The Water Forest

Overview

Trees are the key component of peasant and community strategies to take care of watersheds and recover the water table. The southeast of Mexico has many native species that, although there is generally no literature to say so, can contribute to this recovery through a mechanism known as hydraulic redistribution. All trees move water, from the roots to their branches and leaves, through the xylem, usually in an upward direction. The force needed to lift so much water comes from the sun, since, as the leaf transpires, there is a negative pressure on the xylem, equivalent to suction on a straw, which is able to lift water from the roots to the leaves by pressure gradients. Now, some species of trees-particularly those with deep roots-redistribute a portion of their water, particularly during the cool hours at night, in the first meters of soil, where it can be harnessed by the roots of other trees, shrubs, vejucos, herbs and animals in the soil. This generates a systemic effect, since access to larger amounts of water in the soil produces more foliage, greater cover and, generally, lower temperatures at ground level. Decreased heat reduces evaporation from soil and shade plants, allowing less water to leave the forest, while groundwater begins to cycle in the upper layers of the soil and forest. The effect is the recovery of rivers, streams and water eyes. However, all of the above implies the successful establishment of a large number of tall native trees, which in turn implies a community action initiative that requires many people with the capacity and motivation to reforest, as well as access to seeds and tree stakes-both mature forest species and pioneer species that can establish conditions for trees that raise water. Therefore, it is necessary to take care of the people who are going to take care of the forest, and the autonomous schools provide the opportunity to train the young people in the concepts and methods to heal the watersheds of their communities and territories, with the Water Forest.

Introduction: Why the Water Forest?

This document presents the findings of the civil society organization "Schools for Chiapas" on the theme of the Water Forest. This is an initiative that starts from the Edible Forest, which in turn emerged from the experiences of secondary schools in the construction of autonomy and freedom, as a response to the need to propose an education very different from the conventional one. The development of primary and secondary education in Mexico, like all countries, has been subject to the logic of colonialism. It tends to produce conceptions and perceptions based on the dominant culture, where only one type of knowledge is recognized, the rational-western-reductionist, and things are known through dualisms (quality-quantity, superior-inferior, light-darkness, etc.). It has been enormously difficult for this Western epistemology to recognize that there can be and are other ways of recognizing life and the relationships between the infinite diversities of beings and realities. In this sense, autonomous education seeks, on the one hand, to question the rational orthodoxy that defines what is knowledge and what is not, and, on the other hand, to claim the other forms of knowledge that start from logics other than Western.

During the neoliberal and globalizing stage of the capitalist economy and society, education has served the purposes of this dominant system. Under the pretext of fighting against ignorance, the extension of the school system to peasant communities has facilitated the access of capital to the goods of nature and to the human labor of the sons and daughters of peasants. While the official school prepares these young men and women for jobs that do not exist in their communities, it disorients them for the jobs that do exist there, with the result that they neither want nor know how to maintain the complex relations with nature that peasant and indigenous communities have maintained for centuries. Suertero is the boy who manages to go to the CBTE, where he memorizes the formulas for fertilizers with which he can forget all the knowledge of his grandmothers on how to recycle nutrients to take care of the fertility of the soil. The cultural content of collective capitalist suicide is based on mirage, short-termism and contempt for life in all its forms. The proposal to reclaim knowledge linked to territory, historical memory and ecology is not new; it has long been associated with the struggles of women, Afro communities, peasant resistance, territories and indigenous peoples.

The Water Forest is, until now, an investigation to know better how these community expressions of knowledge and practices of resistance can be systematized in a curriculum based on the capacity of the forests to maintain the health of the watersheds. Specifically, the research seeks to identify campesino strategies for the recovery of groundwater and springs in Mayan communities of Los Altos and La Selva de Chiapas, based on the use of trees in the restoration of ecosystems.

Over three months, the research team reviewed an extensive scientific and popular literature, conducted small rooting and propagation experiments, carried out a microbiology workshop focused on mycorrhizae, renovated the Vivero Muy Otro with the introduction of 12 native forest species, built a plan for the collection and propagation of seeds and stakes of forest species that are key to the recovery of the water table, and drafted a reforestation curriculum to be valued in the autonomous secondary schools.

The combination of information from secondary sources, such as academic texts, with work in the nursery and community, has resulted in a synthesis of key concepts for the Water Forest. We consider this document as a conceptual and methodological guide that can facilitate both the work of community educators and School facilitators for Chiapas, for the collective construction of knowledge and skills relevant to watershed recovery and management. Knowing how to take care of water in a daily, practical and community way is a fundamental base for the defense of Mother Earth.

Watersheds

"The watershed is the first and last nation whose boundaries, though they may vary a little, are indisputable." -Gary Snider, poet

Earth, water, air

Science is finally realizing many things that people have had clear since time immemorial. An example of this is the growing recognition that the best way to understand nature is not as a set of components-as if it were a motor-but as an organic whole, even as a living being. This is because the interrelationships - between moisture, microbes, soil, roots, flowers and fruits, animals, clouds and other biotic (living) and abiotic (lifeless) elements - are so complex and countless that it is futile to attempt to understand any of nature's components outside of its network of material and immaterial exchanges with its environment. Simply put, nature is an irreducible whole, so its social management must also be understood as a unique process, in which food production, transport, employment, housing and health are linked to the ecological processes going on in the earth, water and air. Hence there are now scientists and scientists writing about socio-ecological systems (Lui and colleagues, 2007), of which watersheds are an excellent example.

A watershed is a territory where the rainwater that falls on that surface flows into a common channel, be it a river, a lagoon, a lake or the sea. Within the territory of a basin, there is interdependence between the biophysical environment, including the soil, trees, clouds, crops, streams, rivers, biodiversity, hills and valleys, and the socio-cultural environment (productive practices, agrarian distribution, power structures, rules, technologies, markets, etc.). The geographical boundaries of the basin are demarcated by a line in the highest parts of the mountains, beyond which water flows to other streams, rivers, lagoons or exit points. This line is known as the umbrella of the basin. Figure 1 shows the basic components of a watershed.

It is very important to recognize that watersheds are formed by several sub-basins and micro-basins, where all the water that falls on the surface flows into a common channel, which at the same time are inside a larger basin. Sub-basins tend to be a scale with considerable potential for community efforts to achieve substantial impacts, allowing for integrated and sustainable watershed management.

Why work on a micro-watershed scale?

- The common interest of the stakeholders is much more homogeneous than in a large basin.
- The work area is smaller and therefore the need for resources is smaller.
- It makes it easier to understand the problems, the needs felt and how to solve them.
- Administration is much simpler.
- Environmental and managerial monitoring can be more effective.
- Coordination between basin entities is more immediate.
- The possibility of promoting organization for continuity can be facilitated.
- Stakeholder participation is facilitated.
- Experiences are shared more quickly.
- The social problems to be faced can be more homogeneous.

(Source: World Vision, 2004)

The watersheds combine high, medium and lowlands. The water that enters the basin in the form of rain can move over the ground or infiltrate it until it enters the aquifer, the mass of permeable rocks where groundwater circulates. Groundwater often flows into springs, or water eyes, where surface water begins to flow, in the form of rivers.

Figure 1. Basic scheme of a watershed. The hydrographic divide is the umbrella. The micro-watershed is a smaller scale watershed that exists within a larger watershed. Source Milanes Batista and colleagues, 2015

Water moves through all parts of a basin generally downwards, so actions in the upper part of the basin have consequences in the lower part. When water in the atmosphere forms clouds and falls as rain, or precipitation, it is received by land and plants, where it forms part of their living tissues. Just as animals breathe, plants undergo a process called evapotranspiration, in which oxygen and water are released as air vapour. In this way, the plants provide us with the oxygen we breathe and, at the same time, the water returns to the atmosphere. The water that runs into streams and rivers flows down, reaching larger bodies such as large rivers, lagoons, lakes or the sea. From there the solar heat causes the evaporation of water, which rises in the form of steam and returns to the atmosphere. All that moisture in the atmosphere eventually forms clouds, and then falls back to the earth as rain. All of these processes together are known as the water cycle, or hydrological cycle (Figure 2).

Water in the earth

Water that falls from the sky may run off the earth's surface or be absorbed by it. Monoculture agriculture, promoted by both the capitalist market and various government programmes, often leads to soil compaction and loses its capacity to absorb rainwater. In this way, aquifers stop recharging even though there is rain and rivers do not fill up with springs but with the runoff that runs over the surface of the soil, with the effect of eroding the soil and contaminating the rivers.

On the contrary, diverse and ecological agriculture depends on the soil having health and a non-compacted structure, since it is the extension and exploration of the root in the soil and not the agrochemicals that guarantee that the plant has nutrition. The soft soil, with abundant organic matter, has a greater capacity to absorb rainfall, allowing water to filter slowly into the water table, below which the rock is saturated with water (see Figure 3).

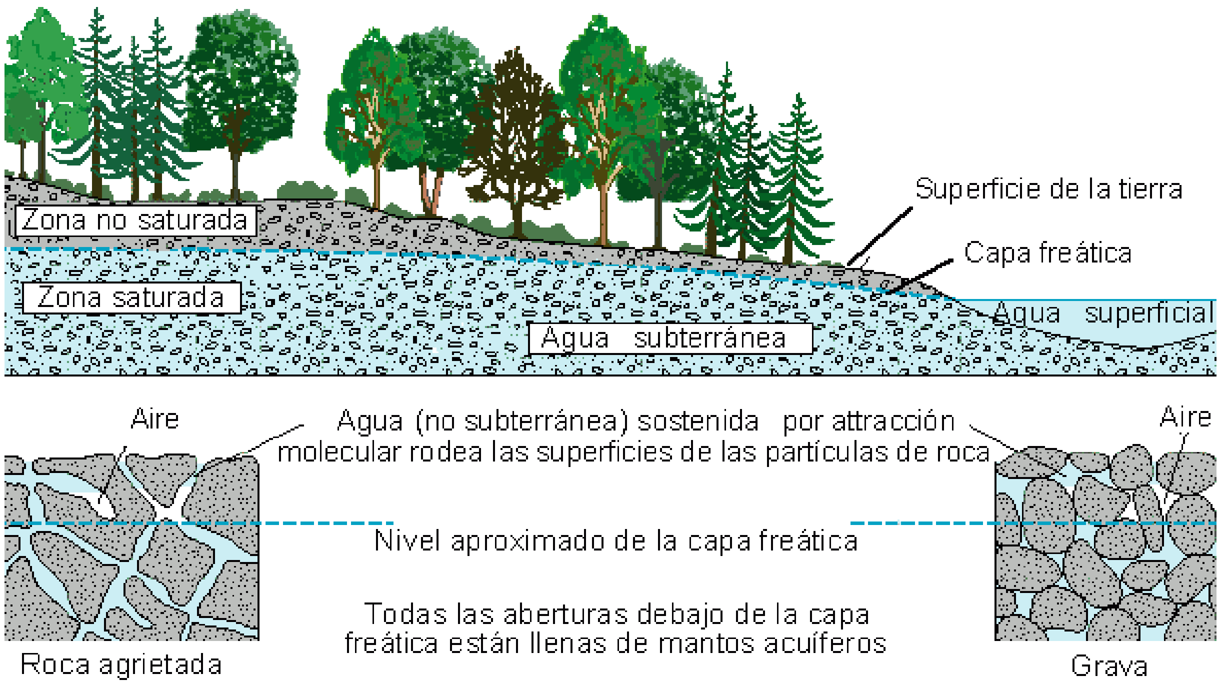


Figure 3. When rain falls on the earth's surface, the water absorbed by the earth filters through the unsaturated zone until it reaches the saturated zone and becomes part of the groundwater. Source: Waller, 1986

Productive management and water absorption

In many places, rural communities have decided that, in order to recover the groundwater, it is necessary to carry out collective works that increase the absorption capacity of the land. These may include infiltration ditches and contour lines (Figures 4, 5 and 6).

Figure 4. Water draining into ditches stays in place longer, allowing time for slow filtration into deeper layers of soil. Source: JALDA, 2009

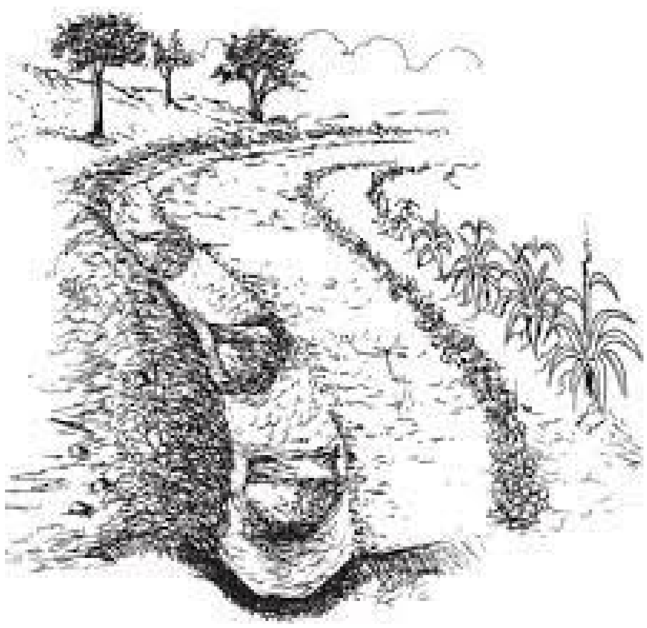


Figure 5. The "A" device is of simple construction, however, it is an ideal tool for drawing contours on slopes and irregular landscapes. Source: JALDA, 2009

Collective sub-basin management works often have a positive impact on food production in the short, medium and long term. This is due, in the short term, to the increased availability of water in the soil. In the medium and long term, this is due to the decrease in erosion and the maintenance or increase of the organic matter content in the soil.

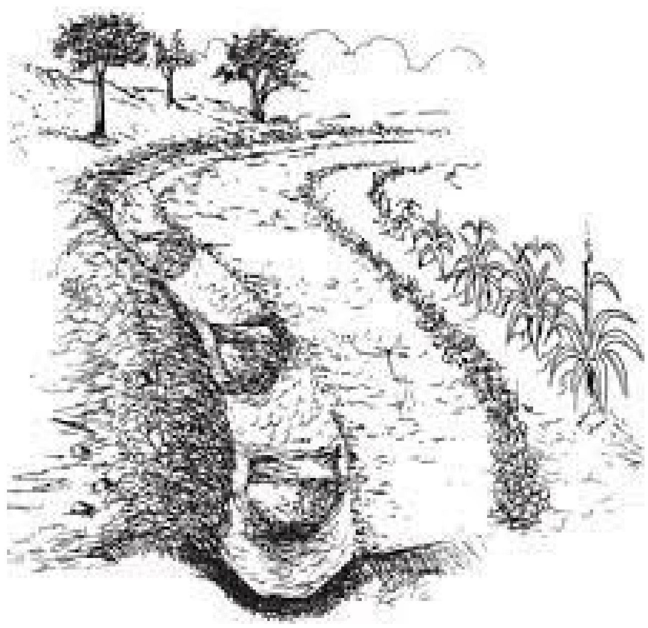


Figure 6. Once filtration ditches are constructed, the greater availability of water means that there is more chance to try high-value crops, such as vegetables. It is planted at the top of the trench with crops such as lemon grass or cane to filter the soil so that water enters the trench cleanly. It is planted next to the trench with crops that need good drainage and below them, with crops that require a lot of water. In this way, the space is used, microenvironments are created around the trenches and greater diversification of the plot is achieved. Source: PASOLAC, 2000

Integrated management of sub-basins in Chiapas communities involves many agroforestry practices, where agricultural activities are combined with forest management. Hence, the milpa is understood as an agroforestry system, and the acahual is an important phase in the recovery of soil fertility. There are examples that will be discussed later in this document of the so-called improved acahual, in which the planting of some forest species produces a change in the conditions of the acahual, avoiding weeds and accelerating the processes of land recovery. In these ways, agroecological land management can contribute to the recovery of the watershed.

Forest ecology

Ecosystems

Nature is distinguished by being composed of complex relationships between living organisms, as well as between them and their physical contours. One of the most useful ways of understanding nature is through the concept of ecosystems. An ecosystem is a set of living and non-living components that interact in a specific place. Living beings include plants, animals and microorganisms such as bacteria and fungi. Non-living components include stones, water, and fallen wood, although more and more scientists are discovering that there is life where it was previously thought not to be, such as in water, wood, and even in the depths of the soil.

Like any system, an ecosystem has limits, entrances and exits. For example, a common boundary in today's ecosystems is a road or other human economic infrastructure. In a terrestrial ecosystem, a main entrance is the energy of the sun, which through photosynthesis is converted into carbohydrates and plant tissues, and later becomes the food of animals. In ecosystems, energy is always flowing and the nutrients needed for life are cycled between living beings, air and soil. One outlet may be the oxygen released by plants and the carbon dioxide released by animals into the air when they breathe, as well as the heat generated by plant tissues when they decompose or animals when they perform physical work.

Within the ecosystem, there are living beings, known collectively as a community of different populations of living species, usually including fungi, bacteria, worms, insects, trees, matitas, birds and other types of plants and animals. At the same time, the populations of each species are made up of individuals that go through life cycles, seek food and try to reproduce.

It is common that, through their daily survival activities, populations of a species perform actions that change the ecological conditions of the ecosystem. Beavers, for example, build dams that turn streams into swamps and predators like felines regulate vertebrate populations. There is talk of ecological roles, which are the functions of each population with respect to other populations in an ecosystem: these include primary producers (plants), primary consumers (who eat plants), secondary consumers (who eat animals), predators, decomposers, among others. Through their different ecological roles, living beings in an ecosystem contribute to the dynamic balance and stability of the system as a whole.

When the activities of a population, or several populations of organisms, produce an impact that favors human activities in some way, we speak of an ecological service. A clear example would be the activity of bees, which at the same time that they are feeding, pollinate the flowers of many plants, which later give fruits consumed by human beings. In this sense, pollination would be an ecological service, performed by bees. This concept, however, is dangerous because it seeks to find equivalences between the positive impacts of ecological relationships and services seen as commodities within capitalism. For this reason, there are observers who criticize that talking about ecological services is a step towards the privatization of nature.

The fact is, however, that ecosystems as a whole benefit both humans and other living things, because they provide clean water for drinking, oxygen for breathing, medicines and food, as well as colours and smells that give meaning to life. Indigenous peoples have established beneficial relationships with many aspects of ecosystems for centuries, without destroying or privatizing nature, nor referring to it as "natural goods", "ecological services" or other terms that take away everything but its economic value.

For the purposes of the Water Forest, it is important to point out that it is not so much one or another tree species that raises the aquatic mantle, but the breath of a forest that has a combination of characteristics, including deep roots and good cover. However, the fact that forests do not exist in stability, but in constant transformation (the so-called dynamic equilibrium) makes it necessary for us to delve deeper into the natural processes of succession and ecological restoration of forests. Since it is a biotic process, the key factors of the process are not only the large trees we want to see in the forest, but also all the organisms that facilitate the forest to mature and produce the conditions for those large tree species. For example, for growth and survival in forest conditions, large trees need shade. In recovering or acahuales forests, that shade is provided by pioneer species, those with rapid growth that take advantage of clearings caused by fallen trees, as shown in Figure 7. In situations of deforestation or degradation, pioneer species are very important for ecological recovery as they tend to be able to withstand degraded conditions that mature forest species cannot withstand.

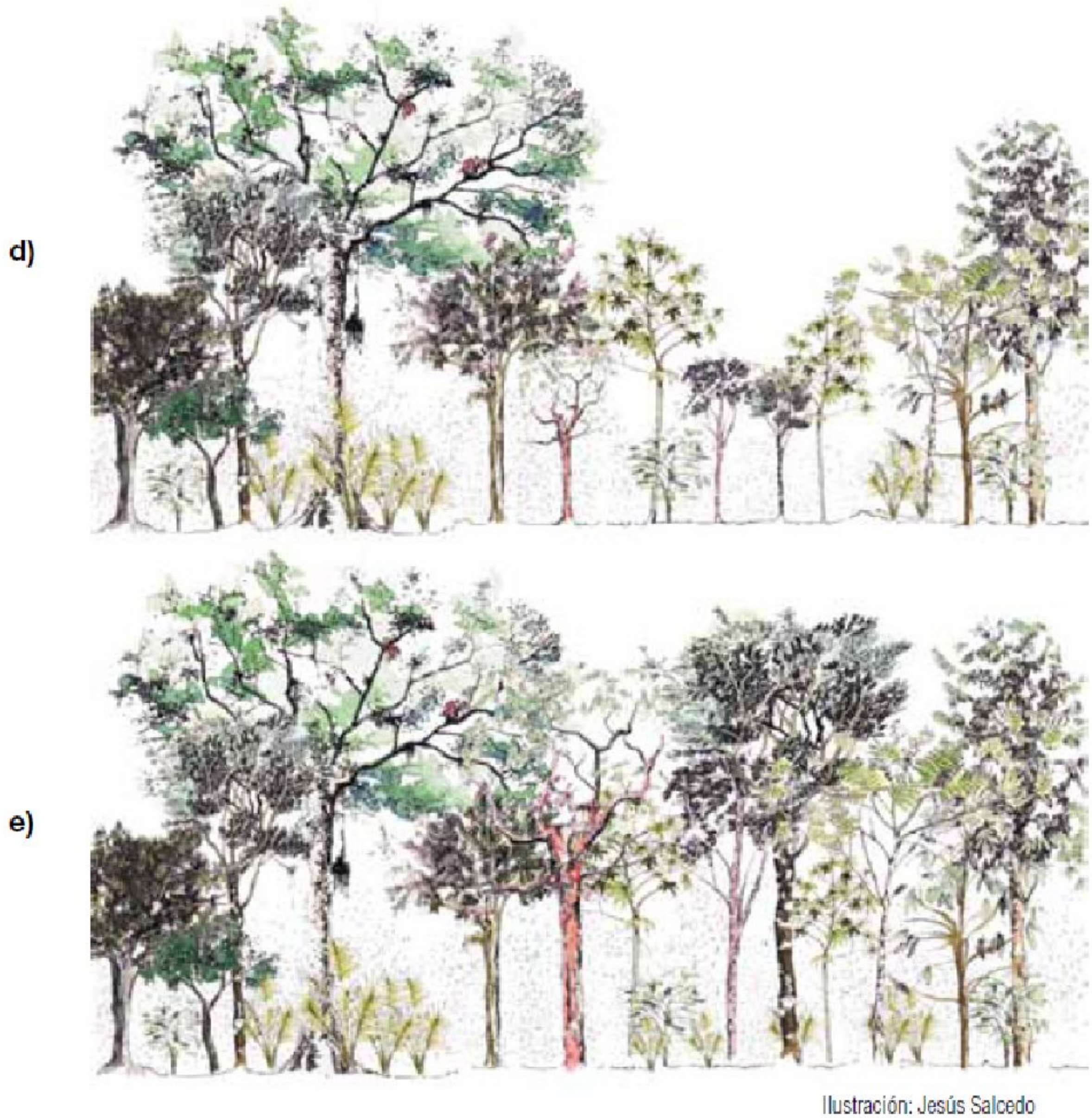


Figure 7. According to authors Meli and Carrasco-Carballido (2011): "Natural regeneration is a normal process of the forest that occurs when a tree falls or some branches are broken, and a "clearing" is formed in which environmental conditions change. In this process there is a change of species. a) The jungle matures; b) Some old trees fall or by a storm, and forms a clearing; c) Some species begin to germinate and establish; d) These species grow and modify environmental conditions (shade and humidity increase). Underneath them begin to grow species of mature jungle; e) The

species of mature jungle surpass the first species and the clearing of the jungle is closed again.

Within the radius of action of the Water Forest, there is a gradient of types of forest ecosystems by height, precipitation and average temperature. These forests also show differentiation in the portion of trees that do not lose their leaves, the evergreen trees, and the trees that lose their leaves during part of the year, the deciduous ones. Figure 8 shows how differences in average temperature and rainfall throughout the year give rise to these characteristics in tropical forests.

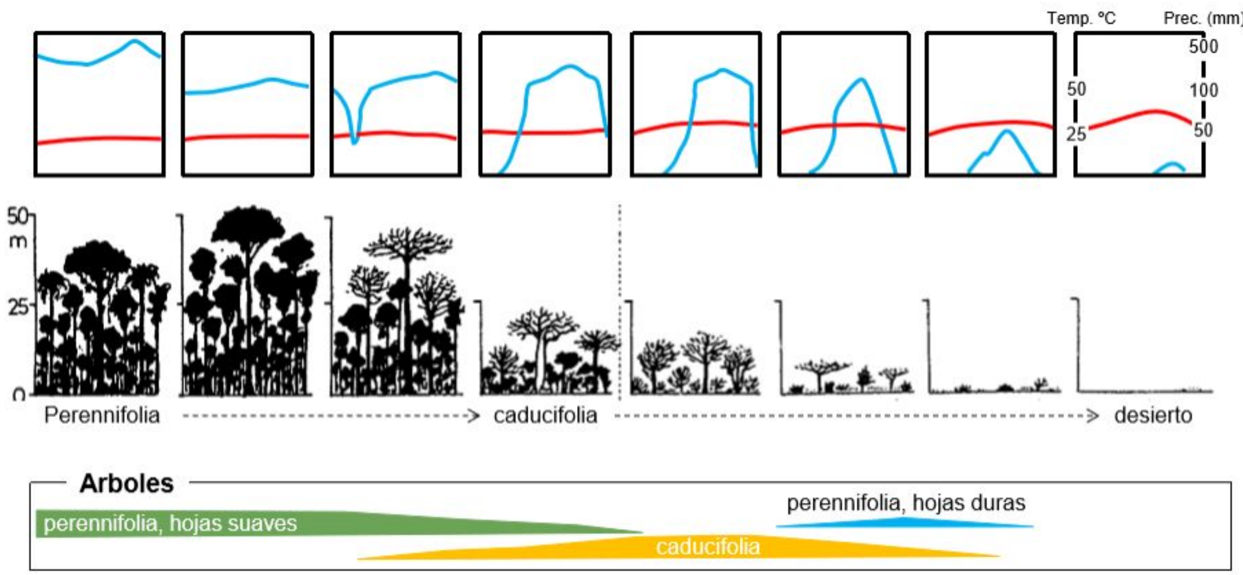


Figure 8. There is a climate gradient in tropical forests, between those with the highest precipitation and lowest average temperature, where tree species tend to be evergreen, to those with dry periods and/or high temperatures, where deciduous tree species tend to predominate. In desert conditions, evergreen trees predominate again, but with hard leaves, to avoid water loss through evapotranspiration. Source: TheTI, 2013

For example, in many parts of the Chiapas Highlands where the forest has not been too degraded, the so-called pine-oak forest predominates, where these two species do indeed predominate. However, within this same region, there are areas of humid air condensation, where dense massifs of clouds are formed, there is high relative humidity and high precipitation. These areas have "cloud forests" or, as biologists call them, mesophilic mountain forests with high levels of biodiversity and complexity (Gual Díaz and González Medrano, 2014).

Within these high altitude humid forests, there is evidence that oaks (Quercus spp.) play a very important role, as a keystone species (López Barrera et al. 2016)-the presence or absence of them determines to a great extent the composition of the forest. Even, as will be seen below, oaks are studied for their ability to redistribute groundwater to the first layers of the soil (Kurz-Besson et al. 2006). This means that, in the Highlands, it is very important to assess the possibility of focusing reforestation efforts on the establishment of oaks and holm oaks.

In the descent from the Altos to the Selva, there is a radical change in the composition of tree species. In the coffee-growing lands around Ocosingo, the genus Inga (known as guaba or paterno) is predominant in many areas. These trees belong to the leguminous family (easy to identify by the pods in which their seeds grow). Like almost all leguminous species, the Inga have a very important attribute: through a symbiotic relationship with soil bacteria, they fix atmospheric nitrogen (from the air) and convert it into plant protein. While the soil is covered with Inga trees, the fertility of the soil is likely to increase over time. This is very important in agroforestry systems, such as those incorporating coffee and shade cocoa, because people's economic need to produce and the ecological processes of soil regeneration go hand in hand.

Around the rivers and also growing hanging as epiphyte from other trees, it is possible to find from Ocosingo towards the jungle the amate tree (Ficus insipida). This enormous tree, like many species of his family (Moracaea), has the gift of taking care of the water. Its dense shade lowers riparian temperatures, its aerial roots can absorb moisture from the fog, reducing its dependence on soil water. Ficus are a keystone species in their habitats due to their relationships with animals that consume their fruits such as bats, monkeys, squirrels and many bird species and even these trees have a mutualistic relationship that has developed over 70 to 90 million years of co-evolution with the pollinator wasps and parasites of the Chalcidoidea and Agaonidea families (Cook and Rasplus, 2013).

The Lacandon Jungle is the largest evergreen high forest relict in Mesoamerica1. There is one of the tree species that most interests us in the context of the Water Forest, the ramon (Brosimum alicastrum). Ramon trees grow very tall (up to 40 meters) and produce an enormous amount of fruit, providing food to various mammals, reptiles and birds. Inside each fruit is a seed that, dried, roasted and ground, is highly nutritious and a traditional food of the native peoples of Mesoamerica. The seeds of ramon, or ax as it is known in tzeltal, are now generally eaten in years of drought, when there is not enough corn. However, it is believed that, in the past, ramon seed tortillas were even more fundamental to the diet of the Maya people in lowlands than corn tortillas themselves. A single ramon tree can produce more than 60 kilograms of seed per year in two harvests, making this tree recognized as one of the most important species for agroforestry systems. In addition, its long roots reach groundwater that other trees cannot reach and it seems that the ramon has several mechanisms to create humid conditions in the microclimate where it is found.

Its foliage is a good source of food for livestock.

Biotic factors

Abiotic factors

Biodiversity

Ecological functions

Ecological theories

Disturbance and succession

Resilience

Forest regeneration

Physiology of trees

Vascular system of plants

All trees move water, from the roots to their branches and leaves, through the xylem, usually in an upward direction. The force needed to lift so much water comes from the sun, since, when transpiring the leaf, there is a negative pressure on the xylem, equivalent to suction on a straw, which is able to lift the water from the roots to the leaves by pressure gradients. Now, some species of trees-particularly those with deep roots-redistribute a portion of their water, particularly during the cool hours at night, in the first meters of soil, where it can be harnessed by the roots of other trees, shrubs, vejucos, herbs and animals in the soil. This generates a systemic effect, since access to larger amounts of water in the soil produces more foliage, greater cover and, generally, lower temperatures at ground level. Decreased heat reduces evaporation from soil and shade plants, allowing less water to leave the forest, while groundwater begins to cycle in the upper layers of the soil and forest.

Photosynthesis and evapotranspiration

Hydraulic lift

Prieto Aguilar (2011) defines hydraulic lift as follows:

"Hydraulic lifting consists of the transport of water by means of roots from deep and humid layers of the soil to more superficial and dry layers without this involving a waste of metabolic energy for the plant. With the stomata open, the plant establishes a gradient of water potential between the soil and the atmosphere that makes water flow through the continuous soil-plant-atmosphere from greater to lesser water potential. With closed stomata, the soil-plant-atmosphere continuum is broken, generating a gradient of potential between the different layers of the soil. Thus, the water moves through the roots of areas of greater water potential (wet layers) to areas of lesser water potential (dry layers)".

Native species

Trees are the key component of peasant and community strategies to take care of watersheds and recover the water table. The southeast of Mexico has many native species that, although there is generally no literature to say so, can contribute to this recovery through a mechanism known as hydraulic redistribution.

Important attributes (Douterlougne and Ferguson, 2012)

Reproduction in nursery:

Produce abundant seeds easy to harvest.

Seeds that do not require complex pregerminative treatments for germination.

Little vulnerability to pests and diseases difficult to control.

Survival and growth in soil:

The species of greater growth require less weeding to guarantee their survival.

Tolerate extreme growing conditions, such as absence of shade, exhausted and compacted soils, aggressive competition from weeds, etc.

Tolerate a certain level of herbivory.

Create favorable microenvironmental conditions for restoration:

Produce abundant litter that decomposes into organic matter or fertilizer.

Presence of nitrogen-fixing nodules or mycorrhizae (bacteria present in small balls in the roots that fix nitrogen).

Attract forest seed dispersing fauna.

Trees that produce fleshy fruits tend to attract more fauna; also native species compared to introduced ones.

Have wide canopies and dense foliage where birds and bats can perch and hide.

Needs of the local population:

Have multiple uses such as producing firewood, charcoal, nutritious forage, edible pods, wood or nectar.

Species known to the local population.

Heliophilic species: those that grow best in the full sun.

Shade-shaded species: those that grow best in shade

Tree species that are likely to lift water

Meliacaea, the mahogany family, are susceptible to boring insects (Hypsipila spp.).

Mahogany (Swietenia mahogoni, S. humillis and S. macrophylla),

Cedro real (Cedrela odorata) chujté (ch'ol, tzeltal), cuché (maya Lacandón)

http://www.verarboles.com/Cedro%20Rojo/cedrorojo.html

Cedar (Carapa guainensis),

Family malvaceae

Ceiba (Ceiba pentandra)

Moracaea

Amate (Ficus insipida)

Ax (Brosimum alicastrum)

Facilitating species for forest regeneration

Cork (Ochroma pyramidale), also known as balsa

Guarumbo (Ceropia spp.)

Capulin (Muntingia calabura)

Cedrillo (Guarea glabra)

Cuaulote (Guazuma ulmifolia)

Mamey (Manilkara zapota)

Jobo (Spondias mombin)

Jocote (Spondias purpurea)

Rubber (Elastic Castile)

Barí (Calophyllum brasiliense)

Paternal (Inga vera)

Guabo (Inga edulis)

Red cork (Trichospermum mexicanum)

Chicozapote (Manilkara zapota)

Caimito (Chrysophyllum cainito)

Biodiversity associated with the restoration process

Birds such as the matapalo (Ficus nyphmaeifollia)

Bats often have a bad reputation, as three species feed on the blood of animals (Desmodus rotundus, Diaemus youngi and Diphylla ecaudata). However, most species of bats eat fruit and disperse seeds as they fly (unlike birds, which disperse seed when they perch) (Douterlougne and Ferguson, 2012). Bats such as the frugivore (Artibeus lituratus) disperse to tree seeds.

Chiapas Context

While, nationally, Mexico loses 400 square miles per year due to desertification, forcing the migration of 80,000 farmers, Chiapas has long been considered a state far removed from this trend. Approximately 1/3 of the water found in Mexico flows from the Chiapas watersheds, much of which is channeled to dams that supply 44% of the nation's hydroelectric energy. However, despite abundance, water scarcity is already a terrible problem for many, especially in the countryside.

In the endless irony of "development," rural communities are experiencing a return to harsh transport conditions and water scarcity, while capitalist agriculture and industry continue their march into the countryside. When visiting the communities of Chiapas, one often hears the memories of mothers and grandmothers of the terrible amounts of labour - often women - who carried clay buckets and hollow pumpkins long distances from rivers and streams. Today, these women and their communities face an even bleaker present and future: clean water is simply not available.

The factors involved in the water crisis are complex. A long-term shift in land use from "dirty" Mayan rotational agriculture to cattle ranching - coinciding with rural migration - has impacted large areas in the Selva de Chiapas region, leaving fewer trees and more solar radiation reaching the ground. In Los Altos, intensive production of flowers and vegetables has contaminated streams and drainage channels. None of these changes is purely local, as each of them has a downstream impact and a microclimate impact. However, it is the combination of these regional factors with global climate change that makes the water crisis felt in the country. As the pumping of fossil fuels into our atmosphere continues, the climate of Chiapas is changing. It is becoming a hotter, drier place at an accelerated pace.

The first sign of trouble is in rainfall patterns. From a historical range of 1,200 to 2,000 mm/year, precipitation in Chiapas since 2010 has dropped to a range of 900 to 1,500 mm/year. The loss of the rainfall regime means that the traditional sowing dates of each crop are no longer applied, so farmers must be much more attentive to inclement weather in order to be able to plant at the right time. The risk of a bad rainy season involves the risk of losing seed varieties. Agriculture requires more work, more local knowledge and more seed diversity; such requirements mean that peasant families must be fully committed to surviving on the land. These issues know no borders. In addition to the anti-peasant policies of bad governments, the lack of water is contributing to the rural exodus manifested in the endless caravans of desperate migrant workers from Guatemala, Honduras and El Salvador.

The lack of rain does not only affect crops. It affects the entire ecosystem. Losing those 300 mm of rain each year is enough to make many streams fall underground. In other words, the water continues to flow, not like a river, but like groundwater, through the microscopic pores of the subsoil and rocks. Birds and other animals, particularly mammals, face a migration crisis of their own as the water hides underground. The loss of surface water has catastrophic impacts on rural farming communities, where the water infrastructure consists of a filter and an intact valve placed in springs and natural headwaters from land to land. In these places, in years past, pure mountain water flowed year-round through plastic pipes and hoses that can travel more than 2 kilometers by gravity to reach a community. Now, however, the springs are drying up, and when they work, they require constant maintenance, as less water means more sludge enters the system. When the spring does not produce enough water, there is no water for drinking, washing clothes, bathing or cooking.

In this context, capitalist agribusiness and mining interests are taking advantage of the situation to quickly appropriate water resources and privatize access to water. The soft drink giant Coca-Cola, for example, was granted exclusive rights to extract 150,000 gallons of water a day from the Huitepec aquifer in the mountain above the city of San Cristóbal de Las Casas. Huitepec farmers are running out of water in their wells, and entire neighborhoods of San Cristóbal are running out of water for several days each week. Coca-Cola pays almost no taxes and now sells more water than soft drinks. However, privatized bottled water has a high price and rural communities will never be able to pay for it. At the same time, however, mass-produced carbonated Coca-Cola drinks are transported in trucks to remote rural communities and towns along Chiapas, leading to a phenomenon of rural people drinking Coca-Cola to hydrate themselves in the absence of available drinking water. This terrible situation has led to a 30% increase in diabetes deaths in just three years, according to The New York Times.

Causes of deforestation

Deforestation

Soil compaction

Livestock

Monoculture

Mining

Roads

In the Lacandon Jungle, the main causes of degradation and deforestation are the establishment of pastures to feed cattle and monocultures of introduced plants, such as the African palm (Elaeis guineensis) (Saldívar et al.), which have unfortunately been promoted by different governments (Márquez et al.).

Community drinking water systems

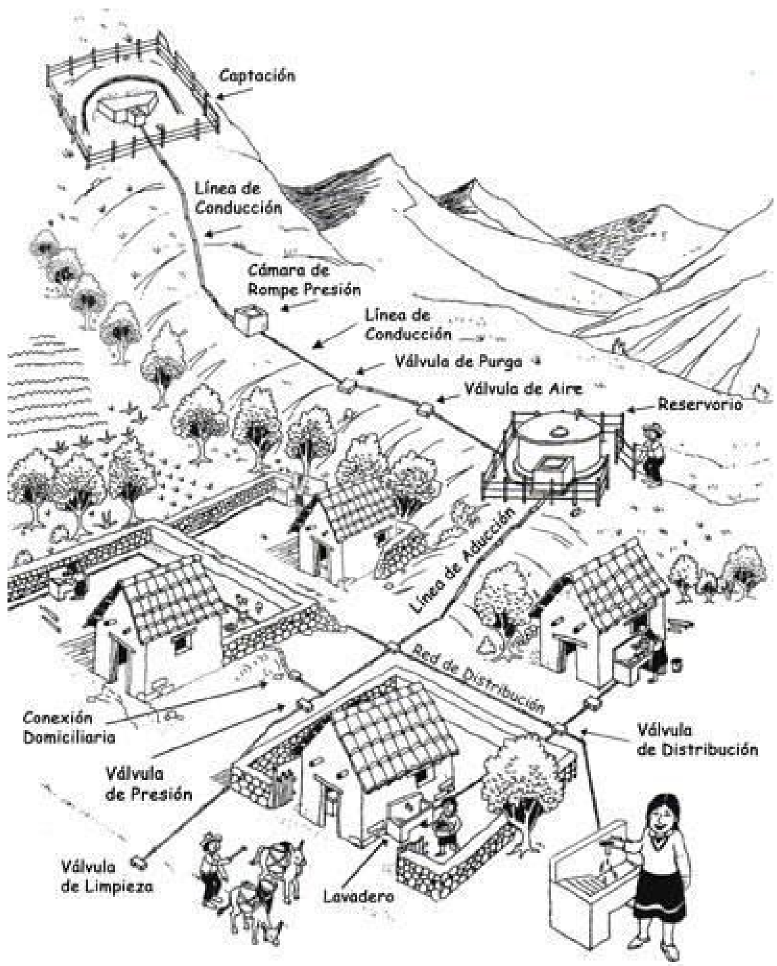


Figure 10. Gravity Drinking Water System. The water is collected from a spring in a place above where it is consumed. These are the systems used by many communities in Chiapas, but some have gone into crisis in recent years because of the reduced amount of water collected.

For the reasons mentioned above, many of the potable water systems installed in the 1990s are no longer functioning for the communities. It is less water that flows into streams and therefore, the water that is there may have a higher concentration of pollutants. Looking for solutions in short, some communities are building or recovering previous water pumping systems, which occupy wells to reach drinking water.

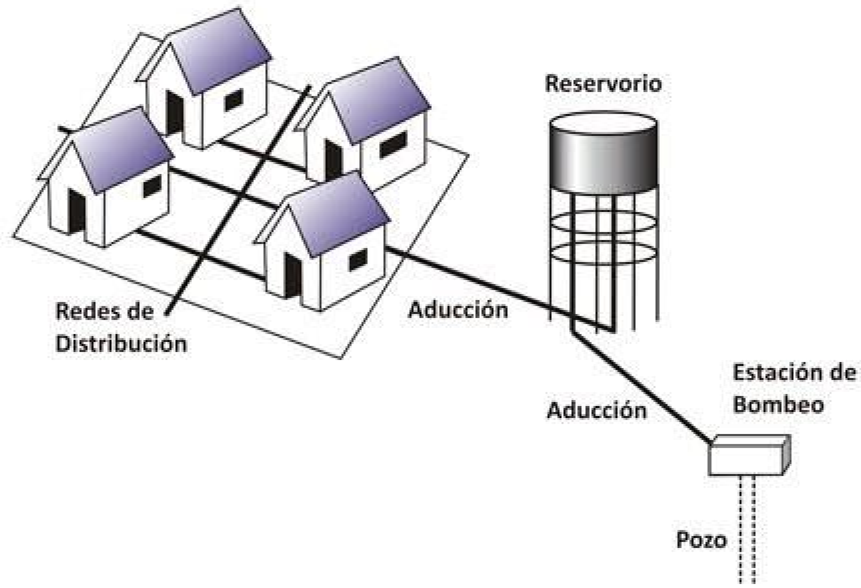


Figure 11. When there is no possibility of providing adequate drinking water through a gravity system, pumping systems are used, in which groundwater is pumped to reservoirs, from where it can reach homes through piped networks. Source: Napurí et al. 2009

In many cases, people build wells to reach groundwater. Shallow wells reach the water sitting above the impermeable soil substrate, while artesian wells are those that reach the water below the impermeable soil substrate layer, making them more permanent and achieving higher quality water, as shown in Figure 12.

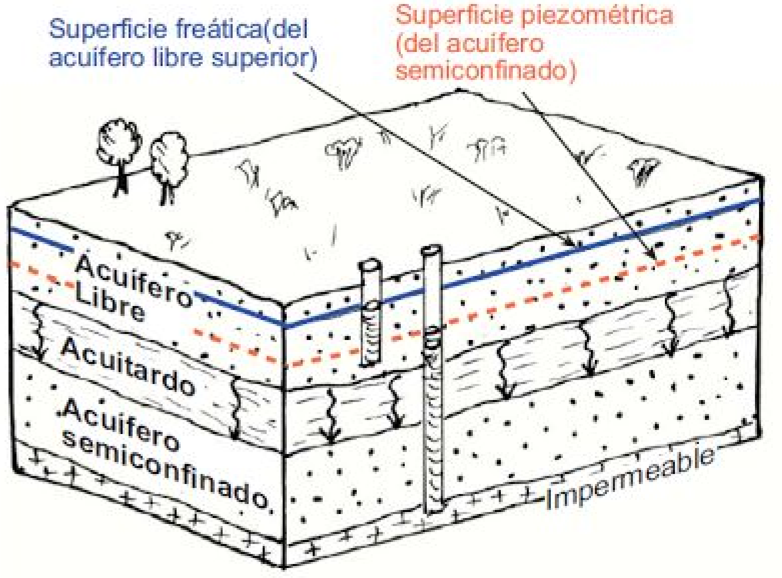


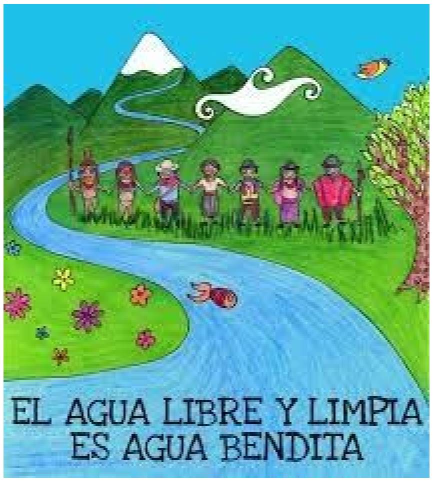
Figure 12. Groundwater is divided in two: the aquifer that flows through the pores of the stones, above the aquitard or almost impermeable layer (the free aquifer) and the aquifer where the water flows below the aquitard (known as the semi-confined aquifer). While hand-built sediments only reach the water in the saturation zone of the soil (the water table), artesian sediments reach the water that is trapped in deeper layers and is less susceptible to pollution. Source: Sánchez, 2007

Climate change

Other knowledge

Water Forest Strategy

"ZAPATISTA HYDRAULIC LIFT!"



Search for seeds

Nursery Very Other

Community nurseries

Organisation at Community, territorial and operational level

Follow-up and monitoring

Cost

Curriculum design for secondary schools

Methodological approach

Curriculum design is a planning tool for schools, as it allows us to organize ideas and activities into a whole, organic, based on the principles of autonomous education. Just as design comes from the Latin word to say "draw", with a curricular design we are drawing how we would like the teaching and learning process to work. In this case, we start from a constructivist conception, which is simply to say that we think that knowledge is constructed in each place and interaction. Knowledge is not something that can be forced into someone's head. On the contrary, it is built on previous experiences and dialogue between people who are sharing their worldview.

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Non-native: Neem (Azadirachta indica)

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