET platform to support the producers of the Irrigation District 017 Lagunera Region and 034 State of Zacatecas in their processes of programming, monitoring, operation, design and evaluation of irrigation systems?

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For that matter, you know the evapotranspiration and with this part of evapotranspiration you can have a better programming, you could have a better operation, design of the irrigation systems, I don't think it's partly the evaluation, but not necessarily, but I think that It would help you a part, what happens is that I know OpenET, what it has shown is the calculation of evapotranspiration, you translate it into volume, how much volume of water is evapotranspiration but that is already done with other systems, here I believe that the utility of OpenET would be the speed, the scale perhaps, and some added values such as crop identification, maybe it could also identify which crop you are talking about and that information could be useful especially at the irrigation module level and for statistical issues, but I am also honest with you about this part, in the SIAP there are very good analysts of all this part of the satellite image and they have very good statistics, but hey, in this case I would come to contribute in that part as long as the issue of the seasons could be resolved of weather.

22. How do you think that the OpenET platform will be useful to regulate and order the concessions of existing Irrigation Units throughout the State of Coahuila?

It would not be possible for me to help regulate and order the concessions of the irrigation units, why, because I have a concession for water that they are going to give me if it is the case of the dam, I have a concession and that concession is going to give me serve to irrigate 1.5-1.7 ha, but I already have that by right, I don't know how OpenET could order the concessions. If you already want to monitor each of these concessions, you already need other types of tools like this one that told you to digitize all the plots and monitor those plots, which ones you are irrigating and which you are not irrigating, which is only possible when you have bare soil from waterlogging and you can hardly follow it because you already have a developed crop and it is difficult in a developed crop to know if you irrigated or not, then it is difficult to follow what irrigation is in an irrigation module. I consider that it would not be so useful to order the concessions. It could be for planning, but I see it as difficult to regulate and order concessions. Unless OpenET provided another type of information, but if it is only evapotranspiration, it would not be so useful.

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