WATER SECURITY AND CLIMATE CHANGE
IN THE REGION OF CENTRAL AMERICA & THE CARIBBEAN

IMPACTS OF CLIMATE CHANGE ON WATER SECURITY

IN THE WATERSHED OF RIO SAMALA, GUATEMALA, AND ADAPTATION MEASURES

CATHALAC
Water Center for the Humid Tropics of Latin America and the Caribbean

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Between 2012 and 2015, with funding from the International Development Research Centre (IDRC, Canada), CATHALAC initiated a study of Water Security and Climate Change at the regional level, with attention focused on the political-institutional conditions of water management in the Dominican Republic and Guatemala. In both countries work was carried out hand in hand with the Ministries of Environment and two national universities, the Technological Institute of Santo Domingo (INTEC) and the University of San Carlos of Guatemala, respectively. Together with national partner institutions, the areas of focus were selected.

In the Central American nation, a study was made of climate change-related vulnerability in the Rio Samala watershed and of local water management in the municipalities of Quetzaltenango and Santa Cruz. In the selected municipalities, those responsible for municipal planning, together with project researchers, drafted Municipal Plans for Adapting Water Resource Management to Climate Change.

Water Security

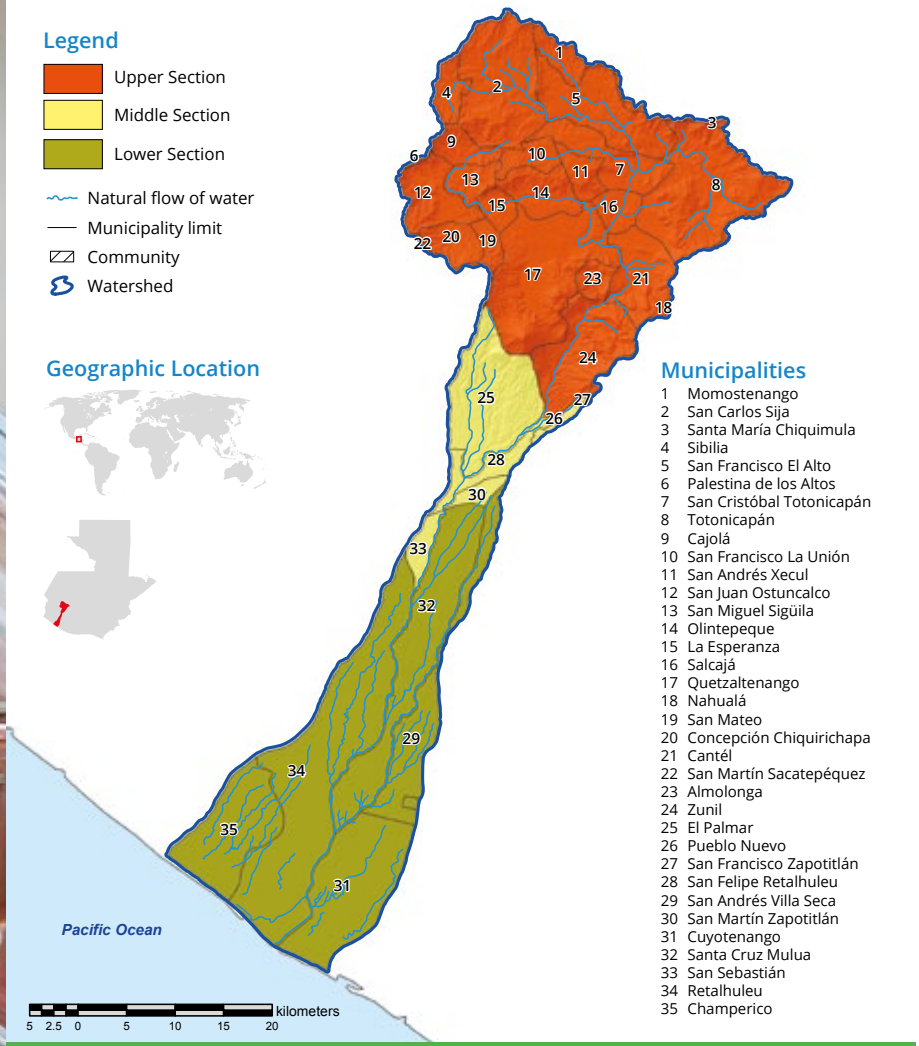
Water security is the "ability of the population to safeguard sustainable access to water in the quantity and of the quality suitable for livelihoods, human welfare[1] and socio-economic development, to ensure protection against water-borne contamination and water-related disasters, and to conserve ecosystems, in a climate of peace and political stability"[2].

The concept of Water Security summarizes the level of success of a given population in water management, including:

- Access to potable water
- Collection and treatment of waste water
- Protection of livelihoods, human rights and cultural values
- Watershed conservation
- Socio-economic development

1 Human welfare has multiple aspects, including the basics for a good life, freedom of choice and action, health, good social relations, and security (MA, 2003 in UN-Water, 2013).

2 UN-Water. United Nations University. Institute for Water, Environment and Health. 2013. Water Security and the Global Water Diary. United Nations University. Ontario, Canada. 37 p.



Municipalities

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4 Sibilia
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THE RIO SAMALA

WATERSHED

The Rio Samala watershed has an area of 1,621.26 km2, with an estimated 725,500[3] inhabitants in 35 municipalities in 5 departments. The basin has a total water availability of 1330 million m3, and an average flow of 42 m3/s (Acabajon, 1973)[4], which has been significant for the development of large populations and economic activities dependent on this hydrological capacity, including power generation. In this watershed, five hydroelectric power plants currently operate and another will be starting operations shortly. Currently, it has a total installed capacity of 102.58 MW plus an additional 23.

Many of the water flows in the basin originate at an average altitude of 3000 masl in the Sierra Madre. Its steep slopes quickly change to softer slopes on the coastal plain, which implies a risk of flooding in the lower section. Added to this risk is the moderate activity of the Santiaguito volcano in the middle of the watershed, producing frequent lahars, mudflows and volcanic ash that make Samala one of the watersheds with the highest incidence of natural disasters in Guatemala (PREVDA, 2008[5], Alvarado, 2014[6]).

3 Calculation performed by LandScanTM based on 2010 data.

4 Acabajon, A. 1973. Estudio hidrológico básico de la Cuenca del Río Samalá. Tesis. Facultad de Ingeniería. Guatemala: Universidad de San Carlos de Guatemala.

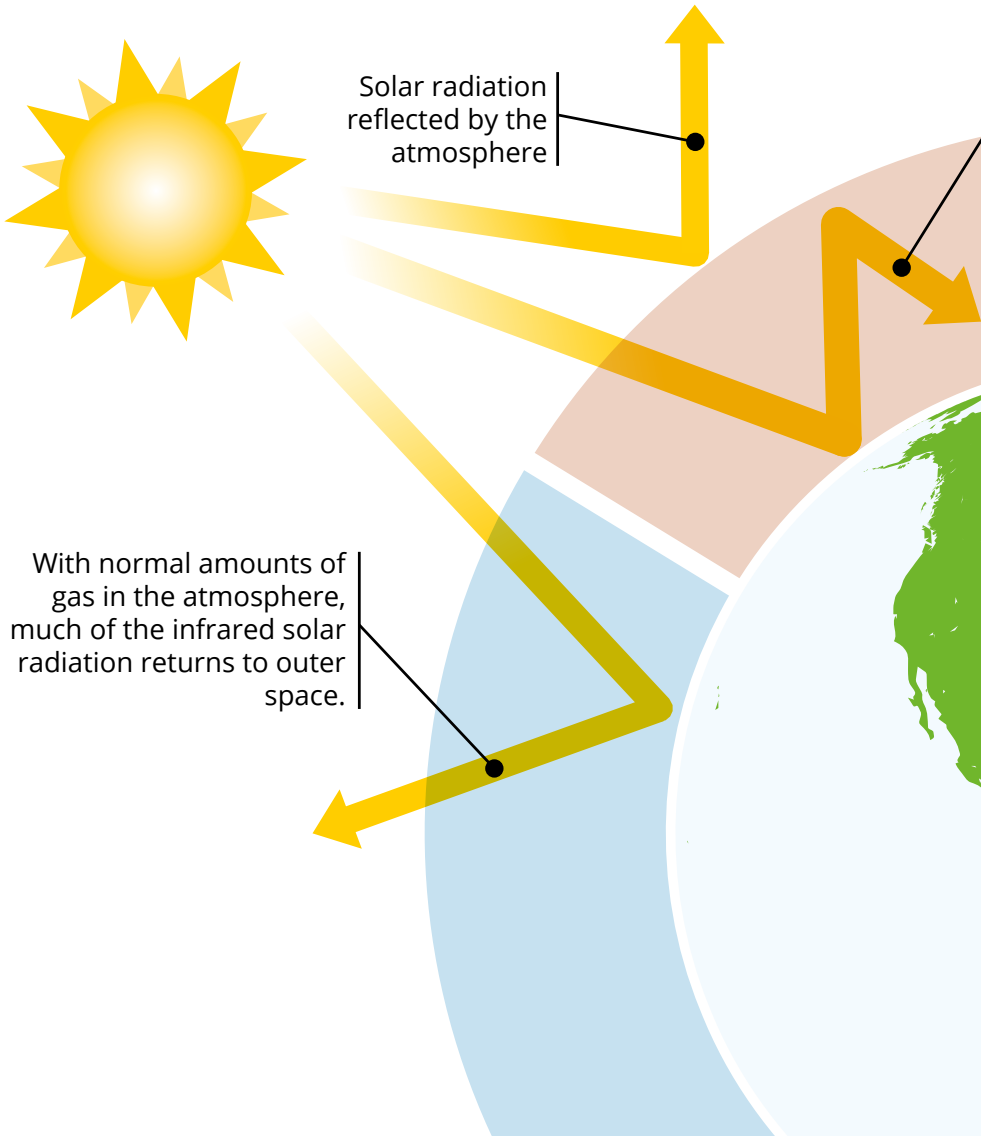
5 PREVDA. 2008. Diagnóstico de la Cuenca alta del Río Samalá. Consorcio CEDEPEM / ALDES.

6 Alvarado, H. 2014. Análisis de sensibilidad y capacidad de adaptación del recurso hídrico al cambio climático, en los diez municipios con mayor vulnerabilidad de la Cuenca del río Samalá, Guatemala. CATHALAC, IDRC y USAC.

What is climate change?

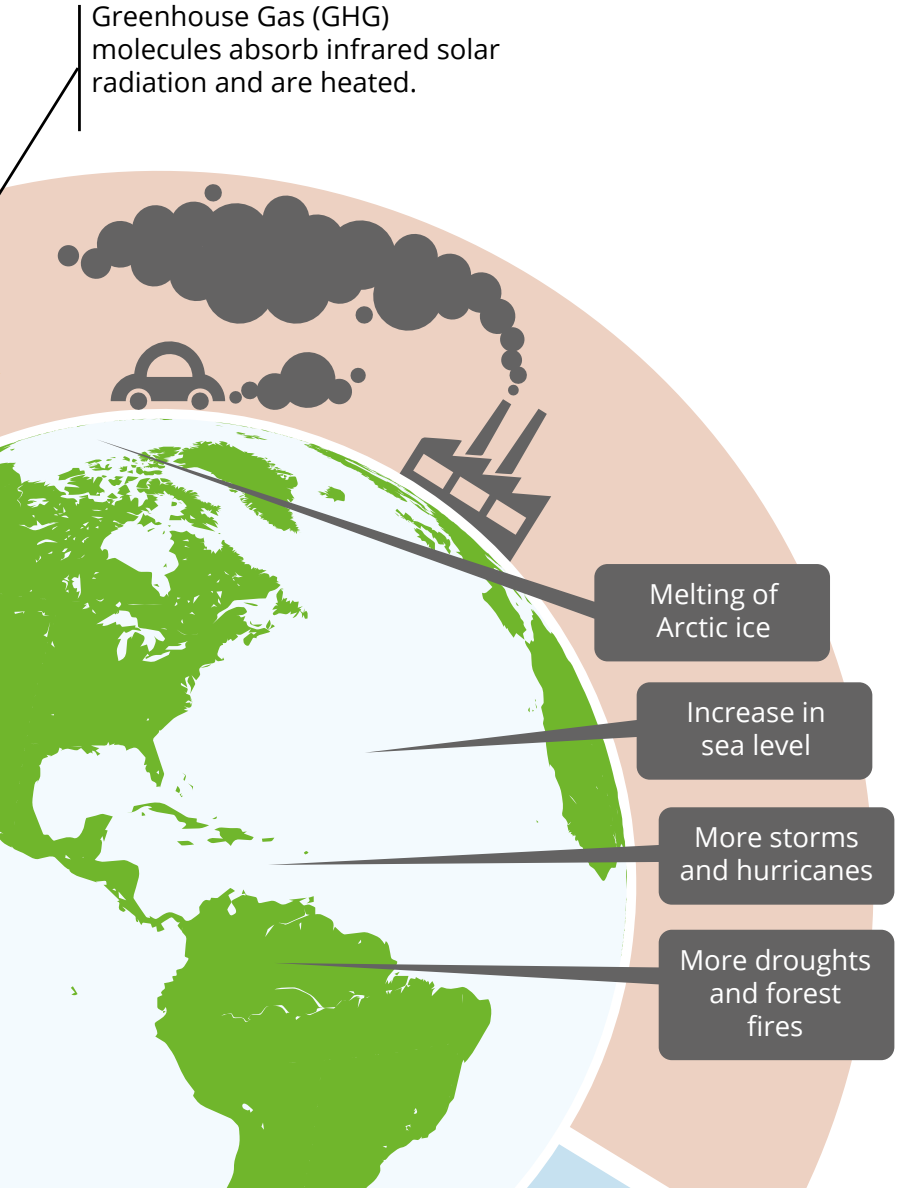
Climate change refers to a change in climate that persists for an extended period, typically decades or more. Climate change may be due to natural processes (such as volcanic eruptions) or people-driven processes (such as the gases emitted by burning vegetation or operating engines). Since human activity in recent years has generated huge amounts of gases called Greenhouse Gases or GHGs (because they function as a layer over the earth similar to the covering over a greenhouse, allowing sunlight to pass through, but storing the heat), the process of climate change has been accelerating in the planet, changing many patterns.

One of the direct effects of Climate Change is on the water cycle, i.e., on water availability, which means a lot in terms of human development, reducing poverty, food security, energy security, etc. Hence the need to analyze how Climate Change will affect Water Security, since this concept summarizes the use that society makes of this precious resource.



How will Climate Change affect water availability?

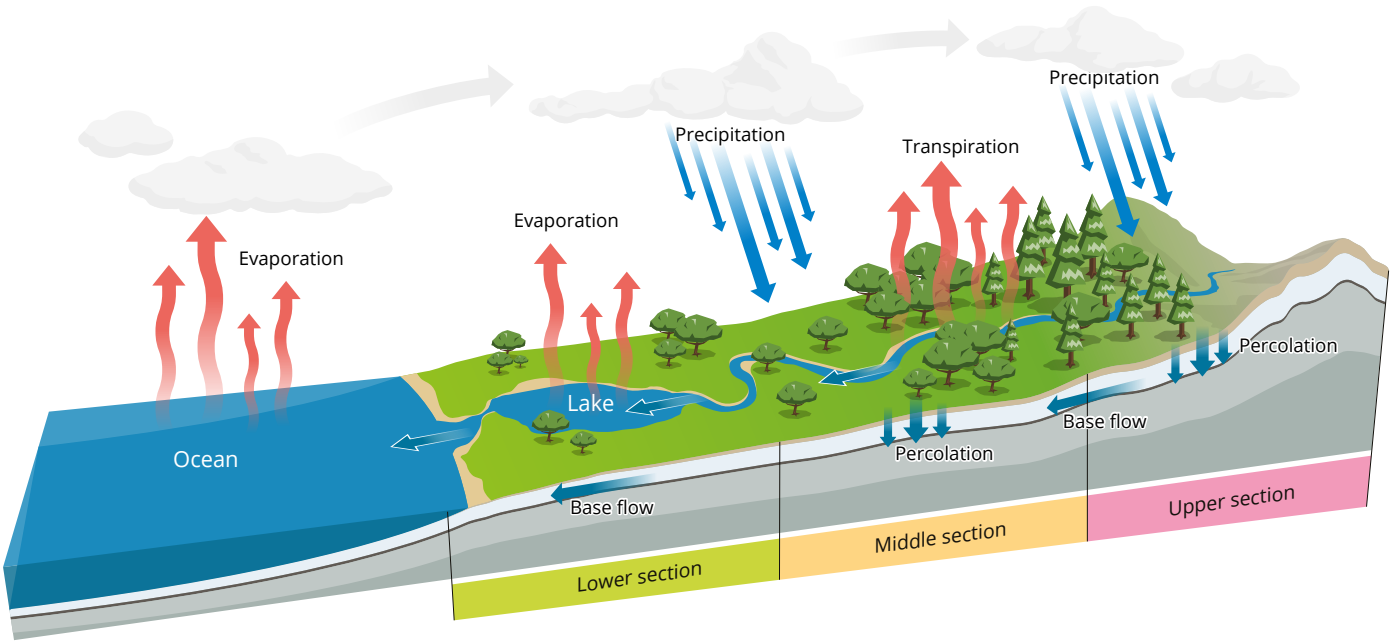
To answer this question, we explored what the climate will be like in the future. Different institutions around the world have modeled the planet's climate for different levels of Greenhouse Gas emissions. CATHALAC selected two of these models, the Norwegian model NorESM1-M and the Japanese model MIROC5, for both a low level (2.6 W/m2) and high level (8.5 W/m2) of emissions to 2050. The annual temperature and precipitation values for both models and their emissions scenarios were used to evaluate changes in the water cycle of the Samala watershed using the SWAT program (Soil and Water Assessment Tool).



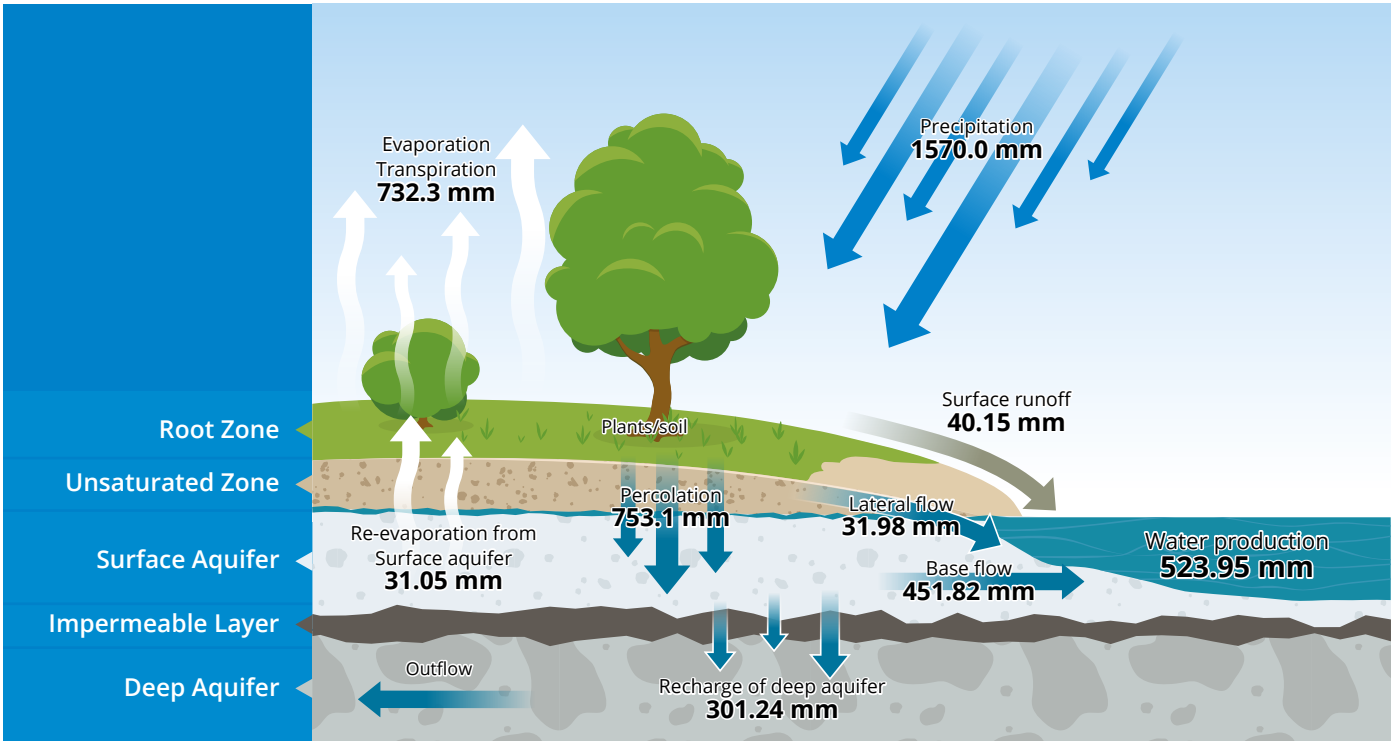
What is the water cycle and how does it work in a watershed?

The water cycle describes the movement of water on the planet. Its movement may be in a liquid, solid or gaseous state and covers several stages: precipitation, which in our Guatemala refers mainly to rain but in other countries includes snow and hail; infiltration, which is water that penetrates the ground; the runoff that creates rivers; and water that evaporates from surfaces (bare ground, ground with vegetation, bodies of water, etc.) to the atmosphere to form new clouds. This process is carried out in a land space called a watershed that acts like a "huge bowl" in which we can quantify how much water there is in each component of the cycle.

Soil and vegetation are key elements in this cycle, since just as water accumulates in lakes or dams, it is also stored underground in what are known as aquifers. The capacity of aquifers to store water depends first on their ability to infiltrate, which in turn depends on the type of surface; for example, in ground without vegetation the water will have difficulty penetrating deeper layers for storage, and in a storm, the water will run off quickly with no opportunity to infiltrate, possibly causing a flood disaster. That is why it is important to take care of forests; otherwise, there will be problems storing the water in rivers and underground, which are the main sources for the systems that transport water to our homes.



Variables in the Water Cycle of the Rio Samala Watershed



The figure Variables in the Water Cycle of the Rio Samala Watershed presents the different components of the water cycle and the volumes of water in millimeters (mm) that have been calculated for each one in the watershed. The average precipitation for the watershed is 1,570 mm. Of this amount, 47% evapotranspires, a portion of the surplus runs over the ground, another part runs through the topsoil as lateral flow and another percolates. Of the water that percolates, part evaporates from the ground, another part flows horizontally and only a small 2% infiltrates to recharge deep aquifers. The amount of water counted as Water Production is the sum of the Superficial Runoff, Lateral Flow and Base flow.

CURRENT VULNERABILITY

The IPCC[7] defines vulnerability to climate change as "the degree to which a system is susceptible or unable to cope with the adverse effects of climate change, including climate variability and extremes." In the Rio Samala, CURRENT vulnerability was evaluated in three aspects: Exposure, which is the type of impact that the watershed is exposed to and the degree or the intensity of the impact; Sensitivity, the degree to which the watershed is affected by the weather; and Adaptive capactiy, which refers to the watershed's ability to adapt to change, mitigate possible damage, take advantage of opportunities or face the consequences. The factors related to vulnerability were determined by the indicators in the following figure and were graded on a scale of 1 to 3, where 1 (low) is better than 3 (high) for the Exposure and Sensitivity indicators, while 3 (high) is better than 1 (low) for Adaptive capacity.

The Sensitivity and Adaptive capacity indices were obtained through indicators which were selected and evaluated using the DELPHI method based on consultation with experts. A Likert-type grading scale of 1 to 5[8] was used. The indicators were added by type of capital, following DFID methodology (1999[5]):

- **Natural resources:** The presence of natural resources on which people depend both directly (i.e. for income or medicine) and indirectly (i.e. flood control, protection from storms).
- **Physical Resources:** the basic structure and productive capital for transportation, buildings, water management, energy and communications.
- **Financial resources:** The existence and flows of money that enable people to achieve their goals with regard to livelihoods.
- **Human Resources:** the skills, knowledge, capacity and good health necessary for achieving livelihoods.
- **Social Resources:** the formal and informal social relationships and institutions on which people's livelihoods depend.

7 Intergovernmental Panel on Climate Change, technical advisory body of the United Nations Framework Convention on Climate Change.

8 Landeta 1999. El método Delphi. Barcelona: Ariel

INDICATORS FOR EVALUATION OF VULNERABILITY VARIABLES IN THE RIO SAMALA WATERSHED

Vulnerability indicators were identified by a research team at the University of San Carlos of Guatemala, University Center West in Quetzaltenango (Alvarado et al, 2015)[9]

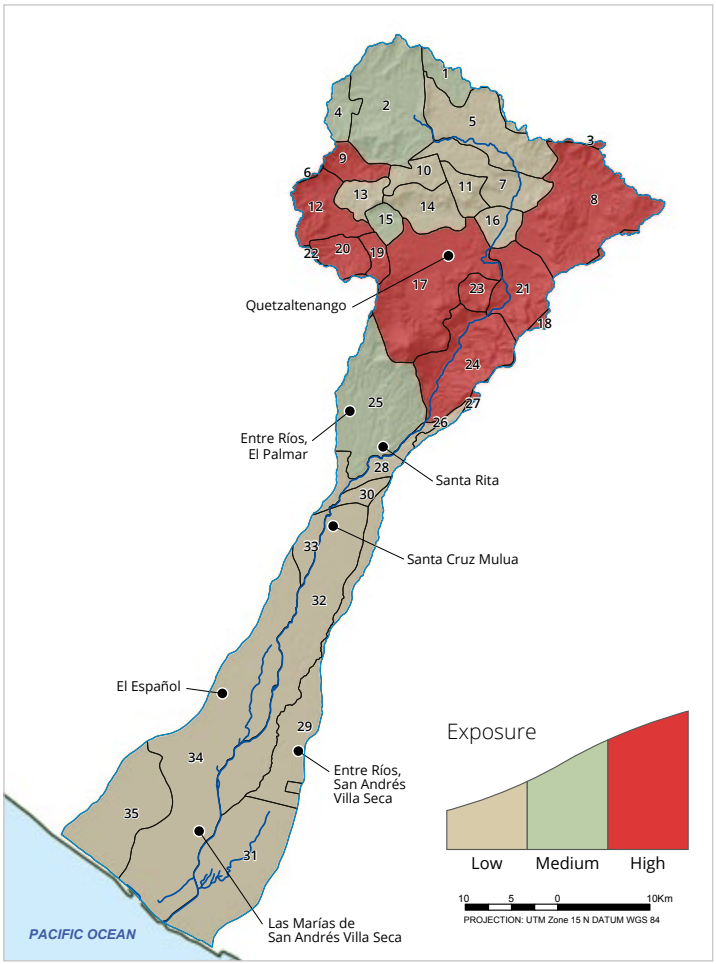
9 Hector Alvarado, Luis Sanchez, Hernan Guzman, Daniel Ruiz and Gabriel Gamboa. 2015. Analysis of sensitivity and adaptive capacity of water resources to climate change, in the 10 most vulnerable municipalities of the Rio Samala watershed, Guatemala. Work document. Water Security and Climate Change Project.

EXPOSURE	SENSITIVITY	ADAPTIVE CAPACITY
Phenomena associated with climate change	What elements of water security will be most affected by the impacts of climate change (drought, floods, frost and landslides) in the municipalities of the Samala watershed?	How can water security be adjusted, maintained or increased to address climate change in the municipalities of the Samala watershed?
▸ Floods ▸ Drought ▸ Frost ▸ Landslides	▸ **Physical resources:** access roads (type of roads), housing (basic services and type of building materials). ▸ **Natural resources:** water access and availability (source, distance and time of supply, seasonal availability, quality for human consumption and increased demand), conservation (percentage of forest cover, percentage of deforestation, increased natural generation, percentage of protected areas), soil and level of deterioration (soil type, slope, cover, land use conflicts). ▸ **Human resources:** health (number of health care centers, frequency of illness, number of doctors per capita), migration (destination and seasonality), basic needs (coverage of primary education, illiteracy, poverty and housing) and population (density and growth rate). ▸ **Financial resources:** cost of maintaining aqueduct infrastructure affected by climate disasters (in relation to the investment budget for 2013), public investment in reconstruction of aqueducts (number of post-Mitch aqueducts built and resources allocated to reconstruction and rehabilitation of aqueducts affected by weather events).	▸ **Physical resources:** viability of aqueduct infrastructure (percentage of aqueducts operating) and codes, norms and standards that respond to climate threats (existence of codes, norms and standards that respond to climate threats). ▸ **Natural resources:** pollution reduction (wastewater treatment and solid waste disposal and management) and conservation (percentage of forest cover and protected areas). ▸ **Social resources:** associativity level (number of existing associations), early warning systems in the municipalities (existence of early warning systems operating in the municipalities); development policies for the water, infrastructure and environment sectors (existence of development policies for water, infrastructure and environment sectors); local risk management plan for disaster response (existence of a local risk management plan for disaster response) and watershed management plans (existence of watershed management plans). ▸ **Human resources:** databases or information systems on hazards, vulnerability and risk management (existence of databases or information systems on hazards, vulnerability and risk management). ▸ **Financial resources:** public investment in protective infrastructure (percentage of public investment in protective infrastructure) and access to credit (credit sources available).

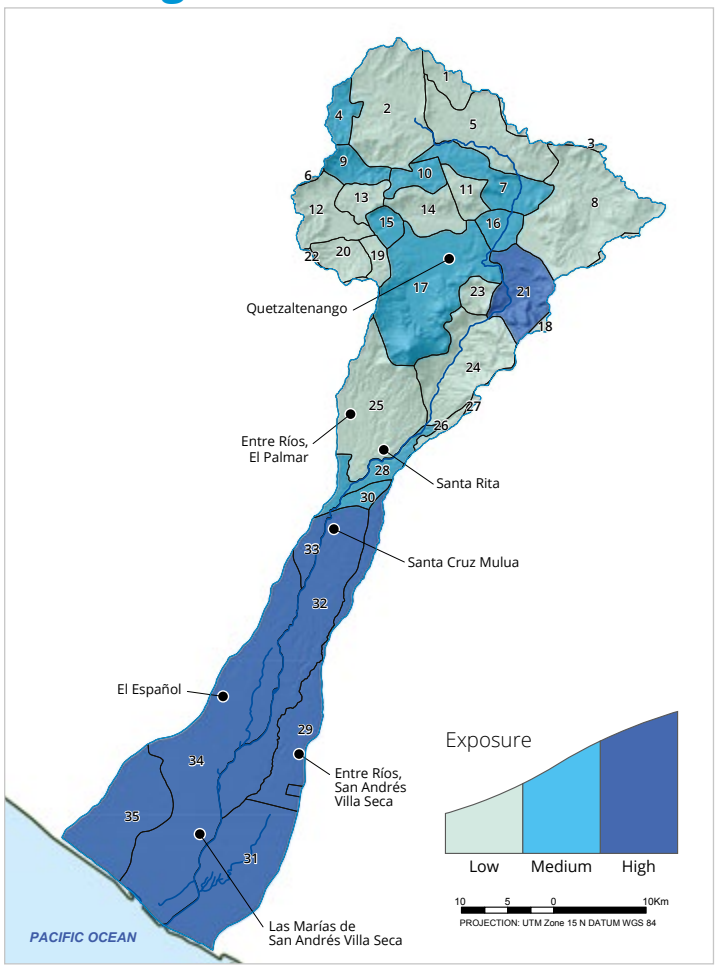
Exposure

Exposure to phenomena associated with Climate Change.

Landslides



Flooding



Geographic location

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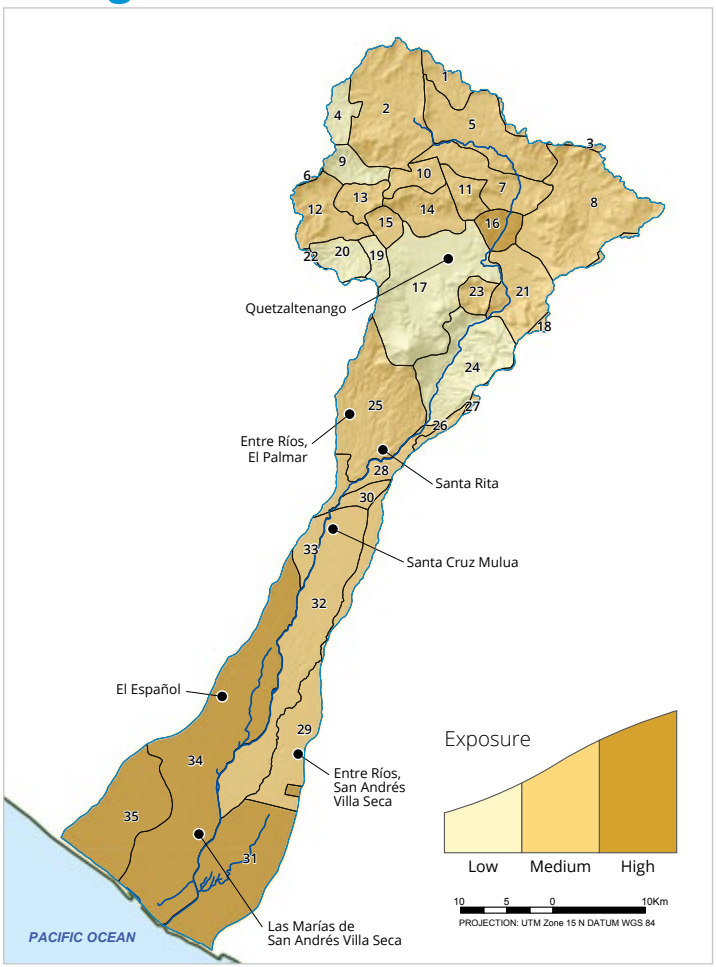
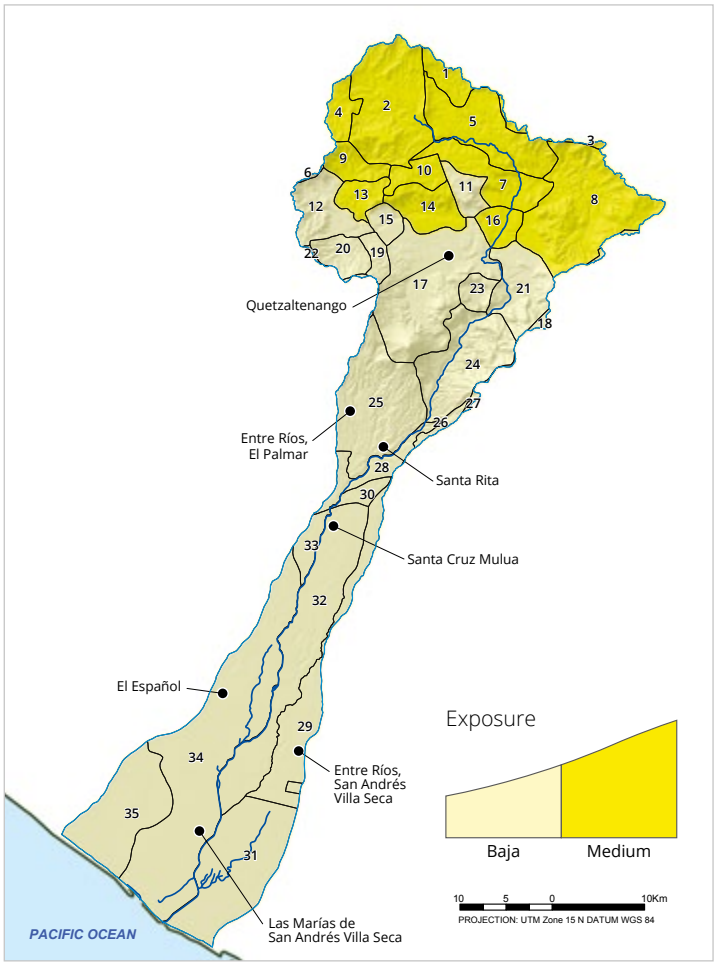
Drought



Frost



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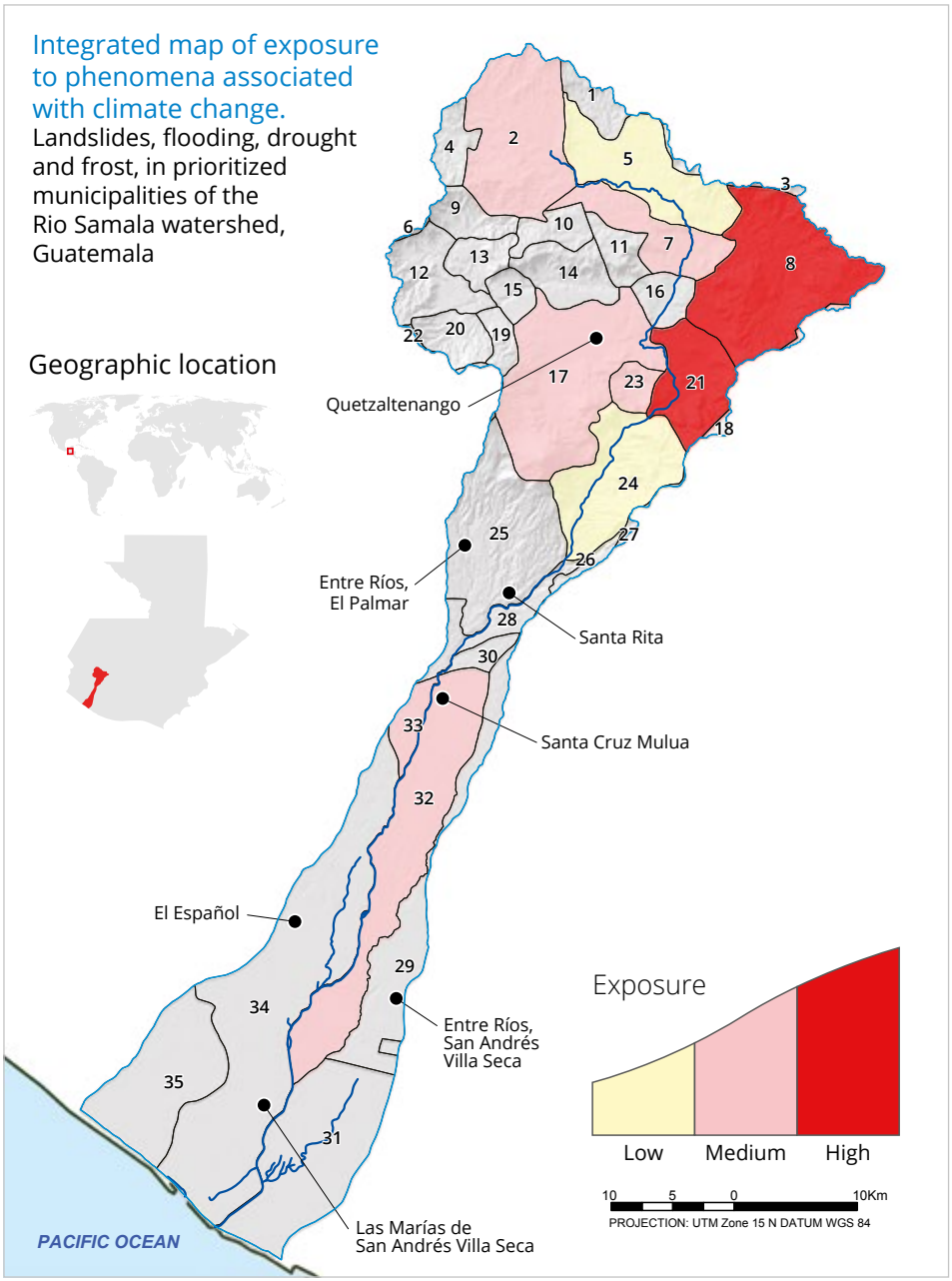
Integrated Exposure

Landslides, flooding, drought and frost in prioritized municipalities



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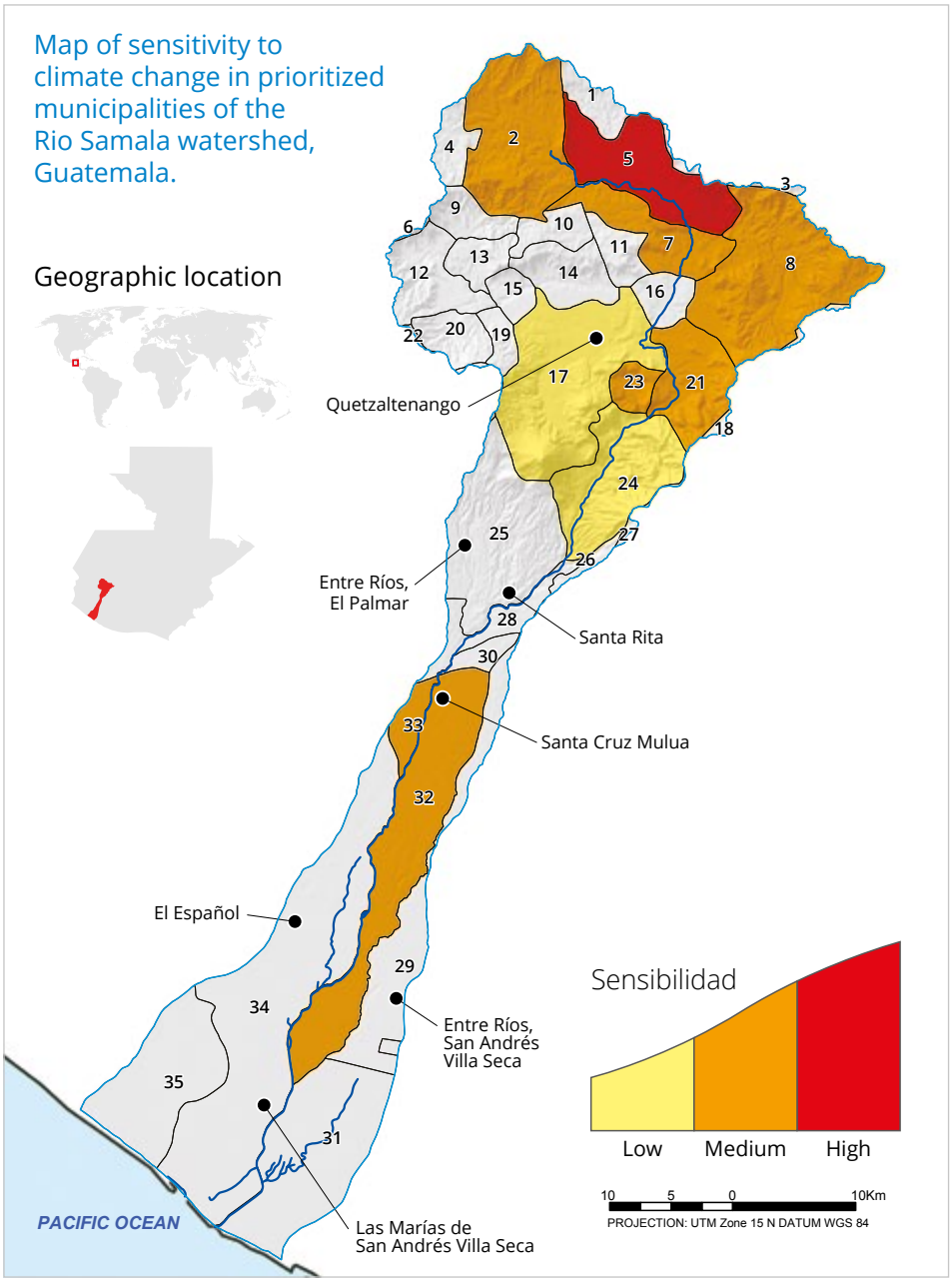
Sensitivity

Map of sensitivity to climate change in prioritized municipalities of the Rio Samala watershed, Guatemala.



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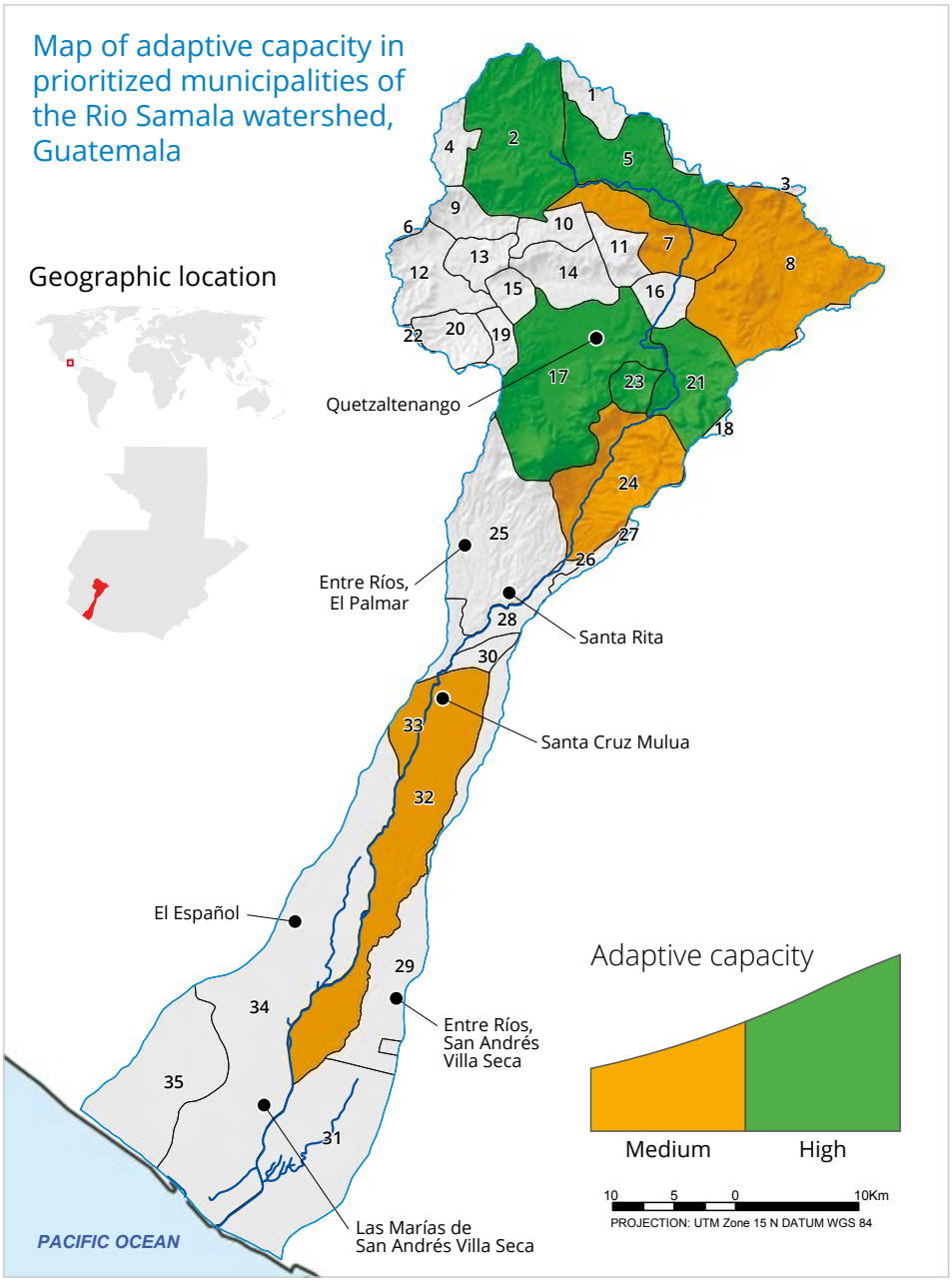
Adaptive capacity



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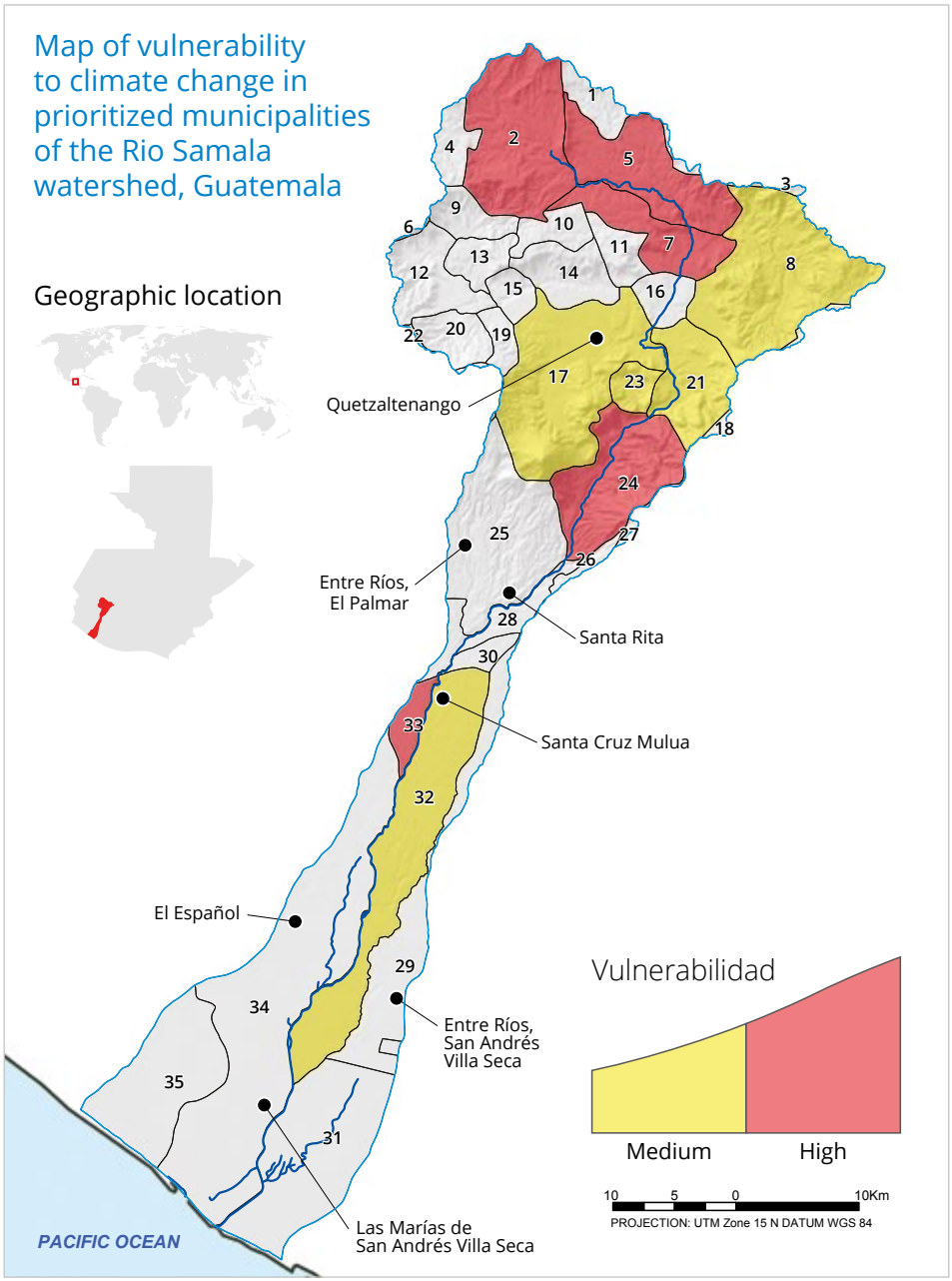
Vulnerability



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Current vulnerability of the Rio Samala watershed, Guatemala

Vulnerability analysis

Following is a vulnerability analysis for 10 priority municipalities in the Rio Samala watershed.

Municipalities	Index			Current vulnerability	Importance
	Exposure	Sensitivity	Adaptive capacity		
Totonicapán	2	2	2.15	1.85	Medium
Quetzaltenango	2.5	2	2.6	1.9	Medium
Santa Cruz Mulua	2	2	1.6	2.4	Medium
Cantel	2.5	2	1.9	2.6	High
Almolonga	2.5	2.5	2.3	2.7	High
San Carlos Sija	1.75	3	1.9	2.85	High
San Sebastián Retalhuleu	1.75	3	1.5	3.25	High
Zunil	2.5	2.5	1.75	3.25	High
San Cristóbal Totonicapán	2.25	3	1.9	3.35	High
San Francisco el Alto	2.25	3	1.9	3.35	High

Totonicapán:

Located in the upper part of the watershed, this municipality is exposed primarily to frost and moderately to landslides and drought. As for sensitivity, the municipality requires attention with regard to the human element, which is characterized by poor access to health care (number of health care centers and doctors per capita), high migrant population, poor coverage in primary education, high poverty rate, high population density and high

population growth rate. Regarding adaptive capacity, in addition to human resources, financial resources are also inadequate, given the reduced public investment in protective infrastructure and the lack of credit sources. Considering the sum of the variables, the municipality of Totonicapan was rated the least vulnerable of the 10 prioritized municipalities in the Samala watershed.

Quetzaltenango:

This municipality is affected principally by flooding and frost and is moderately exposed to landslides and drought. The development of its infrastructure and services give the municipality a low level of sensitivity. Its adaptive capacity is also good. Areas for improvement include waste collection and landfill management.

Santa Cruz Mulua:

Santa Cruz Mulua is particularly prone to flooding and moderately exposed to drought and landslides. It has high sensitivity in the area of natural resources, conditioned by the time families invest in securing water, interruptions in domestic water supply and diminished forest cover. It also has high sensitivity with regard to financial resources, due mainly to the cost of maintaining aqueduct infrastructure and the small amount of funds allocated to reconstruction and rehabilitation of aqueducts affected by weather events. Adaptive capacity is low due to the absence of early warning systems, risk management plans or watershed management plans. Also related to risks, the human variable must improve with regard to databases or information systems on hazards, vulnerability and risk management, as well as financial resources, given the reduced public investment in protective infrastructure and lack of credit sources.

Cantel

Cantel is exposed mainly to landslides and frost, as well as to floods and drought. It has medium sensitivity with regard to financial resources due to the scarcity and poor maintenance of aqueducts; it is also sensitive in the area of human resources because of health services, high migration, poverty, high population density and population growth. Its adaptive capacity needs to be strengthened in the financial aspects (due to reduced public investment in protective infrastructure and the lack of credit sources), as well as in the area of natural resources (does not have wastewater treatment systems or waste disposal).

Almolonga

This municipality was found to be primarily exposed to landslides and frost and moderately exposed to floods and drought. To this is added high sensitivity due to limited forest cover and the lack of protected areas within the municipality, as well as high levels of conflict over land use. Moreover, its adaptive capacity is compromised by the social resource, given the absence of organized social action groups, early warning systems.

San Carlos Sija

The level of exposure to weather events in San Carlos Sija is average for most threats. Its sensitivity levels are high in the natural, physical and financial aspects, due to reduced forest cover, not using the soil according to its natural vocation, poor domestic water service, inadequate development of aqueducts and poor drainage systems. The municipality has low adaptive capacity with regard to human resources due to the absence of data bases or information systems on hazards, vulnerability and risk management, as well as in the area of financial resources given the low level of public investment in protective infrastructure and credit sources.

San Sebastián Retalhuleu

This municipality is affected by floods and is moderately exposed to drought. Its sensitivity is high in the area of natural resources, due to the poor quality of the potable water, reduced forest cover, the absence of protected areas and the presence of conflicts over land use. Similarly, the low number and inadequate maintenance of aqueducts, population density and low educational coverage give a high level of sensitivity to the municipality. Its adaptive capacity is low due to a low organizational level, policies for development of water resources and the environment, absence of risk management plans, reduced investment in protective infrastructure and lack of credit sources.

Zunil

This municipality has a high level of exposure to most threats except drought. Its greatest sensitivity is associated with natural resources and the low level of investment in health systems and aqueducts, as well as housing conditions and migration. Its adaptive capacity is unfavorable due the lack of credit sources, primary wastewater treatment, existing problems with the waste collection system, lack of a sanitary landfill and reduced extension of protected areas in the municipality.

San Cristóbal Totonicapán

San Cristóbal Totonicapan is mainly exposed to frost and moderately exposed to other threats. Its sensitivity is related to the physical resource, due mainly to the predominant type of floor found in homes and the existing aqueducts. The human resource is conditioned by difficult access to health services, the large number of migrants, the high poverty rate and high population density. Adaptive capacity needs to be strengthened mainly in the areas of human resources (risk management information systems), social resources (early warning systems and organization for risk management) and financial resources (investments in protective infrastructure).

San Francisco el Alto

The exposure level of this municipality is higher for landslides and frost than for drought. Its sensitivity is associated with its financial resources, investments in water supply, health services, migration and population density. In addition, the municipality has low forest cover and conflicts over land use. Its adaptive capacity must be strengthened in the financial aspect (protective infrastructure and credit sources) and the social aspect with regard to organizational spaces, policies, plans and risk management.

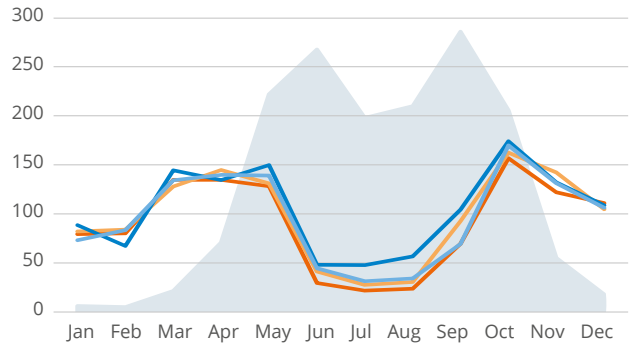
Impacts of climate change on the water cycle in the Rio Samala watershed

Following are four graphs (hydrographs) showing the monthly averages in millimeters (mm) of water in the Rio Samala watershed. The shadow is the current baseline (calculated from 1984 to 2010) and the lines represent the values projected to 2050 according to two models and two scenarios of greenhouse gas emissions.

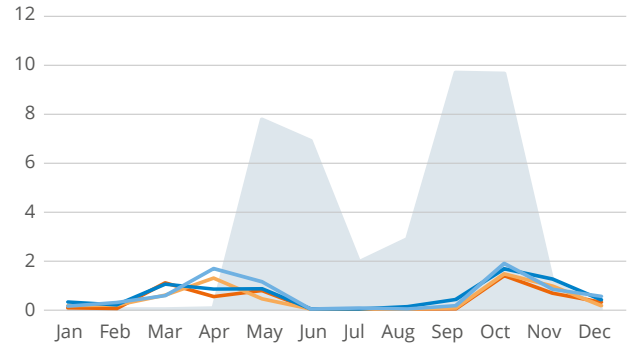
The NorESM1-M and MIROC5 models were selected for their relatively drier and wetter (respectively) behavior relative to historical averages in the region. It can be seen in the first graph for precipitation that both climate change models, at any level of emissions, indicate a significant decrease in the monthly precipitation averages and a very sharp intra-summer period of drought (the veranillo or "little summer"). The graph also shows an onset of the rainy season in March. The change in precipitation in the watershed results in decreases in the remaining variables of the water cycle.

MONTHLY CHANGES (AVERAGE)

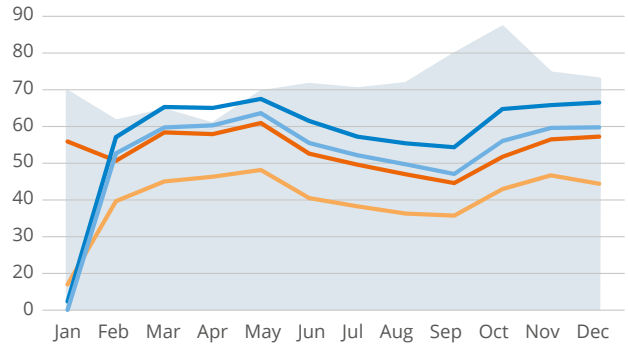
PRECIPITATION (mm)



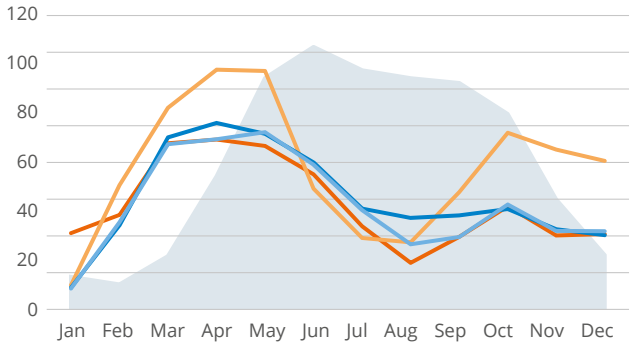
RUNOFF (mm)



WATER PRODUCTION (mm)



EVAPOTRANSPIRATION (mm)



Base line

NorESM1-M (2013-2050), RCP 2.6

NorESM1-M (2013-2050), RCP 8.5

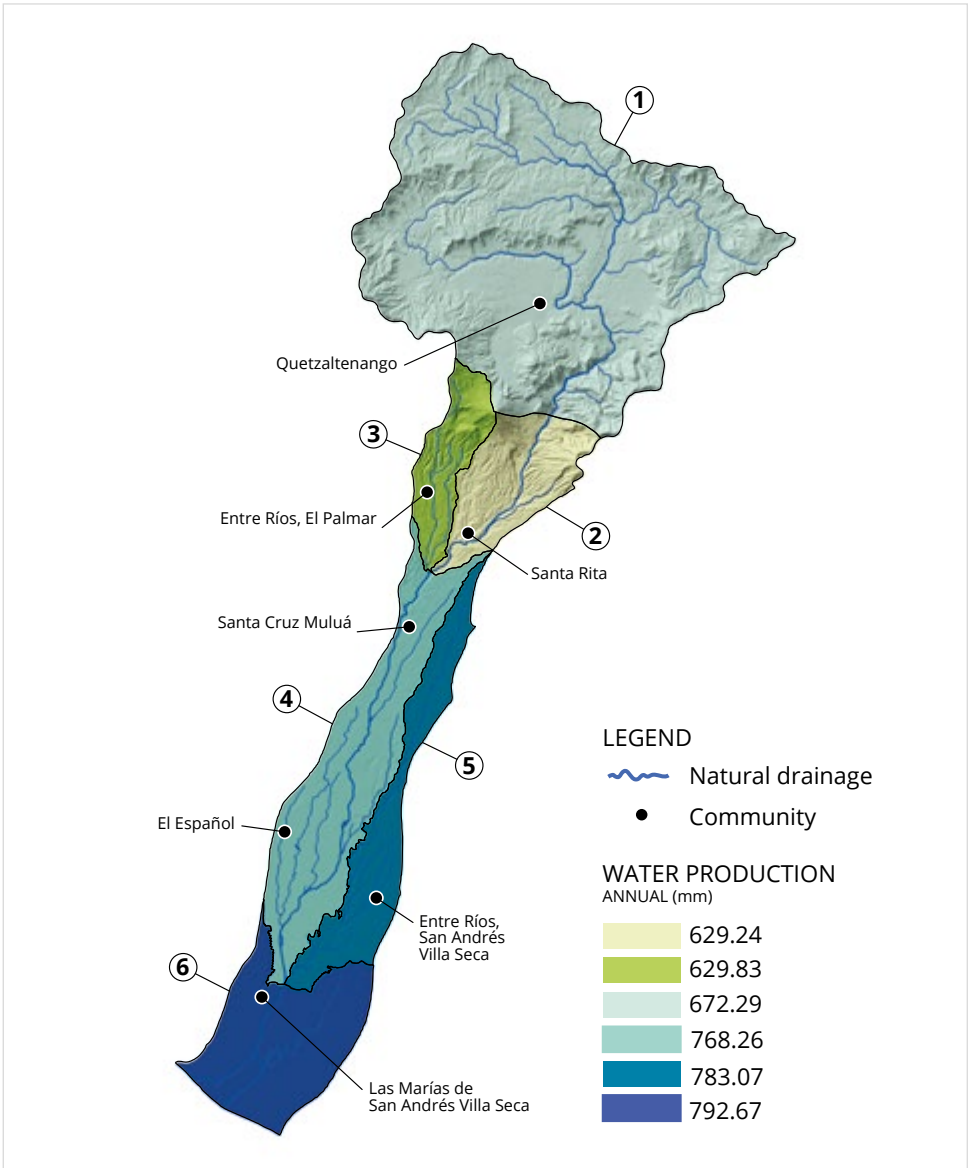
MIROC5 (2013-2050), RCP 2.6

MIROC5 (2013-2050), RCP 8.5

Impacts of Climate Change by subwatershed

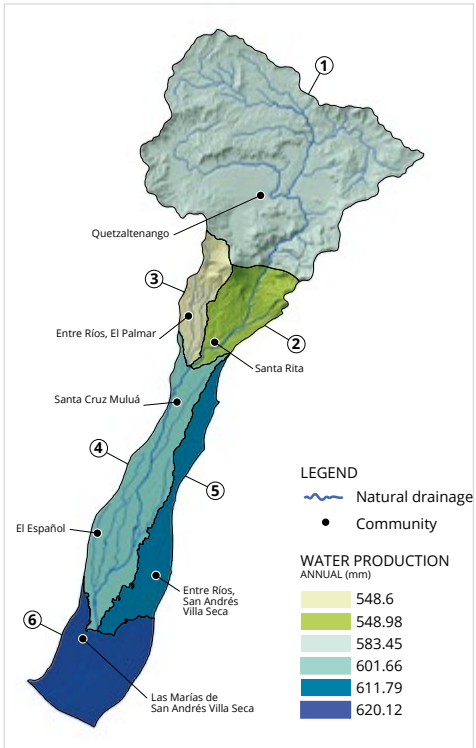
Annual water production

Historical 1984-2010

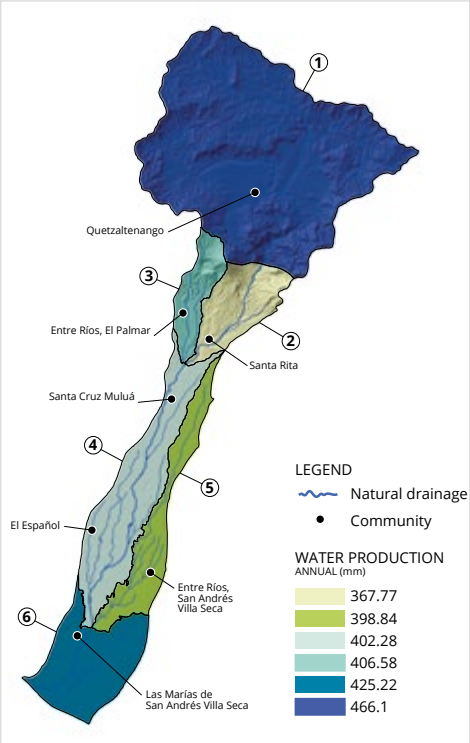


2011-2050

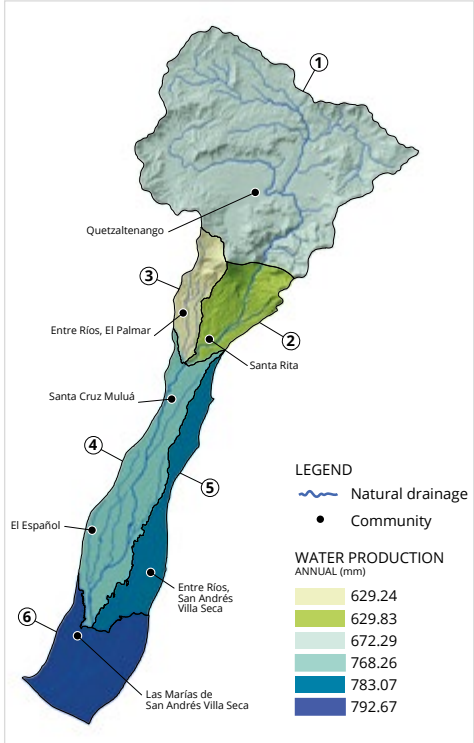
Scenario
NorESM1 RCP 2.6



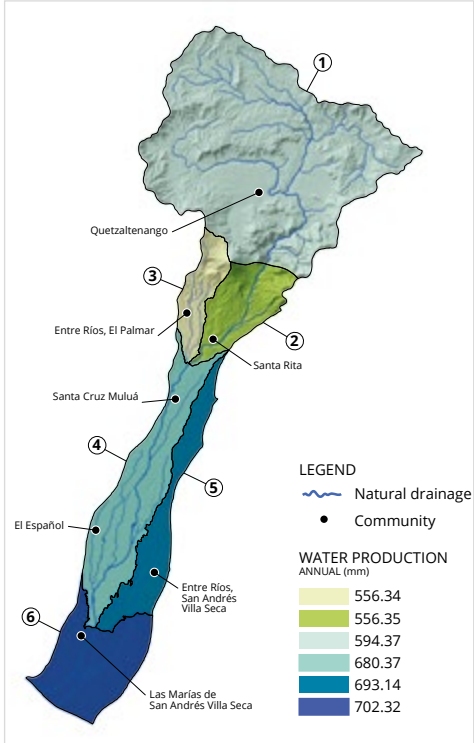
Scenario
NorESM1 RCP 8.5



Scenario
MIROC 5 RCP 2.6



Scenario
MIROC 5 RCP 8.5



Geographic location

IDRC | CRDI
International Development Research Centre
Centre de recherches pour le développement international
Canada

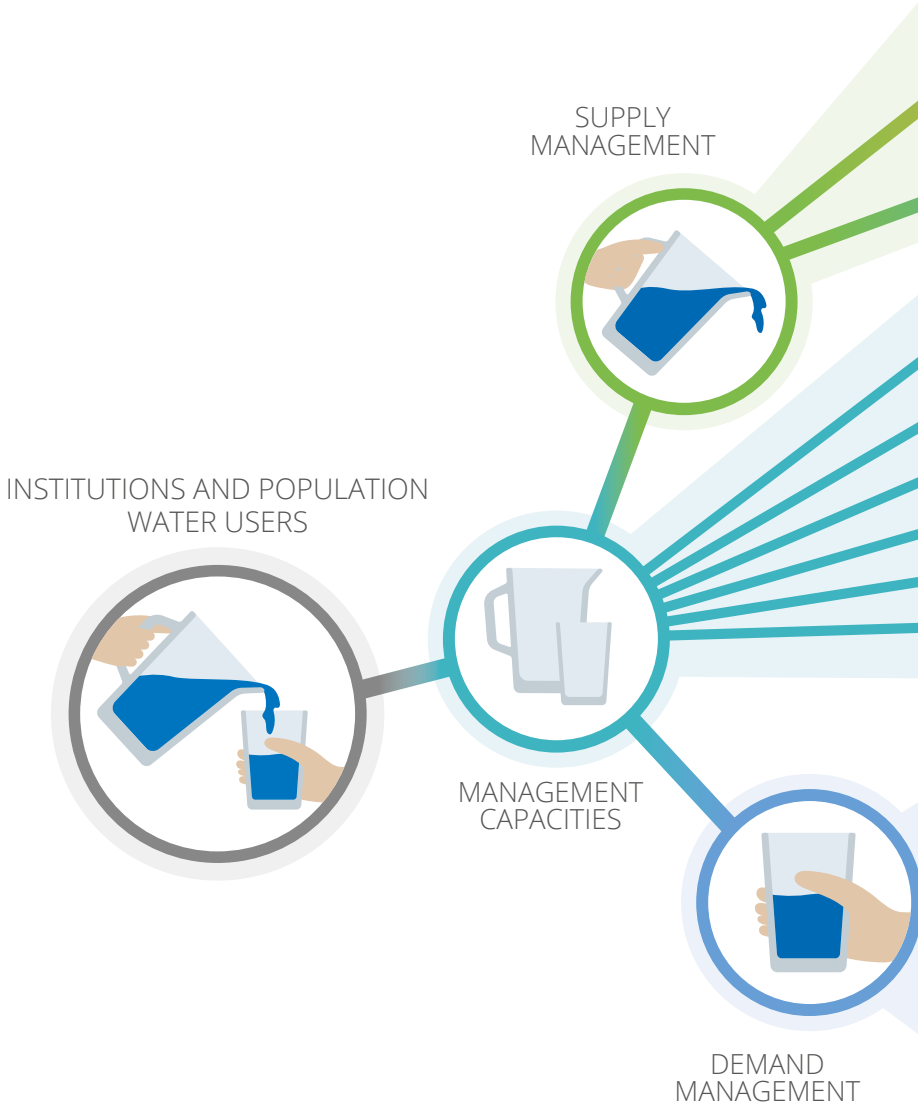
CATHALAC
Water Center for the Humid Tropics of Latin America and the Caribbean

Compiled from the Water Security and Climate Change Project for Central America and the Caribbean. Map processing and GIS, CATHALAC. This work was carried out with the help of a grant from the International Development Research Centre (IDRC, Canada). IDRC – CATHALAC project No. 107084-001

ADAPTATION TO CLIMATE CHANGE

Now that we know how climate change could affect the water resources of the Rio Samala watershed both in time (hydrographs, page 25) and space (maps, pages 26 and 27), and the vulnerability of the population to the possible effects (Pages 10-23), a plan needs to be created in order to be better prepared, i.e., an Adaptation Plan.

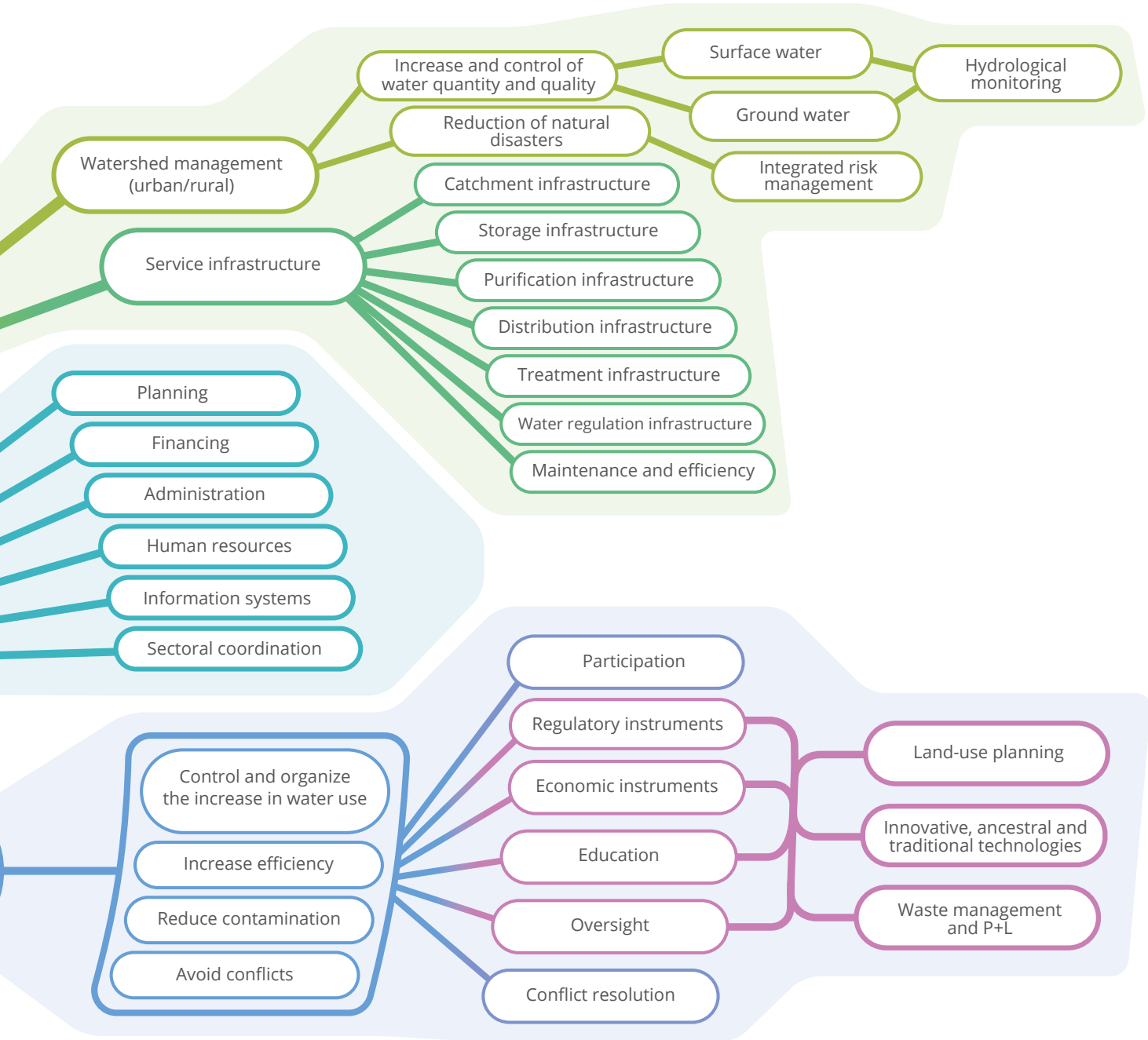
Sadoff and Muller (2010)[6] say the best way to adapt to climate change is by ensuring water security, as climate change has a direct impact on water. In this regard, the international community[7] has found that water management must be integrated in order to progress in terms of water security, so two municipal plans for adapting water resource management to the need for water security were drafted from the integrated water resource management approach, which we have defined as joint management by the various institutions and society to ensure the provision of water to meet the needs of an orderly and efficient demand[8].



6 Sadoff Claudia and Mike Muller. 2010. Water Management, Water Security and Climate Change Adaptation. Anticipated effects and essential answers. GWP. TEC Background Papers No. 14. 101p.

7 For example the United Nations Conference on Sustainable Development (Rio +20) in Planet under Pressure (2012).

8 CATHALAC. Water Center for the Humid Tropics of Latin America and the Caribbean. 2015. La gestión del agua para la Seguridad Hídrica frente al Cambio Climático. Proyecto Seguridad Hídrica y Cambio Climático para la región de América Central y el Caribe. International Development Research Centre (IDRC). Panama. 55 p.



Source: Modified from CATHALAC (2015)*

Prioritized adaptation measures in Quetzaltenango

PRIORITIZATION OF WATER SECURITY ISSUES					
1	Water sources	4	Governance	7	Food security
2	Risks	5	Health	8	Energy security
3	Services	6	Water uses		

*Los gestores del agua en el municipio identificaron las medidas de adaptación para los dos aspectos priorizados de la Seguridad Hídrica en el municipio.

No.	ACTIVITY/PROJECT	TERM		
		C	M	L
1	**WATER SOURCES**			
1.1	Train local human resources; a) watershed modeling, b) GIRH	●		
1.2	Development of municipal agreement to regulate municipal water use	●		
1.3	Massive reforestation campaign	●		
1.4	Massive campaign on the proper use of water	●		
1.5	Coordinated monitoring MARN-Municipality: To check constructions and PTAR	●		
1.6	Restore areas of water sources	●		
1.7	Facilitate PINFOR and PINPET projects at the municipal level	●		
1.8	Delegate sustainable management of NR to communities in water recharge zones	●		
1.9	Change pipelines of entire system, install galvanized iron		●	
2	**RISKS**			
2.1	Institutions must comply with laws governing protection and risks	●		
2.2	Create social oversight team for participation in risk-related decisions	●		
2.3	Institutions comply with OT regulations based on risk prevention	●		
2.4	Designate municipal budget for mitigation and water conservation projects	●		
2.5	Create a governing entity (entities and population) to care for Water Resources		●	
3	**SERVICES**			
3.1	Teach community members about the Law of Urban and Rural Development Councils	●		
3.2	Follow up on compliance by COCODES in accordance with the law	●		
3.3	Comply with the provisions of the municipal code at the municipal level	●		
3.4	Establish agreement between the Ministry of Communications (MICIVI) and the Municipality		●	
3.5	Establish a bilateral MICIVI-Council process		●	
3.6	Systematize procedures for requesting services		●	
3.7	Standardize requests for municipal services		●	
3.8	Establish single records office for municipal services		●	
3.9	Supervision of COCODES by respective government entities		●	

No.	ACTIVITY/PROJECT	TERM		
		C	M	L
4	**GOVERNANCE**			
4.1	Revalidate and update Guatemala's National Water Policies	●		
4.2	Update and communicate municipal water use regulations	●		
4.3	Communicate existing regulations to the population in a clear manner	●		
4.4	Definition of population-municipality roles in water governance	●		
4.5	Promote participation of different chambers (industry, commerce, etc.)	●		
4.6	Sustainability forum, "council of the upper watershed of Rio Samala"	●		
4.7	Implement system of penalties for misuse of water and incentives for good use	●		
4.8	Promote cultural water use zoning, customary rules	●		
4.9	Create database of water management manuals, regulations and initiatives	●		
4.10	Develop proposal for water law (uses: domestic, agricultural, industrial)		●	
4.11	Develop joint regulations for water management		●	
4.12	Program regulation 236-2009 in 3 annual phases		●	
4.13	Create municipal water governance entity in EMAX (water court)		●	
4.14	Promote regulations to encourage water harvesting (rainwater, reuse, etc.)			●
5	**HEALTH**			
5.1	Strengthen municipal mandates to control, regulate and improve water quality	●		
5.2	Develop comprehensive health programs for different sectors of the population	●		
5.3	Strengthen the health commission to take a leading role and be the articulator	●		
5.4	Strengthen and improve the delivery of health services at the municipal level	●		
5.5	Generate a comprehensive municipal health policy		●	
5.6	Generate geographic, socio-demographic and health information, vulnerable areas		●	
5.7	Prioritize implementation of wastewater treatment systems		●	
6	**WATER USES**			
6.1	Protection of water sources and services for regulating private services	●		
6.2	Increase water supply to expand service coverage	●		
6.3	Awareness campaigns on the real cost of the service	●		
6.4	Municipal regulations for private water service providers	●		
6.5	Public-private partnership to promote the use of advanced technologies	●		
6.6	Construction of demonstration project for rainwater collection in urban areas	●		
6.7	Construction of infiltration wells	●		
6.8	Create regulations for different water uses		●	
6.9	Implement monitoring system for wastewater treatment systems		●	

No.	ACTIVITY/PROJECT	TERM		
		C	M	L
6.10	Construction of wastewater treatment plants		●	
6.11	Establish rates according to socioeconomic levels of families		●	
6.12	Implement Land Use Plan		●	
6.13	Demarcation of protected areas, increase private protected areas		●	
6.14	Reforesting processes		●	

*The adaptation measures were identified for the two prioritized aspects of water security in the municipality.

Prioritized adaptation measures in Santa Cruz Mulua

PRIORITIZATION OF WATER SECURITY ISSUES			
1	Water sources	4	Water uses
2	Services	5	Risks
3	Governance		

No.	ACTIVITY/PROJECT	TERM		
		C	M	L
1	**WATER SOURCES**			
1.1	MSPAS, MARN, Municipal alliance for monitoring water quality, sources and reforestation	●		
1.2	Inventory and characterization of water sources	●		
1.3	Create a private fund to promote adequate management of water sources	●		
1.4	Communicate and enforce regulations that prevent deforestation	●		
1.5	Increase personnel dedicated to enforcing environmental regulations		●	
1.6	Develop and implement a solid waste management program		●	
2	**SERVICIOS**			
2.1	Review and update models for provision of municipal services	●		
2.2	Follow up on well processes begun by the municipality for potable water	●		
2.3	Training in: legal framework, water security, solid waste policies	●		
2.4	Strengthen the process for improving water quality for all uses		●	
2.5	Incorporate new technologies for improving the provision of municipal services		●	
2.6	Prepare a technical study on Waste Water, to comply with norm 236-2006		●	
2.7	Improve system of fee collection for public municipal services		●	
2.8	Create a procedures manual for water service administrators		●	
2.9	Strengthen water department (personnel, equipment, information systems)		●	

No.	ACTIVITY/PROJECT	TERM		
		C	M	L
3	**GOVERNANCE**			
3.1	Strengthen Court of Municipal Affairs to deal with water security	●		
3.2	Strengthen and train COCODES and COMUDE personnel (legal aspects and SNP)	●		
3.3	Prepare plan for community outreach and communication	●		
3.4	Create private fund to improve governance in water security	●		
3.5	Study possible alternative water sources and needs of the population		●	
4	**WATER USES**			
4.1	Identify, classify and regulate the different water uses in the municipality	●		
4.2	Implement differentiated of rates for different water uses	●		
4.3	Issue norms regulating the different water uses	●		
4.4	Work program to environmentally align polluting businesses		●	
4.5	Create Land Use Plan		●	
4.6	Develop an environmental education program		●	
5	**RISKS**			
5.1	Creation, accreditation and training of COMRED and COLRED in light of SE-CONRED	●		
5.2	Create alliance with INAB, MARN, CONRED, sugar mills for reforestation, dredging and borders	●		
5.3	Coordinate with entities of upper watershed, lower watershed, INSIVUMEH for SAT	●		
5.4	Create municipal Land Use Plan (medium term)		●	

*Adaptation measure were identified for the two prioritized water security issues in the municipality

Educational Resource

What is Climate Change?

What is the water cycle?

What is a watershed; what does it look like?

How can climate change affect water availability?

How can climate change affect you or the activities you or your family do?

What climate change-related phenomena is your community most exposed to?

If you look at how sensitivity and adaptive capacity are measured, what are the greatest vulnerabilities of your community?

What can you do in your community for greater water security, considering the possible effects of climate change?

Why must we protect the forests in a watershed?

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CATHALAC is an international organization established in 1992 and recognized as an intergovernmental body by Act No. 45 of September 16, 2010, whose main objective is to promote sustainable development through applied research, education and transfer of technologies related to water resources and the environment, providing the means to improve the quality of life in the countries of the humid tropics of Latin America and the Caribbean. CATHALAC focuses on: integrated watershed management, risk management, climate change and environmental analysis and modeling.

The International Development Research Centre (IDRC, Canada) is a public corporation created by the Parliament of Canada in 1970 to help developing countries use science and technology to find practical and long-term solutions to the social, economic and environmental problems they face. IDRC has funded more than 2,000 research projects conducted and managed by researchers and institutions in the region

WATER SECURITY AND CLIMATE CHANGE
IN THE REGION OF CENTRAL AMERICA & THE CARIBBEAN

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