

WATER FOOTPRINT IN MEXICO



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About AgroDer
AgroDer is a consulting firm founded in 2004.

We provide advisory, consulting, and analysis services in Agriculture, Nature Conservation, and Sustainable Development.

We work with a range of organizations and companies in Mexico, the Americas, Europe, and Africa, offering market intelligence, strategic planning, communications, and public policy services, among others, through which we actively drive actions aimed at sustainability.

About WWF
WWF is one of the world’s largest and most experienced independent conservation organizations. WWF was founded in 1961 and is recognized worldwide by its Panda symbol. It has a global network working in more than 100 countries.

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WHAT IS THIS INFORMATION
USEFUL FOR?



GLOSSARY

Understanding water Key to an informed sustainability

Making responsible decisions about water use involves understanding some essential concepts. This glossary brings together the most important definitions related to water management to understand its relevance and impact on everyday life and the environment.

Aquifer: Geological formation capable of storing and transmitting groundwater. It can be exploited to supply communities, industries, or agricultural irrigation.

Blue water: Corresponds to the water contained in rivers, lakes, reservoirs and underground aquifers. It is used for irrigation, industrial processes, energy production, and domestic use.

Grey water: The volume of water necessary to dilute and assimilate pollutants generated in agricultural, industrial, or domestic processes, until they meet acceptable quality standards.

Green water: Rainfall water stored as soil moisture that does not generate runoff. Plants absorb it directly and it is mainly associated with rainfed agriculture.

Virtual water: The total amount of water used, directly and indirectly, to produce a good. The term was proposed by Tony Allan in 1998 and helps visualize how much water is “hidden” behind what we consume, from food to clothing and industrial products.

Environmental flow: The minimum water flow necessary to preserve aquatic and terrestrial ecosystems and the environmental services they provide.

Direct and indirect consumption: Direct consumption is the use of water visible in everyday activities such as drinking, cooking, or washing. Indirect consumption is the water used in the production of goods and services that we consume, but we do not see.

Virtual water trade: It refers to the exchange of products between regions or countries, considering the amount of water used for their production. This trade can shift the water pressure from one place to another.

Watershed: Geographic area where all surface streams (rivers, streams, runoff) converge toward a common outlet point, such as a lake or the sea.

Differences between virtual water and water footprint: Virtual water focuses on the amount of water used to produce a single good. The water footprint, on the other hand, evaluates all water use associated with a product throughout its life cycle.

Water scarcity: Occurs when demand exceeds available supply, affecting ecosystem health and people’s quality of life.

Water stress: Indicates the level of pressure a region faces regarding water availability and demand, potentially generating social, economic, or environmental tensions.

Water footprint: Represents the total volume of freshwater used to produce goods or services throughout their entire value chain. It is expressed in litres and includes three components: green water, blue water and grey water.

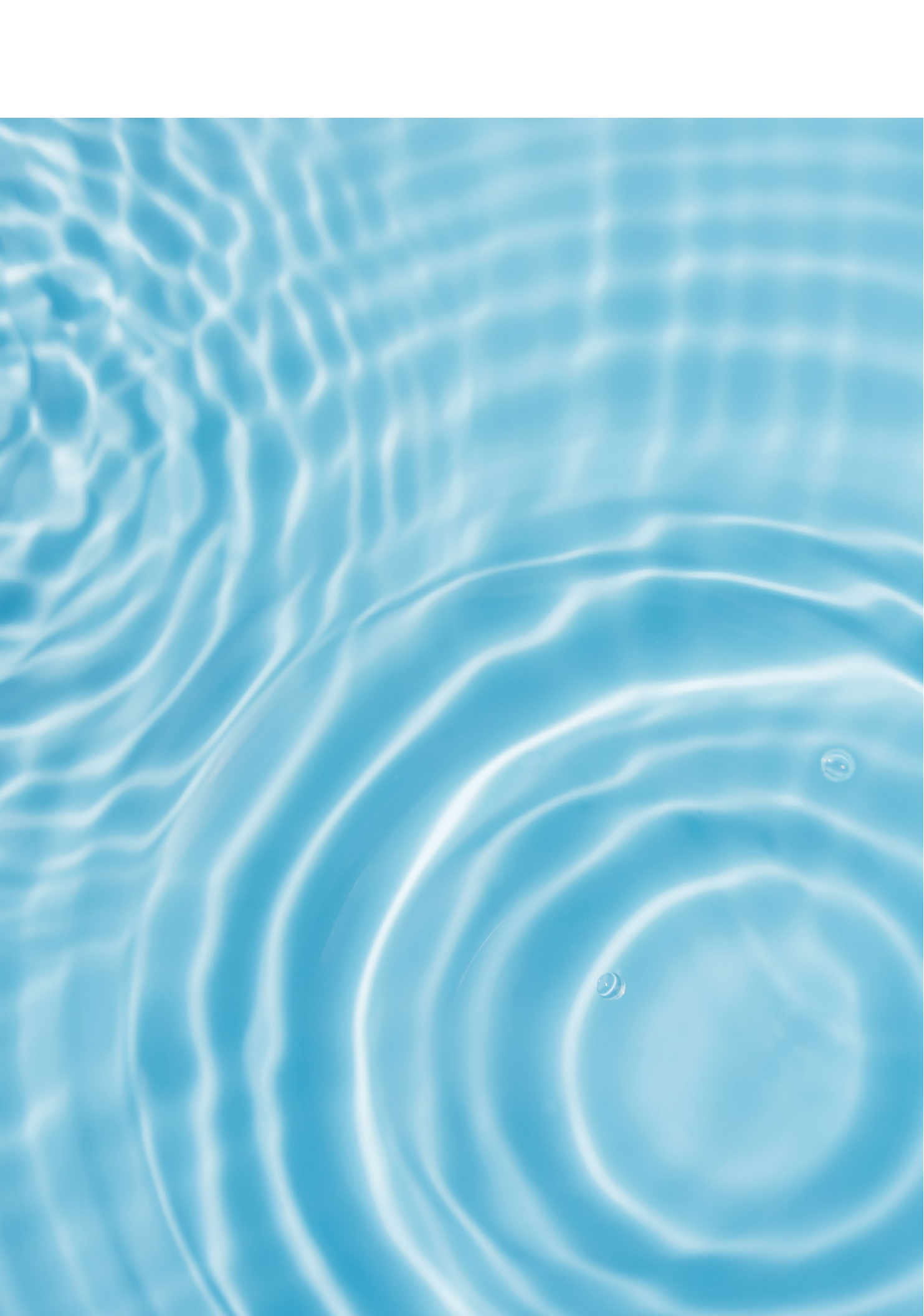
Infiltration: It is the process by which rainwater or runoff penetrates the soil, feeding aquifers and contributing to the natural water cycle.

Critical sites or hot spots: These are regions where water demand exceeds availability or natural recharge capacity. In these areas, it is urgent to improve efficiency in water use and apply conservation measures.

Sustainability of water use: It is the management of water resources in a way that meets current needs without compromising the ability of future generations to meet theirs.

Consumptive use: It is the use of water that does not return to the hydrological cycle under conditions similar to those of origin, for example, by evaporation or incorporation into products.

Non-consumptive use: It refers to water use that remains available in the hydrological system without affecting its quantity or quality, as occurs in some recreational or hydroelectric activities.



Water Footprint in Mexico Data, decisions and a future to build

More than a decade ago, in 2012, WWF in collaboration with AgroDer pioneered the publication *The Water Footprint of Mexico in the Context of North America*. This document sought to reveal a frequently hidden reality: that the water we use directly in our households represents only a small fraction of the total that we actually consume through the products and services that surround us. We then highlighted that the exchange of goods is, in essence, an exchange of large volumes of water, and that understanding this complete cycle is fundamental to addressing scarcity and water stress.

Today, in 2026, we are proud to present the update to the aforementioned publication on the water footprint in Mexico, with the help of new allies. This new edition not only reaffirms the innovative concept of the water footprint, but also deepens it with current data and contexts, offering a more accurate view of the impact of water use in our country and its role in global trade.

The data is compelling: our production water footprint has increased, driven by population growth and the development of various economic activities, mainly in the agricultural sector. This sector is responsible for 92% of the production water footprint, with products like corn, sugar cane, sorghum, coffee, and bean concentrating 60% of the national footprint. Although most of our consumption water footprint is met internally, we import 2.8 times more virtual water than we export, evidencing the close interconnection of our consumption and production patterns in the global scenario.

Despite these challenges, opportunities exist. The water footprint per capita has shown a slight decrease, indicating changes in our consumption habits, such as a reduction in the intake of products with a high water footprint. This reminds us that every decision counts, no matter how small it may seem.

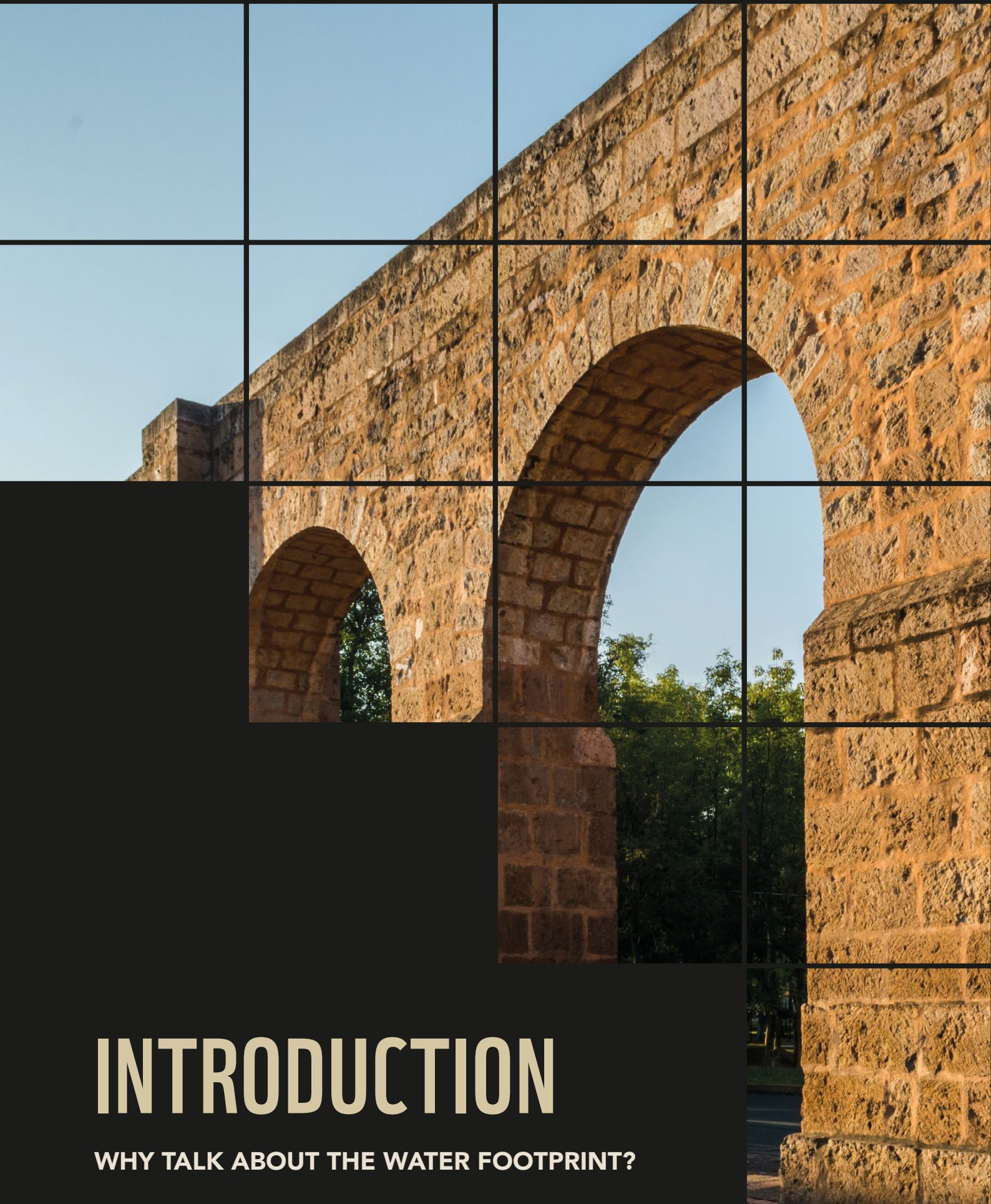
The path to sustainability is not easy, but the water footprint presents itself as an invaluable tool for informed decision-making. From the formulation of public policies and corporate commitments, to the actions of small producers and consumers, incorporating this concept can transform the way we value and manage this vital resource.

We invite you to explore this new publication. In it, you will not only find data, but also analyses of emblematic cases that will help us understand the specific challenges faced by different sectors and regions in Mexico. It is crucial that we all work together — government, industry, civil society, and citizens — to ensure a sustainable water future for all.

The challenge is great, but so is our determination. Let's continue to build a future where water is an abundant and accessible resource for generations to come.

Help us bring nature back!

María José Villanueva
General Director, WWF-Mexico



INTRODUCTION

WHY TALK ABOUT THE WATER FOOTPRINT?

Talking about water footprint is talking about the water we use every day, not only when we turn the tap open, water the plants or wash the dishes, but also when producing the food we eat, the clothes we wear or the energy we consume.

In recent years, innovative concepts have emerged and they have changed the way we understand and manage water. One of the most relevant is precisely the water footprint. This tool allows us to measure the volume of fresh water used to manufacture a product or provide a service, considering its entire life cycle. This approach not only considers the volume of water, but also its type (green, blue or grey), the moment it is used and the impact it generates, offering a more complete and useful vision for making decisions towards a more responsible use of the resource.

The water footprint has become an essential tool for more accurately assessing water use across different sectors and regions. Thanks to its versatility, it can be applied from the analysis of individual products to the design of public policies and business strategies, promoting sustainable practices at all levels.

In this endeavour, WWF has played a key role. Since the early years of the last decade, together with strategic allies, it has promoted the use of this concept within conservation projects, sustainable development, and water governance.

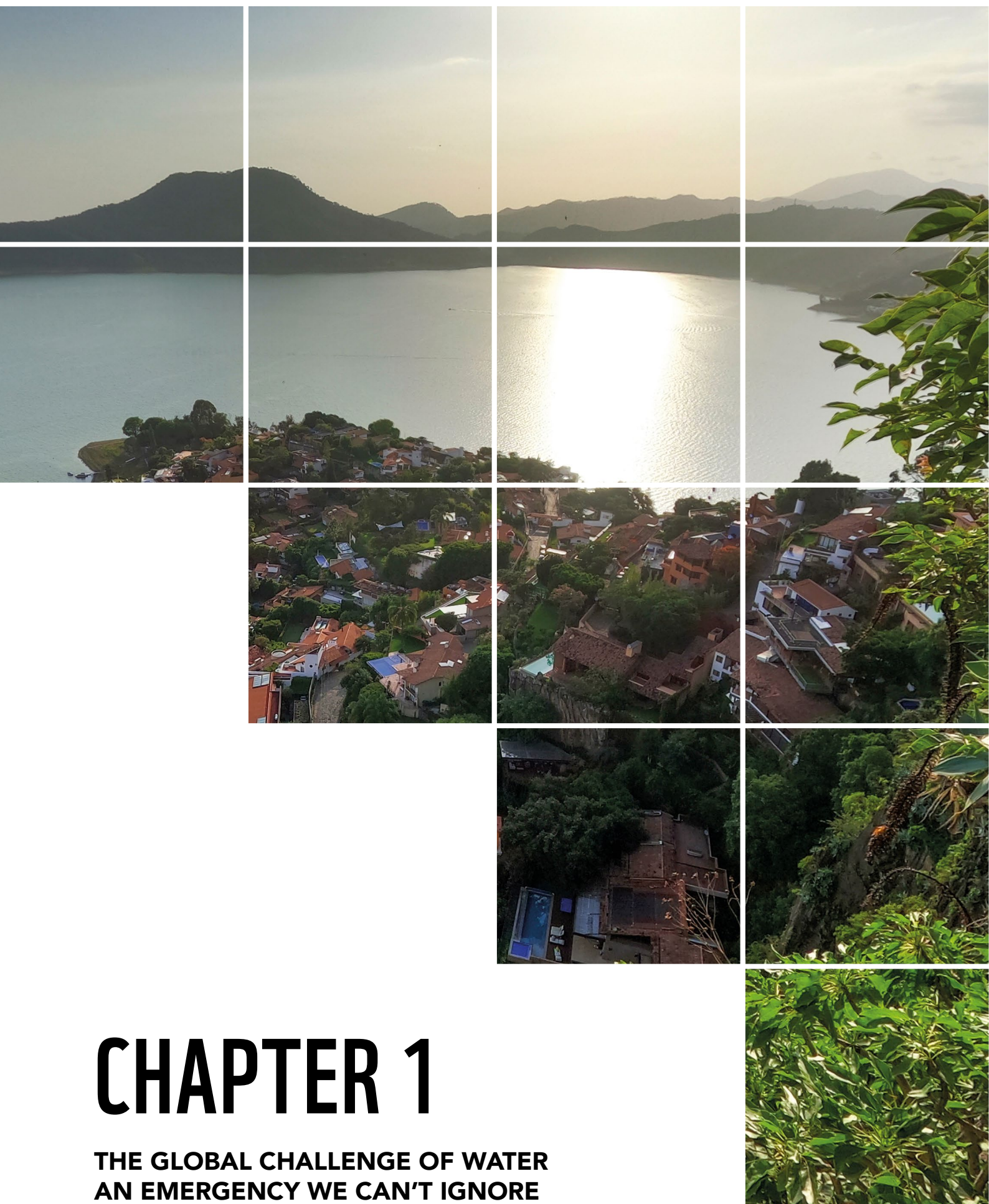
In 2012, the document “The Water Footprint of Mexico in the Context of North America”, developed in collaboration with AgroDer, was a landmark. It was the first study of its kind in the country and managed to position the water footprint as a central issue on the national agenda, arousing the interest of academics, authorities and companies.

This report is an update of that study, with current figures and emblematic cases that reflect water use in a Mexico that forms an active part of an increasingly interconnected world. This recent version not only shows data, but also specific paths towards sustainability. This analysis examines the sectors with highest water consumption, the challenges we face, and the opportunities available to improve decision-making at both personal and institutional levels.

In Mexico, the water footprint has grown in recent years. Population growth, expansion of irrigated agriculture, dynamism of the industrial sector, and the country's participation in international markets are factors that have intensified this pressure on our water resources.

Facing this scenario, it is urgent to incorporate the water footprint as a key tool in decision-making, both in public policies and in corporate commitments, agricultural practices and daily consumption habits. This document offers a clear and accessible guide to understanding the current situation of water in Mexico and the steps needed to build a more sustainable future. 💧





CHAPTER 1

THE GLOBAL CHALLENGE OF WATER
AN EMERGENCY WE CAN'T IGNORE

Ensuring sustainable water management is more necessary today than ever. We are facing a water crisis that is exacerbated by multiple factors: pollution of water bodies, overexploitation of aquifers, desertification and the increasing variability of the climate. All of this has altered the natural water cycles and exert unprecedented pressure on water resources.

On a global scale, the situation is worrying. According to the United Nations World Water Development Report 2024, more than 733 million people currently live without secure access to water. And the trend has not improved: it is estimated that in 2025, nearly 1.8 billion people will live in countries with absolute water scarcity, and two-thirds of the world's population will be exposed to water stress conditions, according to the UN.

In Mexico, the picture is equally critical. 77% of water bodies show some level of pollution, according to the National Water Commission (CONAGUA) data from 2020. Moreover, water availability is affected by phenomena such as droughts that are becoming more frequent and intense, driven by climate change. This situation has direct effects on food production and access to drinking water, compromising the food security of millions of people.

Agriculture, which accounts for 76% of total global water use, remains a sector with significant challenges. Up to 60% of the water used in agricultural activities is lost due to inefficiency, according to the FAO. To make matters worse, global water demand is projected to increase by about 30% by 2050 compared with 2010 levels, which will intensify pressure on water systems if urgent actions are not taken (Burek, et al. 2016).

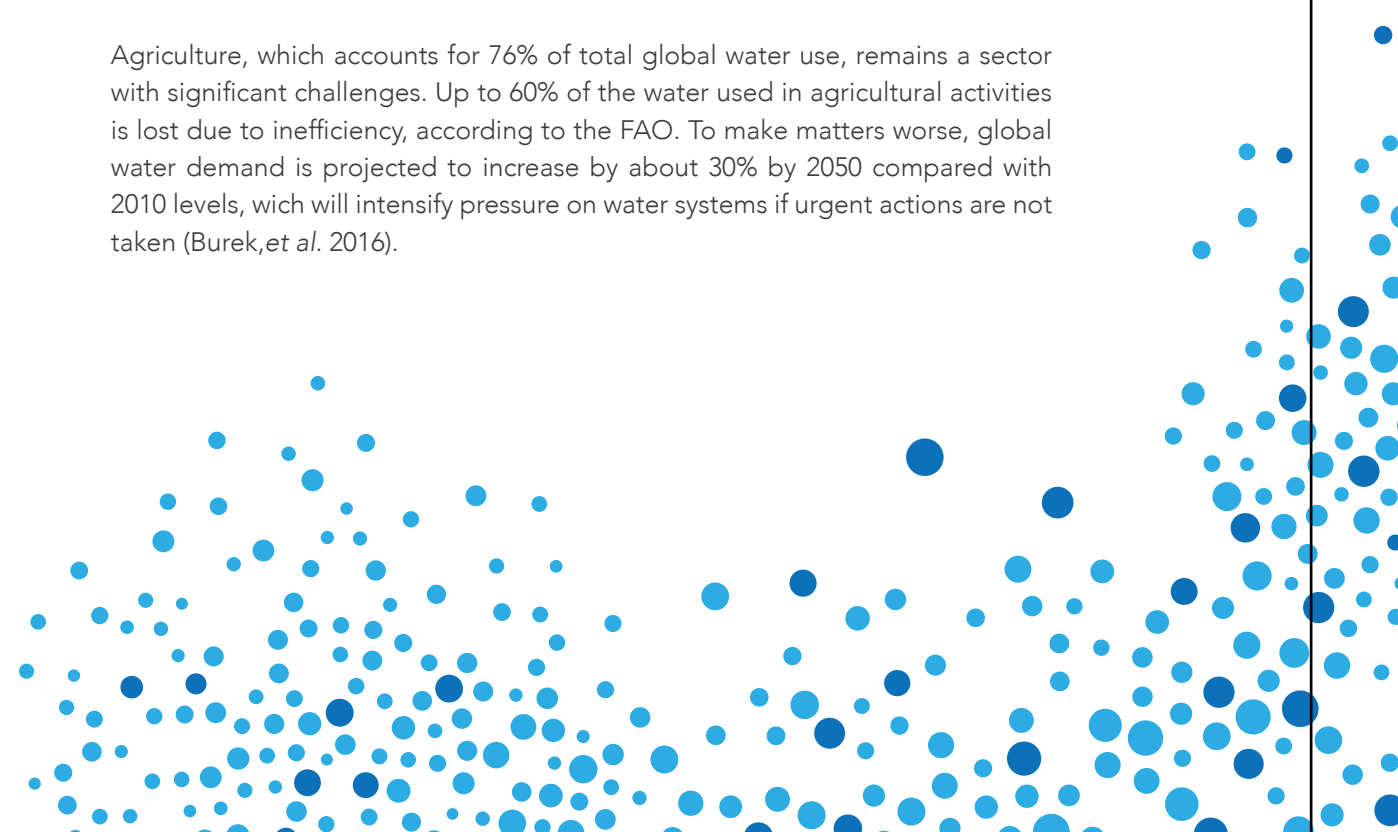


FIGURE 1

DATA TO BE CONSIDERED

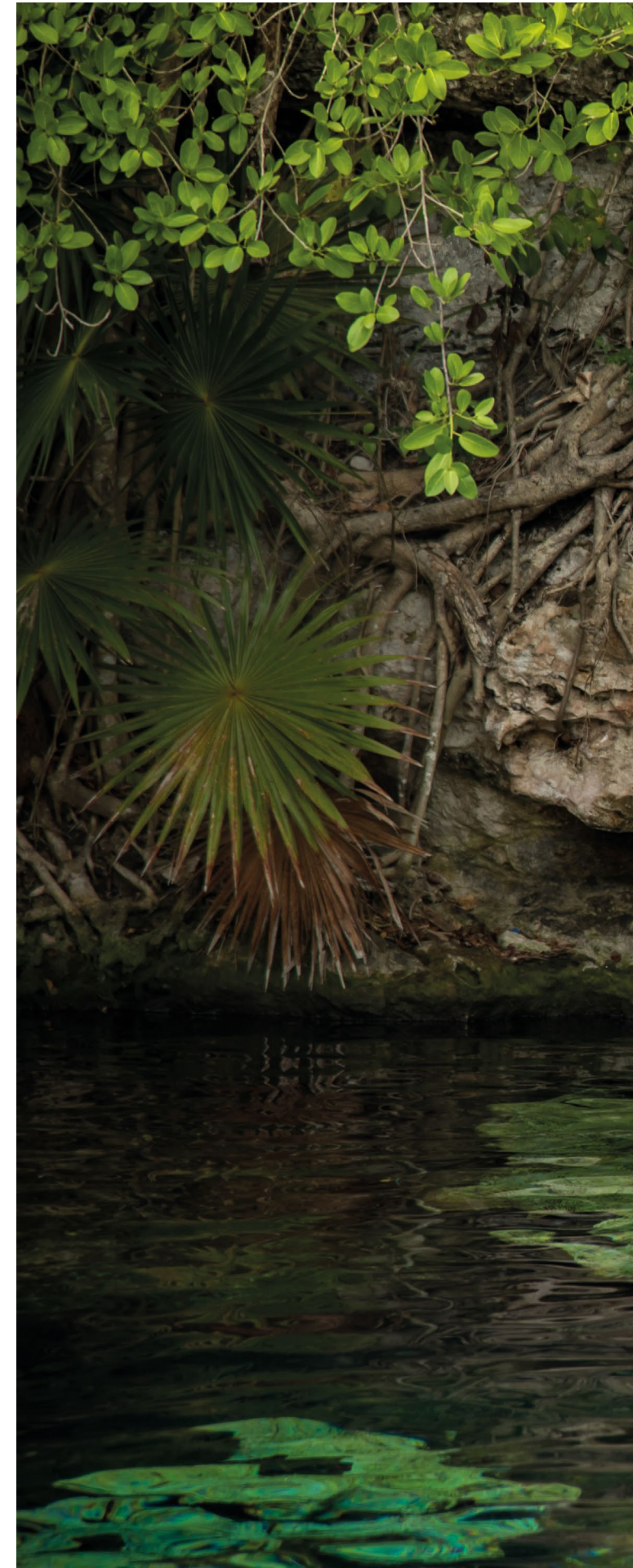


Key data on the global and national context surrounding water use and availability. Globally, it is reported that 733 million people currently live in areas with water stress (UN, 2021) and that the demand for water will grow by 30% between 2010 and 2050 (Burek et al., 2016). In addition, it is estimated that by 2025 around 1.8 billion people will be living in countries or regions facing absolute water scarcity (UN, 2018).

In Mexico, 76% of water withdrawals are used by the agricultural sector, and 77% of water bodies show some degree of pollution (CONAGUA 2020). These figures highlight the urgency of improving water management—both in its productive uses and in protecting water quality—to move towards truly water sustainability.

The crisis is not limited only to the quantity and quality of water. It also faces important obstacles in its management. In Mexico, for example, the lack of investment in sanitation infrastructure and wastewater treatment exacerbates pollution. At the same time, uncontrolled urban growth and weak governance make it difficult to implement effective solutions, as warned by SEMARNAT (2021).

Faced with this scenario, it is essential to adopt tools such as the water footprint to make evidence-based decisions. Unless we understand in an integrated way how, when and where we use water, we will not be able to design public policies, business practices, conservation strategies and consumption habits that are aligned with smarter, fairer and more sustainable water management.



Mexico and the challenge of its national water resources

Mexico is one of the countries with greater ecological, social and climatic diversity on the planet, which is also reflected in its unequal distribution of water. This reality poses substantial challenges for planning water use, especially when it is assessed from a water footprint perspective.

The water footprint (WF) quantifies the volume of water used directly or indirectly by people, sectors, and territories, and it becomes a fundamental indicator for understanding the stress on national water resources.



“The interest in water footprint stems from the recognition that the impacts of human activities on freshwater systems can ultimately be traced back to consumption, and that issues like water scarcity and their pollution can be better understood and addressed if we consider the chains of value as a whole.”

Arjen Hoekstra

Water Footprint: the water we don't see, but still consume

In a global context marked by climate change, population growth and increasing pressure on natural resources, understanding how we use water has become indispensable. The water footprint is a key tool to achieve this. This concept allows us to quantify and visualize how much water we use, directly and indirectly, in our daily activities, industrial processes, agricultural practices and consumption habits.

The water footprint represents the total volume of freshwater used, evaporated or polluted during the production of goods and services. It can be calculated for a person, a company, a community, a region or a country. Its main value lies in its multidimensional nature: it not only measures how much water is used, but also the type of water, its source, the timing of withdrawals and where that water ultimately goes.

This approach makes it possible to analyse water use from a much more integrated perspective, linking our consumption decisions to concrete environmental impacts. It also helps to design more effective public policies, implement sustainable production strategies and promote responsible lifestyles.

Equivalencies	Litres	m ³
Hectoliter	100	0.1
m ³	1,000	1
hm ³	1,000,000,000	1,000,000

Table 1. Equivalencies

Table 1 presents the equivalencies between different units of volume commonly used to express water use or availability in water footprint studies. Water can be measured in hectoliters, cubic metres (m³) or cubic hectars (hm³), depending on the scale of analysis.

One hectoliter is equivalent to 100 litres or 0.1 cubic metres. One cubic metre corresponds to 1,000 litres. A hectoliter, on the other hand, represents a much larger unit: it is equivalent to 1,000,000 cubic metres or one billion litres. The latter measure is often used to quantify large volumes of water, such as those stored in dams or used by large-scale productive sectors.

Essential components of the water footprint

The water footprint is composed of four key elements: the total volume of water used, the type or color of water (green, blue, or grey), the place of origin, and the moment of extraction. This combination allows for a detailed understanding of the water impact associated with any activity or product.

THE COLORS OF WATER

For its analysis, water is classified into three categories:



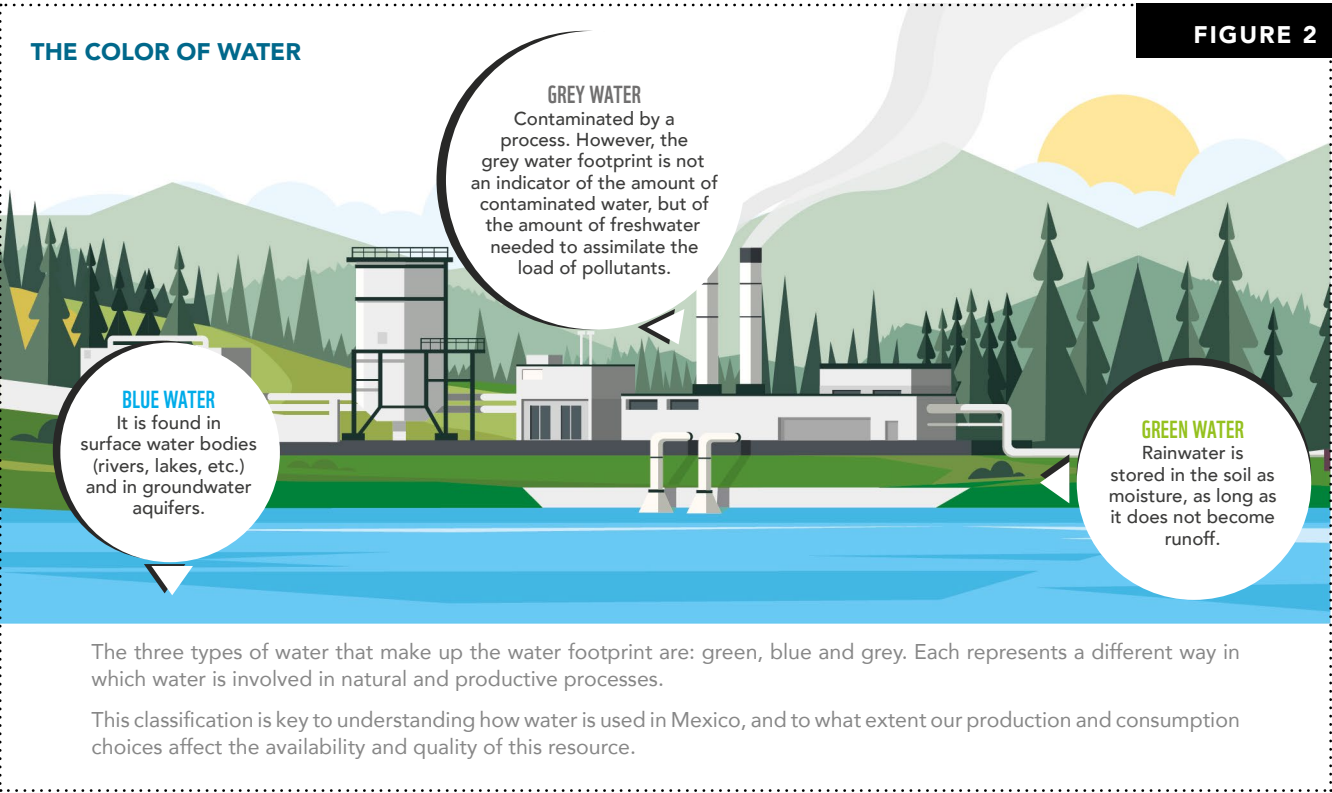
Blue Water: This is the water found in surface and underground sources, such as rivers, lakes, or aquifers. It is used for irrigation, industrial processes, domestic use, and energy generation. It is only considered part of the blue water footprint if it does not return to its original source within a short period.



Green Water: Corresponds to rainwater stored in the soil and absorbed by plants. It is especially relevant in agriculture and natural ecosystems, as it evaporates or transpires without becoming runoff.



Grey Water: Refers to the amount of fresh water needed to dilute pollutants and meet water quality standards. It does not represent contaminated water itself, but the volume required to assimilate such pollution.

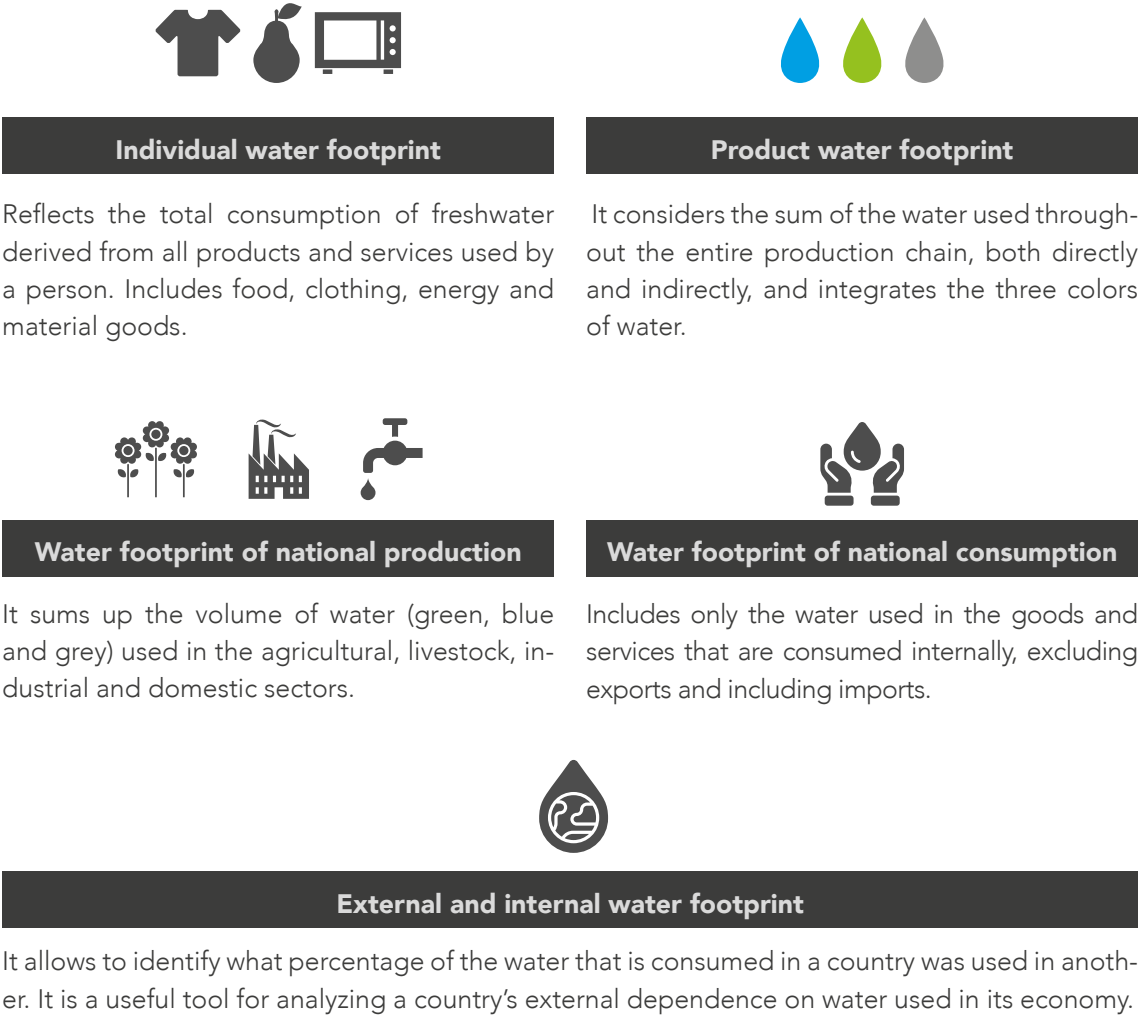


VIRTUAL WATER: THE HIDDEN RESOURCE BEHIND EACH PRODUCT

The concept of virtual water, developed by Tony Allan in 1998, complements the water footprint by focusing on all the water needed, directly or indirectly, to produce a good or service. For example, producing a cotton t-shirt can require up to 2,700 litres of water, considering everything from cultivation to textile processing. This approach allows us to understand how our consumption impacts, even when we don't see the water we are using.

METRICS AND LEVELS OF ANALYSIS

The water footprint can be calculated at different scales depending on the objectives of the analysis. The main forms of measurement include:



The use of water in the development of artificial intelligence

Artificial intelligence is advancing rapidly and is becoming a strategic tool for multiple sectors. At the same time, its development involves significant use of water resources, which opens an opportunity to reflect on how to innovate more efficiently and responsibly.



Around 9 litres of water evaporate for every kWh consumed by an AI server during its cooling process, an essential step for its functioning funcionamiento.



To generate the electricity that powers data centers, up to 43.8 litres of water per kWh may be required in some countries, which shows that the water consumption associated with AI is not always direct, but it is relevant.



It is estimated that by 2027, global water consumption linked to AI could reach 6.6 billion m³, a volume comparable to more than 2.6 million Olympic-sized swimming pools.



Today, more than 2.7 billion people experience water scarcity at least one month per year, which highlights the importance of considering the global water context in technological development.



The manufacturing of silicon wafers, key components for AI, requires large volumes of water and still faces major challenges in terms of recycling.



Various players in the tech sector have set goals to replenish or offset the water used in their processes by 2030, boosting new strategies for efficiency and water management.

Artificial intelligence can also be part of the solution. According to the Annual Report of the United Nations Environment Programme, the challenge is to decouple economic growth from intensive water use, through public policy, technological innovation and efficiency improvements that reduce or stabilize consumption without compromising performance or development.

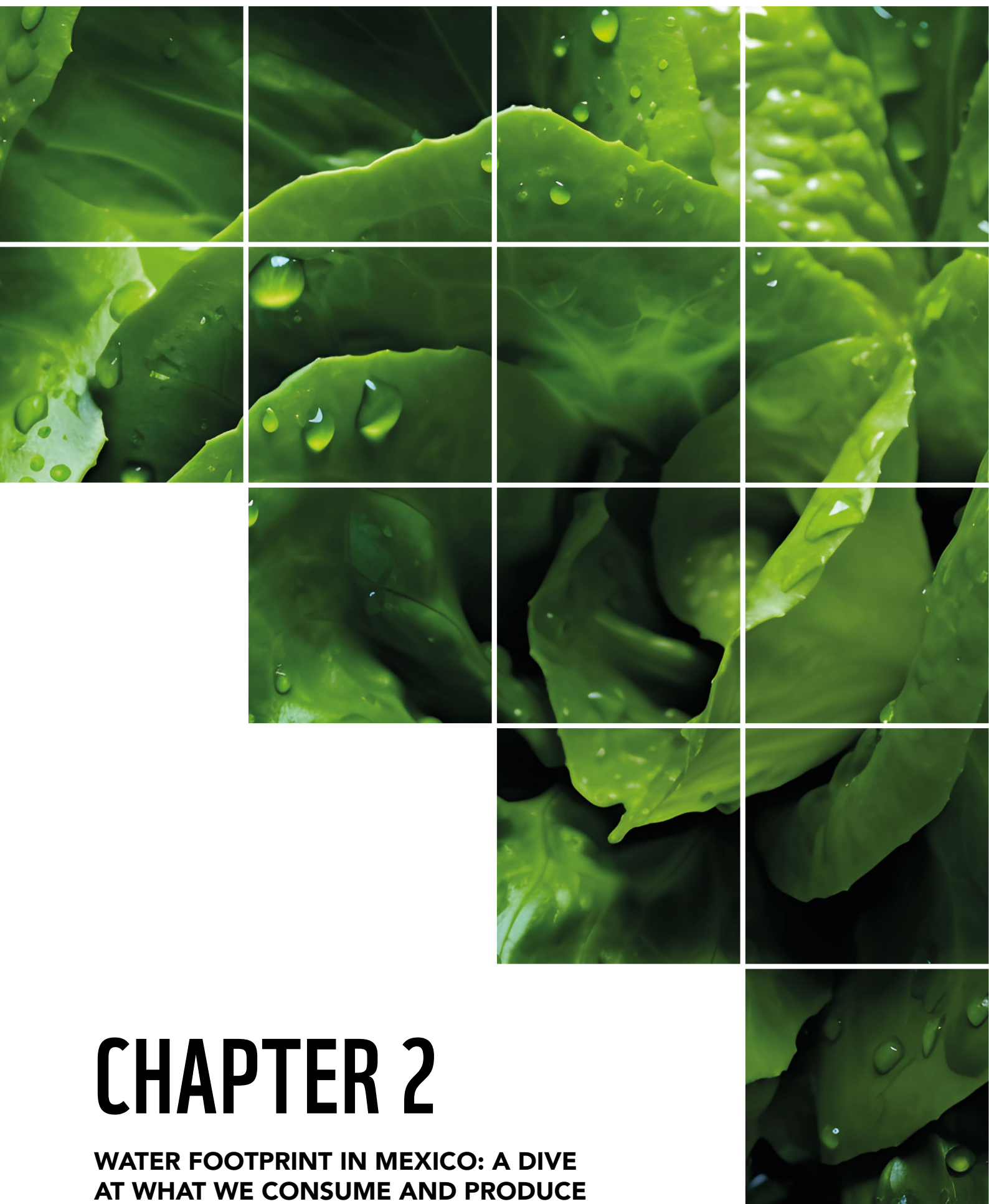
Source of information: Gordon, C. (2024, 25 February). *AI is accelerating the loss of our scarcest natural resource—water*. Forbes. <https://www.forbes.com/sites/cindygordon/2024/02/25/ai-is-accelerating-the-loss-of-our-scarcest-natural-resource-water/>



A TOOL TO TRANSFORM THE FUTURE

Thanks to its versatility, the water footprint has become a fundamental tool for water management at multiple levels. From governments seeking to design more sustainable public policies, to companies looking to reduce their environmental impact, to more conscious citizens who want to change their consumption habits.

In Mexico, where much of the territory faces water scarcity and where the challenges of resource management are urgent, applying the concept of water footprint can make a difference. Adopting it as an axis for policies, productive strategies, and personal decisions is an opportunity to ensure a better water conservation, in balance with the ecosystems and with future generations. 💧



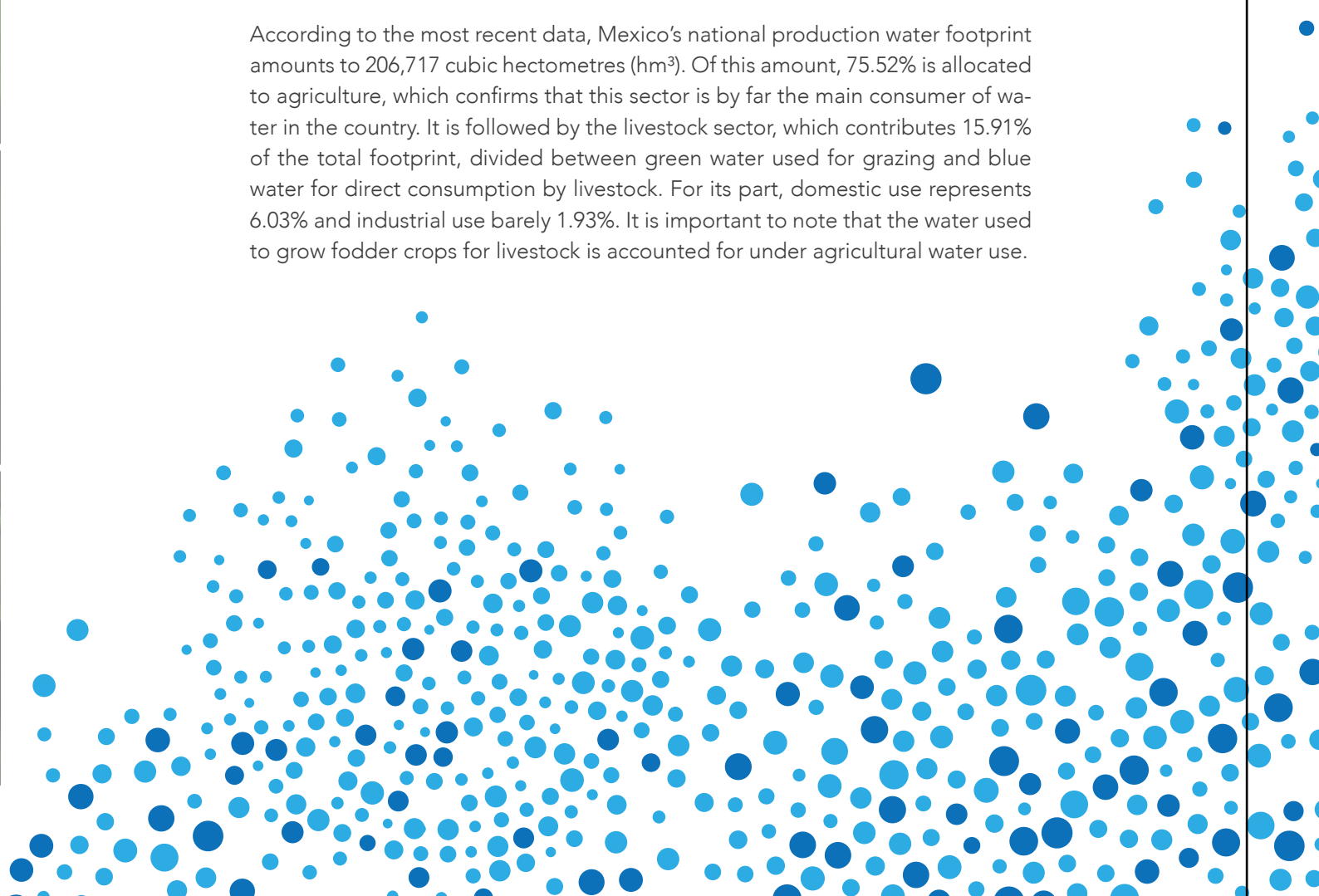
CHAPTER 2

WATER FOOTPRINT IN MEXICO: A DIVE
AT WHAT WE CONSUME AND PRODUCE

Every country has a unique water footprint, determined by its way of producing, trading and consuming. In the case of Mexico, this footprint reflects both the particularities of our diet and lifestyle as the main characteristics of our agricultural, livestock and industrial production systems.

The national water footprint represents the total volume of freshwater used or polluted within the Mexican territory to produce everything we consume and export. This analysis includes the origin of the water (green, blue or grey), its use in the different economic sectors and the relationship between what we produce and what we import from other regions of the world.

According to the most recent data, Mexico's national production water footprint amounts to 206,717 cubic hectometres (hm³). Of this amount, 75.52% is allocated to agriculture, which confirms that this sector is by far the main consumer of water in the country. It is followed by the livestock sector, which contributes 15.91% of the total footprint, divided between green water used for grazing and blue water for direct consumption by livestock. For its part, domestic use represents 6.03% and industrial use barely 1.93%. It is important to note that the water used to grow fodder crops for livestock is accounted for under agricultural water use.



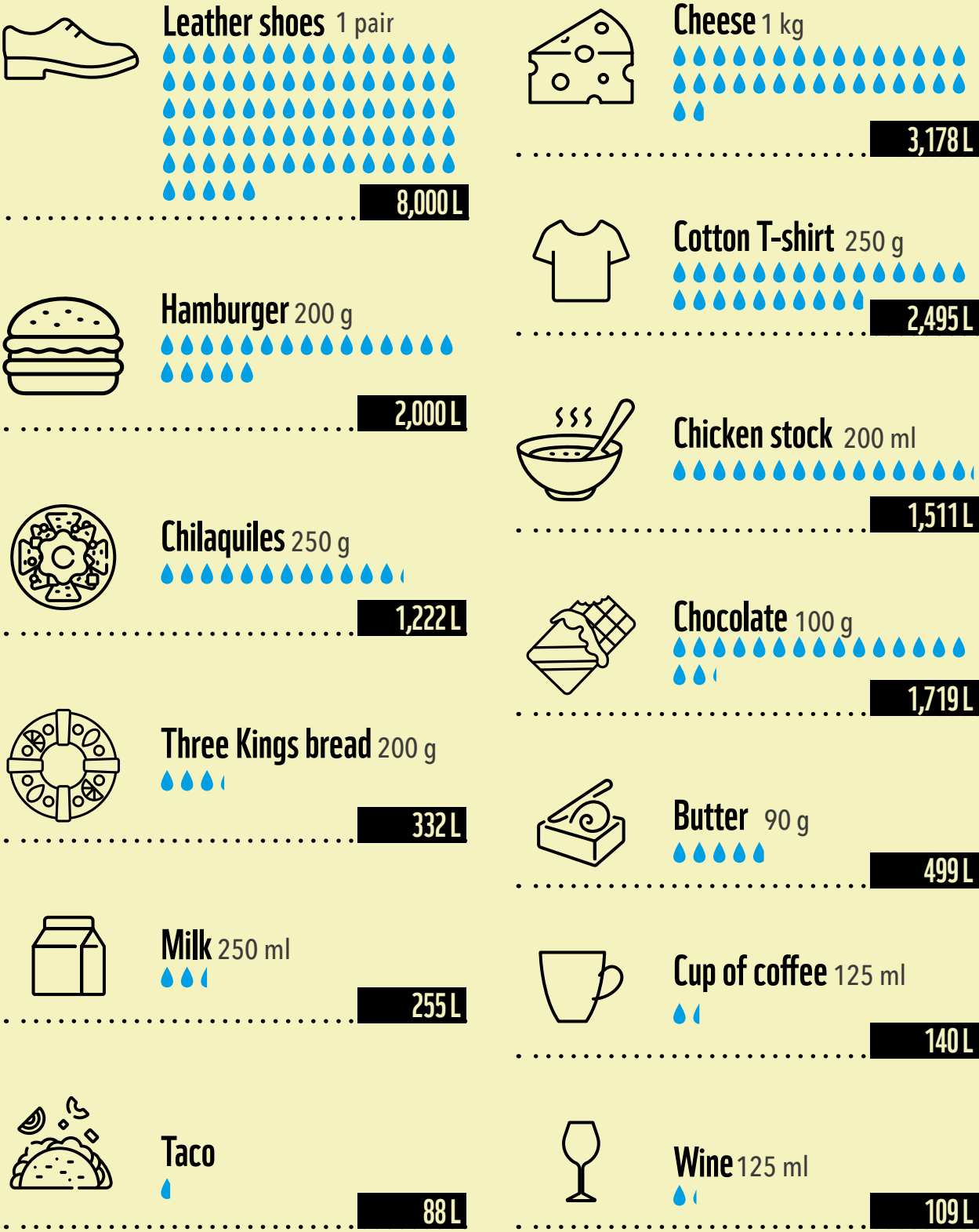
Main products by WF in Mexico (hm³)					Production		Unitary WF
Product	Blue	Green	Grey	Total	Thousands of tonnes		m³/t
 Corn	2,608	24,580	5,071	32,259		26,626	1,211.56
 Milk	1,715	21,830	1,861	25,405		13,728	1,850.60
 Beef	1,431	22,274	878	24,584		2,176	11,297.79
 Chicken	1,169	15,695	1,336	18,200		3,800	4,789.47
 Pork	1,361	14,120	1,232	16,713		1,730	9,660.69
 Egg	1,141	11,200	1,256	13,597		3,102	4,383.30
 Other fruits	3,946	5,095	959	9,999		8,688	1,150.90
 Sugarcane	1,747	5,243	608	7,597		55,279	137.43
 Beer	3,077	2,560	111	5,747		14,171	405.55
 Coffee and products	16	5,361	160	5,537		1,182	4,684.43
 Bean	515	3,972	469	4,956		1,002	4,946.11
 Wheat and derivatives	2,366	1,613	825	4,804		3,688	1,302.60
 Sorghum and derivatives	1,378	2,994	98	4,470		4,754	940.26
 Other vegetables	1,784	2,255	428	4,468		11,616	384.64
 Oranges and Tangerines	1,604	2,011	383	3,998		5,365	745.27
 Walnuts and products	1,165	1,515	-	2,680		305	8,786.82
 Lemons, limes and derivatives	906	1,135	217	2,258		3,102	727.81
 Soybean oil	871	568	182	1,620		986	1,643.16
 Oil from other oilseeds	792	517	165	1,474		897	1,643.16
 Goat and sheepmeat	31	1,348	0	1,379		108	12,768.82

Table 5. Main products by water footprint in Mexico

The table presents the products with the highest water footprint in Mexico, considering the use of green, blue and grey water. Corn tops the list, followed by milk and beef. The data allows us to identify which foods require more water in their production and helps us reflect on more sustainable agricultural and consumption practices.

WATER FOOTPRINT OF COMMON CONSUMER PRODUCTS

 = 100 litres



The figure shows how much water is needed to produce some common foods in the Mexican diet, as well as other everyday items. Notably, the hamburger stands out with a water footprint of 2,000 liters—higher than chicken stock (1,511 liters) and chilaquiles (1,222 liters), but lower than leather shoes (8,000 liters). This comparison helps visualize the impact that our dietary and consumer choices have on water use in Mexico.

Virtual water trade

POTENTIAL PRESSURE REDUCER IN WATER RESOURCES

Mexico is also a key player in the trade of virtual water, a concept that reflects the amount of water used in the production of goods that are imported or exported. We export 29,997 hm³ per year, mainly in products such as coffee (5,324 hm³) and beef (4,135 hm³). Our main trading partners are the United States, China, Canada, Japan, Germany and South Korea.

Country	hm ³ total	Country	hm ³ total
 United States	23,443	 Guatemala	313
 Japan	2,042	 Germany	271
 Canada	552	 Spain	224
 China	487	 Algeria	197
 Belgium	426	 Other	2,042

Table 6. Exportation of virtual water of Mexico

Among the countries that account for the largest share of the water footprint of products exported from Mexico, the United States leads the list by far, followed by Japan and Canada. International trade has a strong impact on the use of national water, especially in agri-food sectors, and underlines the importance of promoting exports with more efficient and sustainable water management.

Main export products according to their water footprint, by color (hm ³)				
Sector	Blue	Green	Grey	Total
 Coffee	15	5,155	153	5,324
 Beef	241	3,746	148	4,135
 Other fruits	1,260	1,627	306	3,194
 Pork	216	2,236	195	2,647
 Other vegetables	1,030	1,302	247	2,580
 Cocoa	366	2,082	73	2,521
 Wheat	998	681	348	2,027
 Beer	852	709	31	1,592
 Nuts	543	705	-	1,248
 Lemon and lime	226	284	54	564
 Milk	33	417	36	485
 Corn	36	338	70	443
 Oranges, tangerines	167	209	40	416
 Tomatoes	100	137	69	307
 Legumes	29	220	46	295

Table 7. Main export products according to their water footprint, by color

Among Mexico's export products with the highest water footprint, broken down by type of water, coffee tops the list, followed by beef, fruits and pork. Most of these products mainly use green water, reflecting a strong dependence on rain. This information allows for an analysis of the water impact of Mexican exports on national resources.

In contrast, Mexico imports 113,512 hm³ of virtual water from 67 countries, with the United States being the source of 81% of this volume. The main imported products are beef (21%), pork, corn and soy. Of all the virtual water we import, 81% is green, 9% blue and 10% grey. Nine of the top ten import flows come from the United States, the rest, from Canada.

Country	Blue WF hm ³	Green WF hm ³	Grey WF hm ³	Total (hm ³)
 United States	8,636	72,537	10,259	91,432
 Canada	421	5,383	828	6,632
 Brazil	182	3,463	249	3,894
 Indonesia	29	1,277	39	1,346
 Guatemala	22	1,094	21	1,136
 Ivory Coast	19	1,083	2	1,103
 Spain	169	843	52	1,064
 Argentina	45	669	21	735
 Uruguay	240	294	29	562
 Nicaragua	27	503	17	546

Table 8. Virtual water import by country and color

Regarding how much virtual water is imported from different countries through the products that Mexico acquires from abroad, the United States stands out with more than 91 thousand cubic hectometres, mainly in green water. Followed by Canada, Brazil and Indonesia. This information allows us to understand how trade also involves an invisible exchange of water, relevant for the global management of the resource.



Virtual water imports by product				
Sector	Blue (hm³)	Green (hm³)	Grey (hm³)	Total (hm³)
 Beef	652	22,209	790	23,652
 Pork	1,904	11,852	2,050	15,806
 Corn	802	9,481	2,692	12,975
 Soy	387	8,981	55	9,423
 Others	537	6,835	801	8,173
 Wheat	443	6,697	852	7,993
 Rice	2,190	1,734	463	4,387
 Chicken	331	3,228	562	4,121
 Cocoa	121	3,256	49	3,425
 Soybean oil	156	3,165	19	3,340
 Canola seed-Mustard seed	215	2,631	393	3,239
 Palm oil	-	1,975	77	2,051
 Sugar cane	545	1,342	126	2,013
 Milk	149	1,644	209	2,002
 Cotton	468	1,096	111	1,676
 Nuts	228	721	558	1,507
 Bean	60	287	1,042	1,339
 Other vegetable oils	311	566	81	958
 Sorghum	120	672	124	916
 Sunflower seed oil	27	577	21	624

Table 9. Virtual water imports by product

Among the products that Mexico imports with the highest embedded water footprint, beef, pork, and corn stand out, with high volumes of virtual water, especially green and blue. The above allows us to understand the external water impact associated with national consumption, and reflect on the need to adopt more sustainable and efficient trade practices.

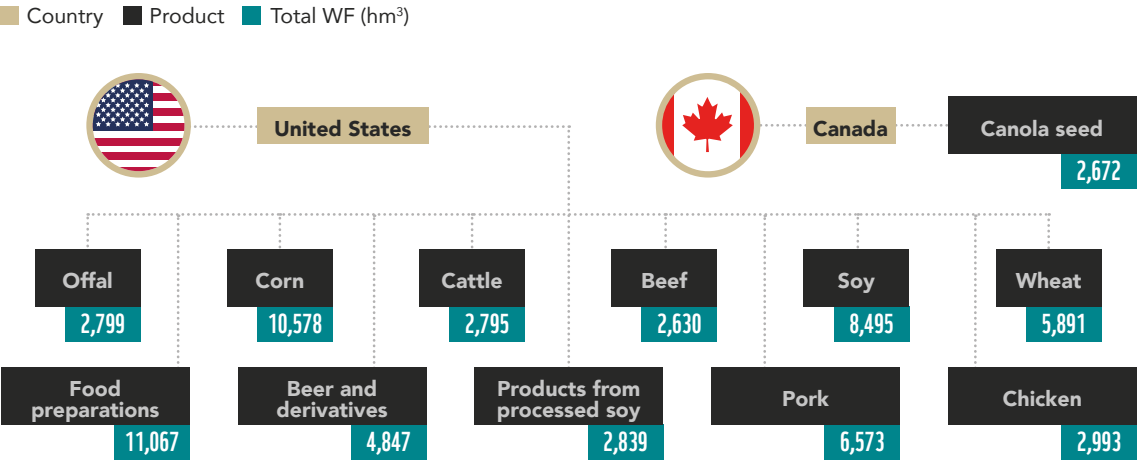


Table 10. Main water import flows to Mexico

Mexico's imports with the highest embedded water footprint, mainly from the United States, include prepared foods, corn, soy, and pork. These flows reflect how foreign trade not only moves goods, but also large volumes of virtual water, which influences the sustainable management of the resource at the international level.



This is how virtual water moves in global trade

Volumes of virtual water trade are based on two criteria: the magnitude of trade (the volume of goods traded) and the water footprint of each product. Thus, even if the trade volume is low, if that product has a high individual water footprint it will have a high virtual water flow. The opposite occurs when products with low individual water footprints are traded in large volumes.

Virtual water

POTENTIAL PRESSURE REDUCER IN WATER RESOURCES

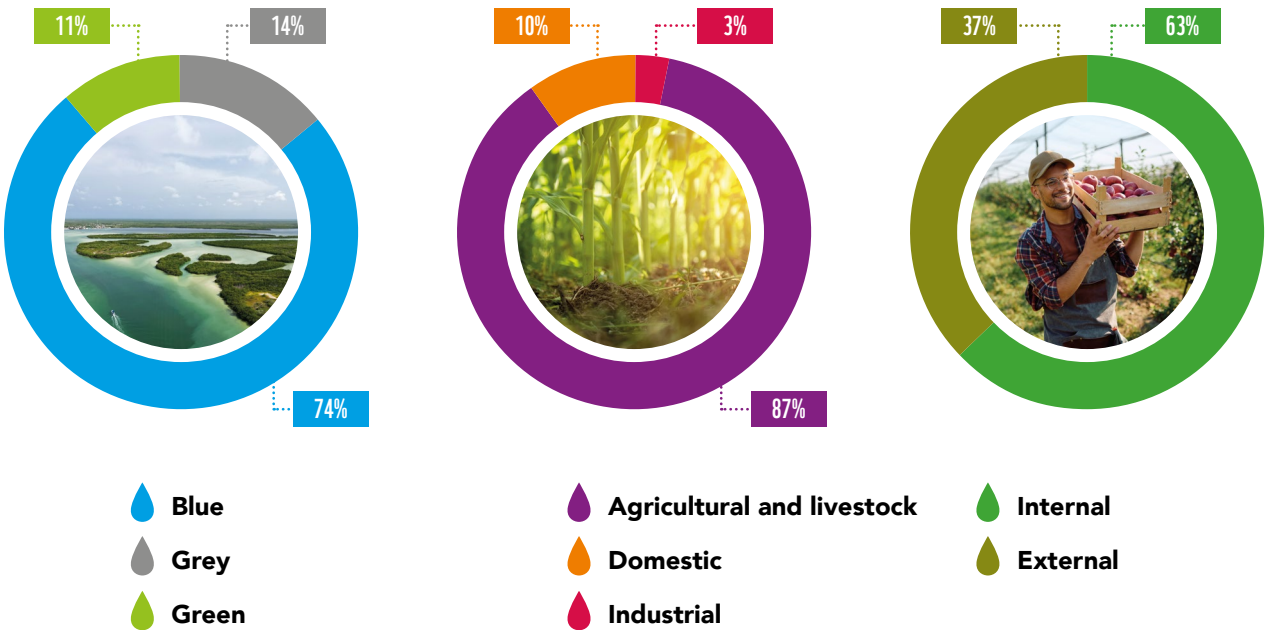
When we exchange goods and services, we are also implicitly trading virtual water. The export of products with a high water footprint implies shifting the pressure on water resources from producer countries to consumer countries. This demonstrates that trade decisions have a direct impact on the availability and use of water in different regions of the world.

This international trade can have positive effects on the availability of water in the country. By importing products with a high water footprint, we reduce the pressure on our own resources. This exchange (import-export), if managed intelligently, can work as a global mechanism to distribute water resources more equitably and ensure long-term sustainability.

In this context, countries with water surpluses can benefit economically by specializing in the export of water-intensive agricultural products. On the other hand, nations facing shortages can improve their food security by importing food that would otherwise be costly or unfeasible to produce locally due to a lack of water.

WATER FOOTPRINT OF CONSUMPTION BY COLOR, SECTOR AND ORIGIN

FIGURE 5

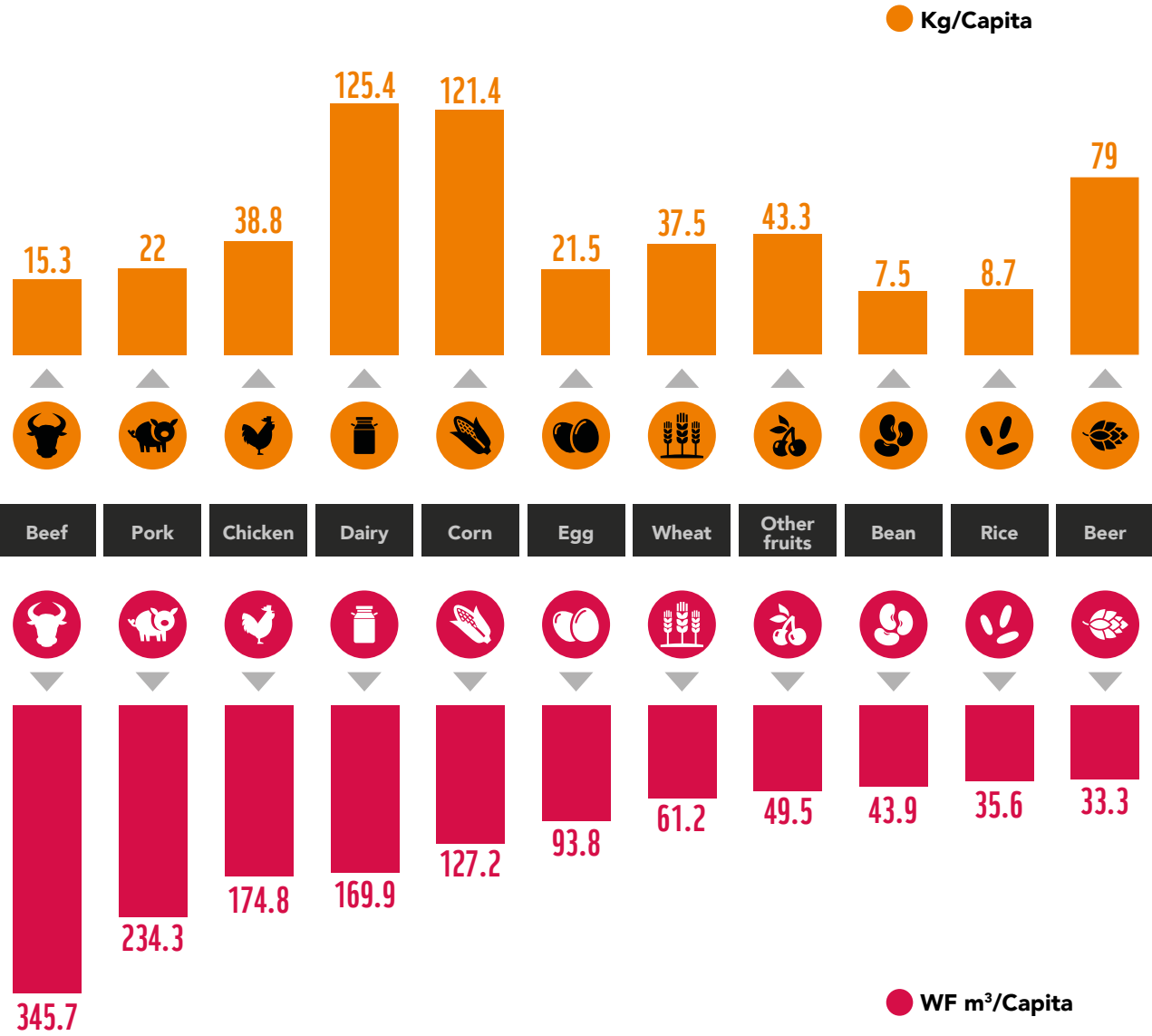


An analysis of Mexico's water footprint shows that 74% consists of blue water, which is primarily used in the agricultural sector and accounts for 87% of the total. Moreover, 63% of the water footprint is internal and 37% comes from outside. The data demonstrates the strong national pressure that exists on water for agricultural production.

The water footprint of consumption in Mexico – that is, the one generated by the products and services we use in our daily life – amounts to 229,340 hm³ annually. 74% of this amount is green water, 11% blue and 14% grey. Of that total, 87% comes from the agri-food sector, 10% from household consumption and only 3% from industry.

COMPONENTS OF WATER FOOTPRINT PER CAPITA CONSUMPTION IN MEXICO (% TOTAL WF)

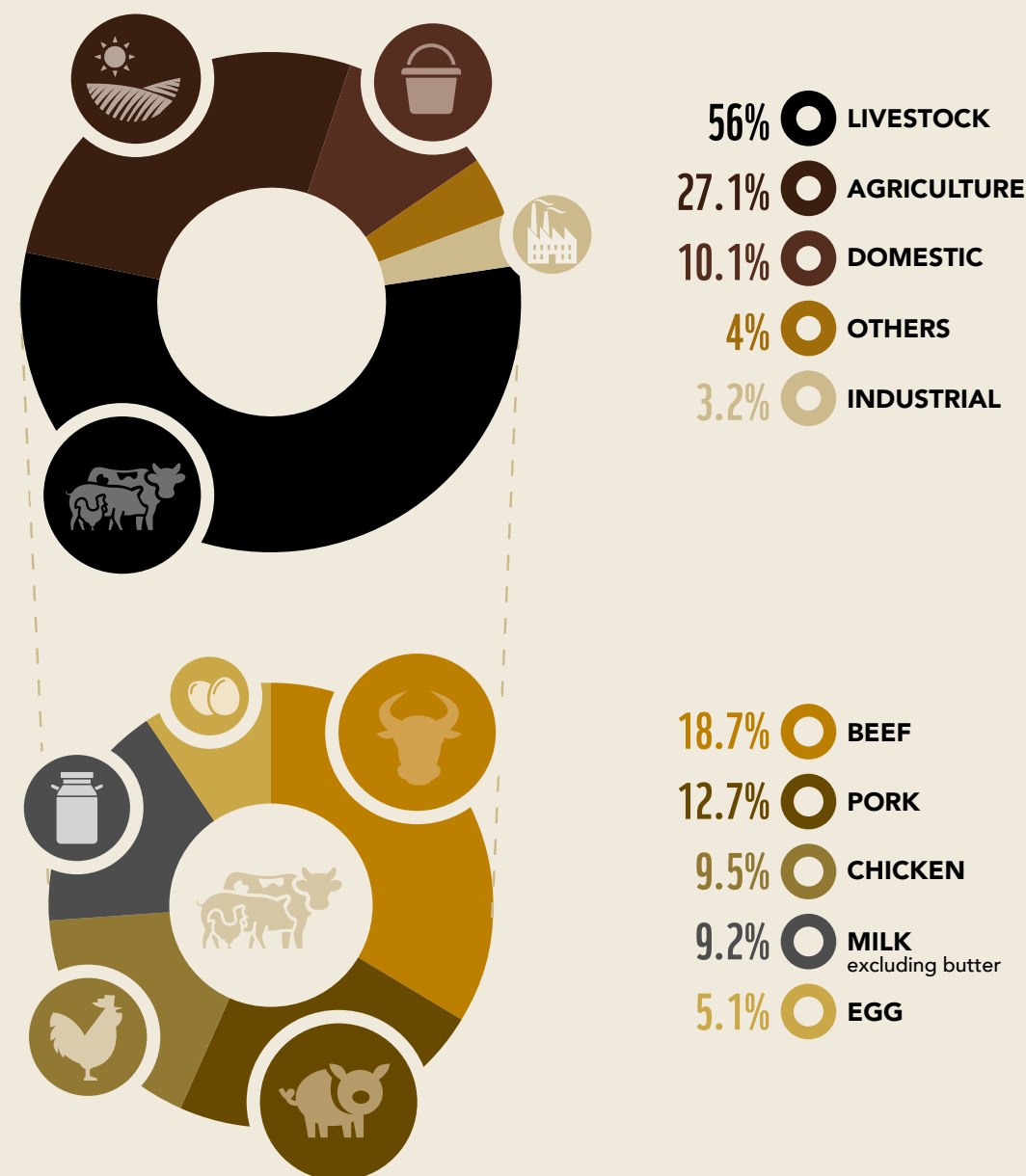
FIGURE 6



Comparing per capita consumption in kilograms with the per capita water footprint in cubic metres for different foods shows that, although dairy and corn are the most consumed, beef has the highest water footprint per person. This relationship shows that certain products, although less consumed, require much more water to be produced.

RELATIONSHIP BETWEEN CONSUMPTION AND PER CAPITA WF IN MEXICO

FIGURE 7



56% of the water footprint in Mexico is associated with the consumption of livestock products, with beef being the largest contributor. This is followed by the agricultural sector (27.1%) and the domestic sector (10.1%). The above highlights how dietary choices have a strong impact on water use, especially in the production of animal protein.

On an individual level, each person in Mexico has a water footprint of 1,849m³ per year. In terms of food, four out of the top five products that contribute to this footprint are of animal origin: beef (18.7%), pork (12.7%), chicken (9.5%), and milk (8.2%). The water used at home ranks third, while industrial products are ninth, with 3.2%. Most of this water footprint, 63%, comes from internal resources, while the remaining 37% corresponds to imported products and services, which makes up the external water footprint.

“87% of the consumption water footprint corresponds to agri-food products, 10% to domestic use and only 3% to industry.”

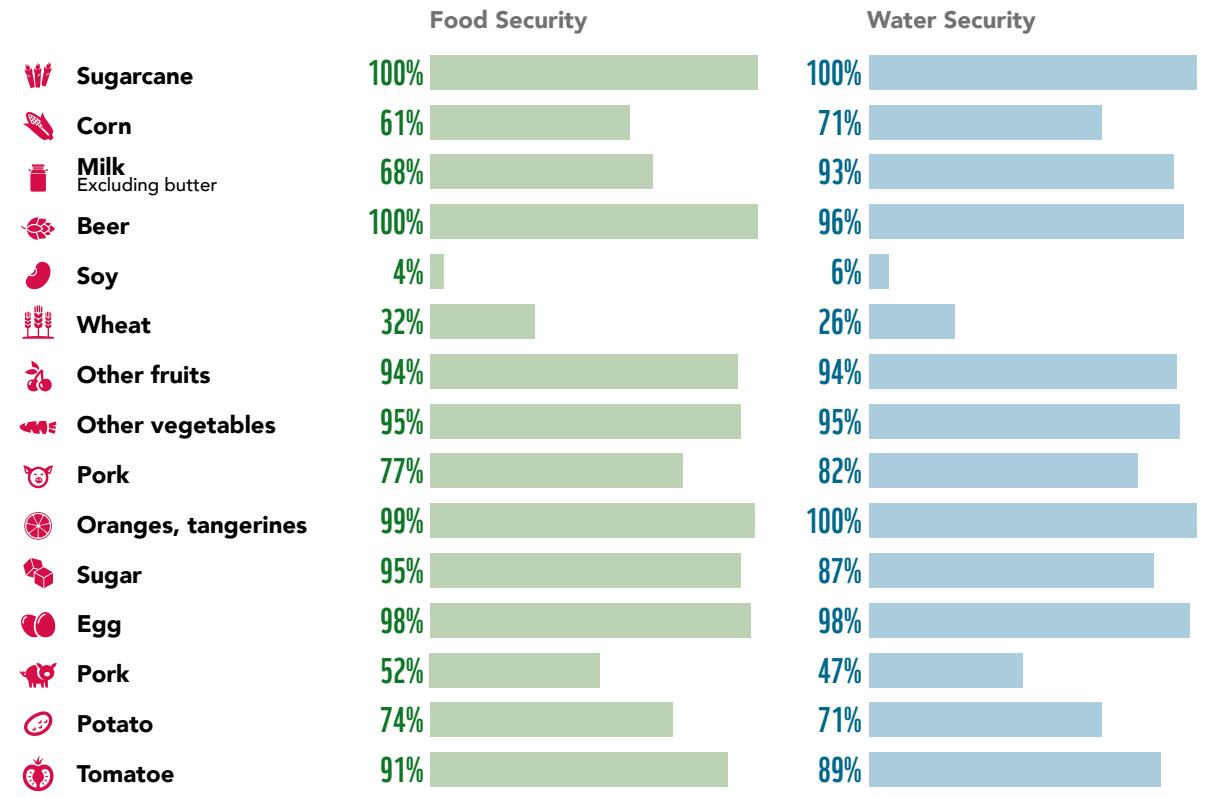
FOOD AND WATER SECURITY

Finally, it is worth analyzing the link between water footprint and food security. This latter is achieved when a country produces at least 80% of the food it consumes, considering not only the quantity, but also its quality, accessibility and sustainability. The same applies to water security: it is not just about how much water we have, but whether it is of good quality, whether it is accessible and if we use it responsibly.

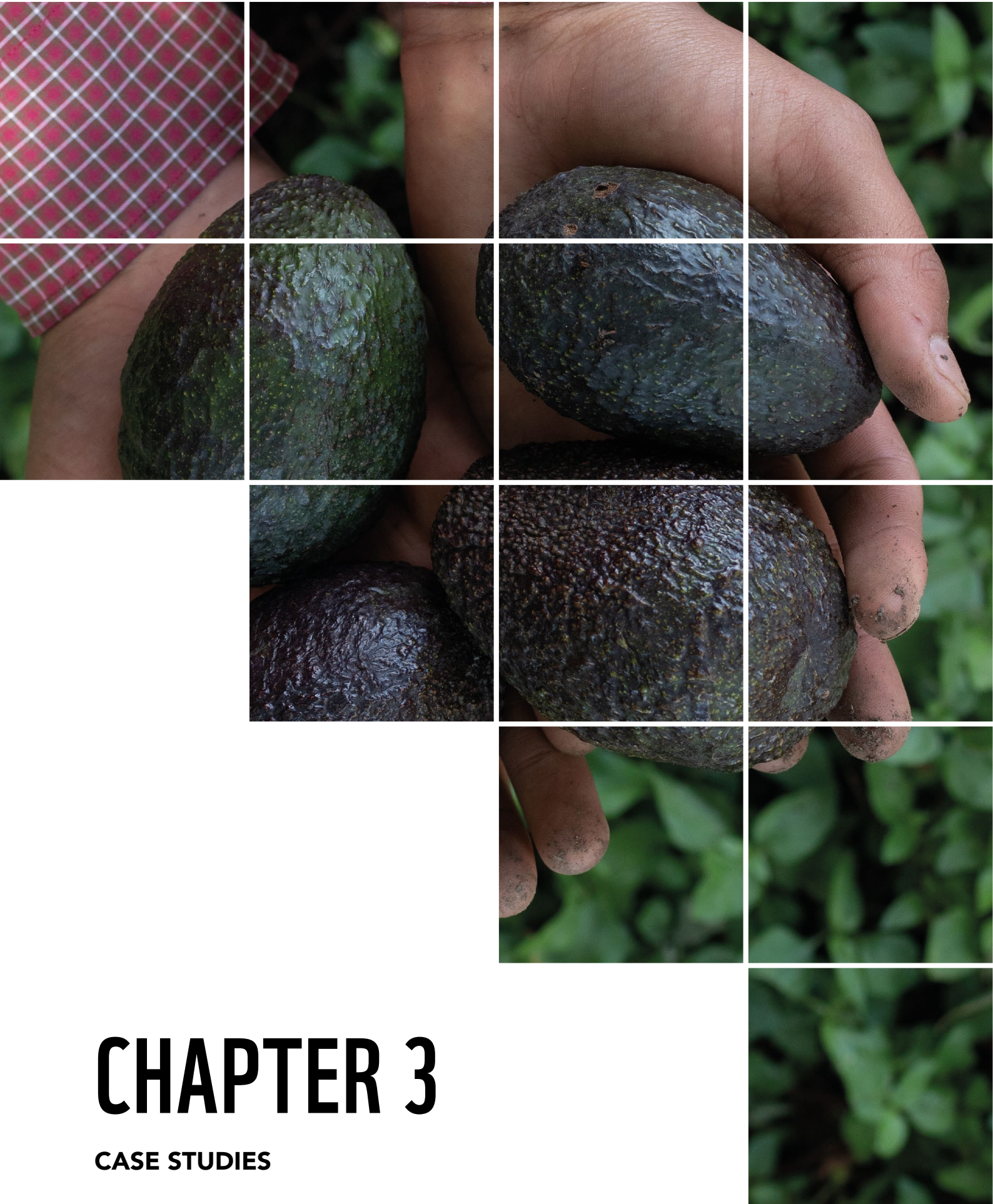
For example, sugar cane is the only crop that shows 100% food and water security. At the opposite end is soy, with less than 10% in both indicators. Corn, the staple food in Mexico, has a food security of 61% and a watersecurity of 71%. This indicates that there is still room for improvement to strengthen our water security from a holistic perspective. 💧

FOOD AND WATER SECURITY BY PRODUCT

FIGURE 8



The food and water security of different products in Mexico shows that some, such as sugar cane and beer, have high levels in both dimensions. However, products like soy and wheat show low food self-sufficient, despite having enough water. This highlights the importance of aligning production, consumption, and water availability for more sustainable planning.



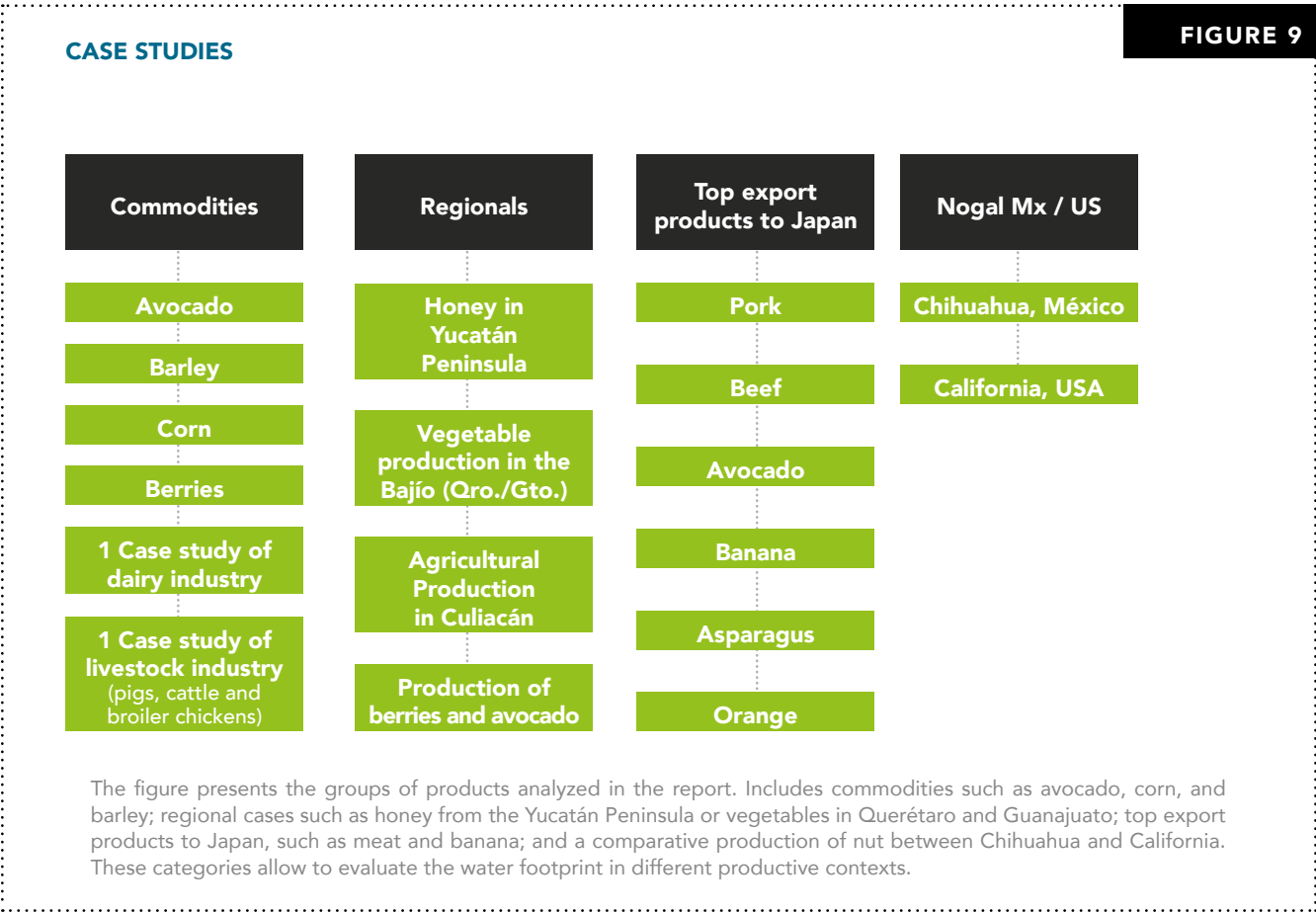
CHAPTER 3

CASE STUDIES

Water stories

WHAT CROPS AND PRODUCTS REVEAL ABOUT OUR WATER FOOTPRINT

This section offers an in-depth look at several illustrative cases that significantly shape Mexico’s water footprint. Through the analysis of crops such as avocado, barley, corn, berries, as well as milk and meat, it examines how production patterns relate to water use, taking into account the specific characteristics of each sector and its economic, social and environmental relevance.



The selected products stand out as strategic commodities for the country, whether due to their production volume, their role in exports, or the pressure they exert on natural resources. It also includes an international comparison with the case of the nut produced in Mexico and in the United States, and it reviews the role of Japan as one of the main destinations for Mexican virtual water exports.



Avocado

BETWEEN COMMERCIAL EXPANSION AND HYDROSTATIC PRESSURE

Mexico is the largest producer and exporter of avocados in the world. It produces more than 2.5 million tonnes per year, equivalent to 28% of the global total. To meet the growing global demand, especially from the United States and Europe, the country has increased its cultivated area by 97% since 2010, going from 134 thousand to more than 250 thousand hectares in 2023. This expansion has generated jobs and economic spillover, but it has also brought with it environmental impacts such as changes in land use and increased pressure on water resources.

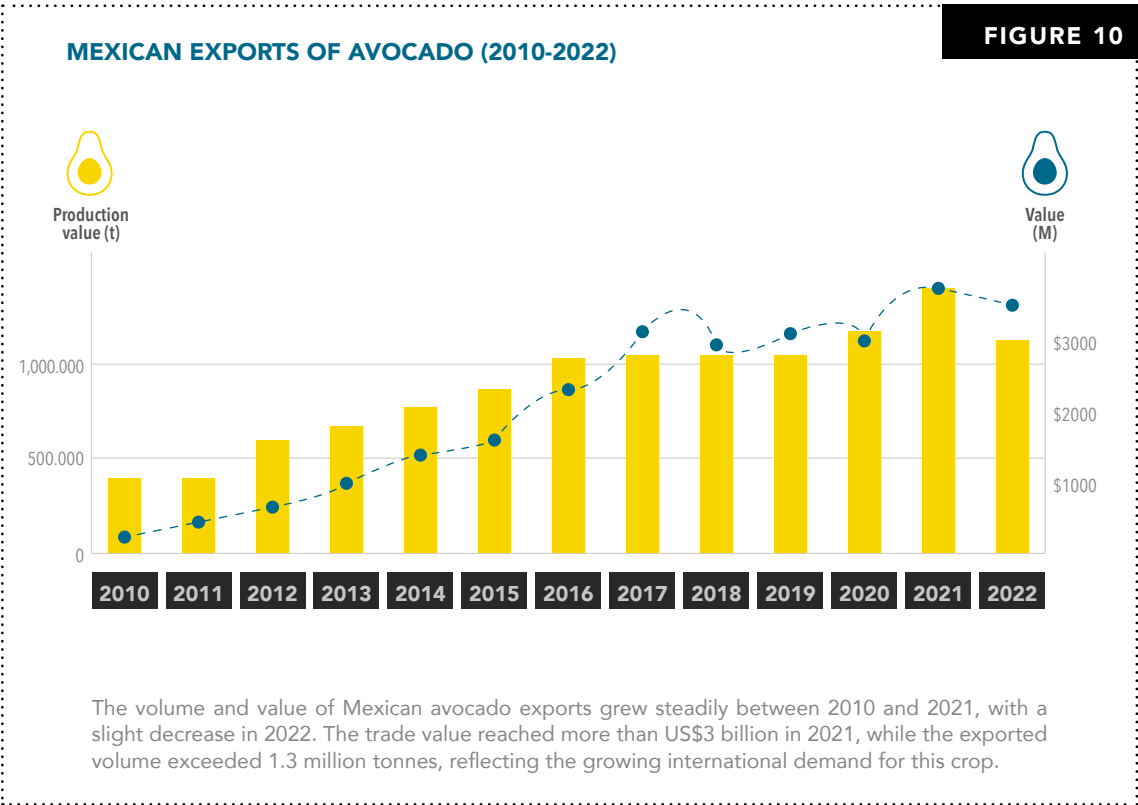
Equivalencies	Irrigation	Rainfed	Total
ha	113,249.8	151,339.3	264,589
t	1,376,515	1,596,829	2,973,344
Yield t/ha	12.2	10.6	22.7

Table 11. Avocado production in Mexico 2023

Avocado production data in Mexico during 2023, indicate that more than 264 thousand hectares were cultivated, of which 43% had irrigation and the rest were rainfed. In total, almost 2.97 million tonnes were produced, with a national average yield of 11.2 tonnes per hectare, slightly higher in irrigated areas than under rainfed conditions.

Although it has created economic spillover and jobs, which allow for the economic development of different regions, this production has implied an increase in water consumption for this crop, in addition to the change in land use in different regions, with serious implications for biodiversity.

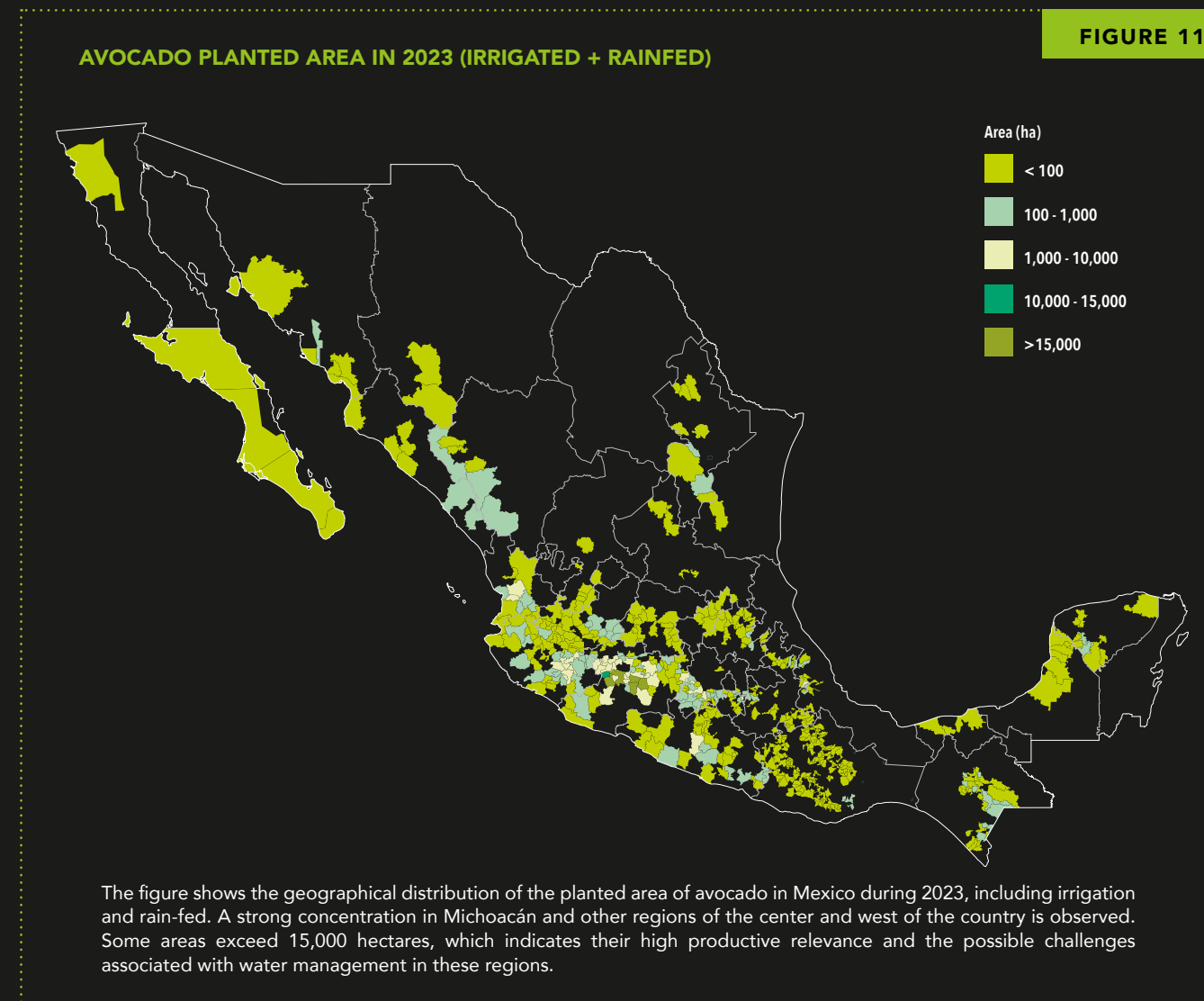
Currently, avocado is produced in 648 municipalities in the country. Of these, 7 account for 51% of the production value¹.



Of the total area cultivated with avocado, 43% is under irrigation and 57% is rainfed. The average water footprint per tonne is 907.8 m³ for irrigated crops, and 875 m³/t for rainfed. Although the total difference between the two modes is only 4%, the components of the water footprint show significant contrasts:

- In irrigated crops, 38% of the footprint corresponds to blue water (superficial or underground), while in rainfed it represents only 23%.
- Green water (rain retained in the soil) is higher in rainfed crops with 65%, against 51% in irrigated.
- The grey footprint (water needed to assimilate pollutants) is similar in both, with 11% for rainfed and 10% for irrigated.

1. Tacámbaro, Tancitaro, Salvador Escalante, Ario, Uruapan, Peribán de Michoacán and Zapotlán el Grande de Jalisco (2023).



These proportions vary according to the technology used, climate, irrigation system, production practices and crop genetics. Taking into account these variables, the total water footprint of Mexican avocado is 2,647.3 hm³ annually: 1,397.7 hm³ come from rainfed crops and 1,249.6 hm³ from irrigation. This represents 1.7% of the total water footprint of Mexican agriculture.

	Irrigation	Rainfed
Green	467.1	573.1
Blue	345.6	202.2
Grey	94.9	100
Total	907.8	875.3

Table 12. WF of Mexican avocado (m³/t)

The figure shows the comparison of the water footprint of Mexican avocados produced under irrigation and rainfed conditions compared to a value international benchmark. In both cases, the avocado national shows favorable performance: 812.7 m³/t in irrigation and 775.3 m³/t in rainfed, both below the benchmark of 820 m³/t, suggesting competitive water efficiency.

	Irrigation	Rainfed	Total
Green	643	915.1	1,558.2
Blue	475.8	322.8	798.6
Grey	130.7	159.7	290.5
Total	1,249.6	1,397.7	2,647.3

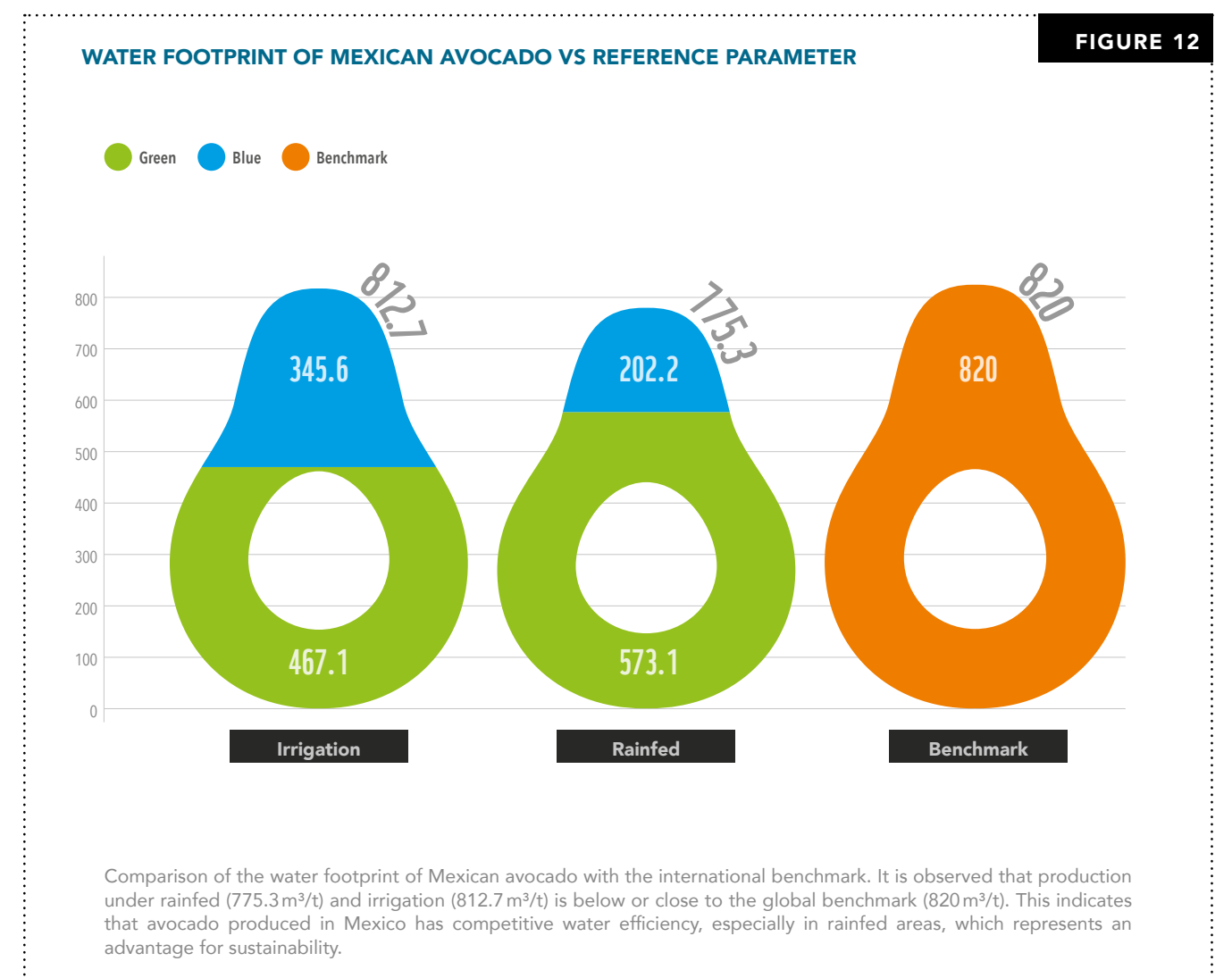
Table 13. WF of avocado production in Mexico (hm³)

The table shows the total water footprint of avocado in Mexico, distinguishing between irrigated and rainfed production. In total, 2,647.3 hm³ of water is used, with the majority being green water (1,558.2 m³), followed by blue (798.6 m³) and grey (290.5 m³). This reflects a high dependence on natural sources and highlights the importance of improving sustainable practices.

“The cultivation of avocado in Mexico faces important challenges of sustainability. The expansion of cultivation should align with criteria of productive vocation, water availability, and environmental conservation.”

EFFICIENCY PARAMETERS

Although Mexican avocado is more efficient in water footprint than the international benchmark per tonne, in both irrigation and rain-fed mode, the challenges towards sustainability are considerable. This relative efficiency provides a competitive advantage, but also imposes the responsibility to maintain and even improve these metrics in a context of increasing pressure on natural resources.



CHALLENGES TOWARDS SUSTAINABILITY

Avocado farming in Mexico faces significant sustainability challenges. The expansion of cultivation should align with criteria of productive vocation, water availability, and environmental conservation. It is urgent to adopt good agricultural practices, promote efficient infrastructure, and reduce the use of chemical pesticides, prioritizing biological alternatives that reduce the grey water footprint.

Moreover, it is crucial to improve territorial planning to prevent the growing international demand for Mexican avocado from continuing to generate deforestation or damage to forested areas. Some organizations are already working on sustainability certifications and standards that aim to ensure that exported avocados are aligned with good environmental practices.

There are also efforts to optimize water use through more efficient irrigation technologies, resource monitoring, and changes in fertilization patterns. While many of these initiatives have been adopted by innovative producers, it remains a challenge to generalize them in all producing regions.





Barley

KEY INPUT FOR BEER FACING INCREASING CHALLENGES

Barley is a crop of great importance in Mexico, especially because of its link to the brewing industry. It is grown in 259 municipalities throughout the country, covering an approximate area of 342 thousand hectares. Although the presence of the crop is widespread, only 15 municipalities concentrate 50% of the total production value².

Equivalencies	Irrigation	Rainfed	Total
ha	52,500	253,111.3	305,611.3
t	309,037	523,001	832,038
Yield t/ha	5.9	2.1	2.7

Table 14. Barley production in Mexico in 2023

The table shows the production of barley in Mexico during 2023, distinguishing between irrigation and rainfed systems. More than 305 thousand hectares were cultivated, of which 83% corresponds to rainfed. However, the yield per hectare was notably higher in irrigation, with 5.9 tonnes, compared to 2.1 in rainfed. In total, 832,038 tonnes were produced, which stands out the influence of the type of management on productive efficiency.

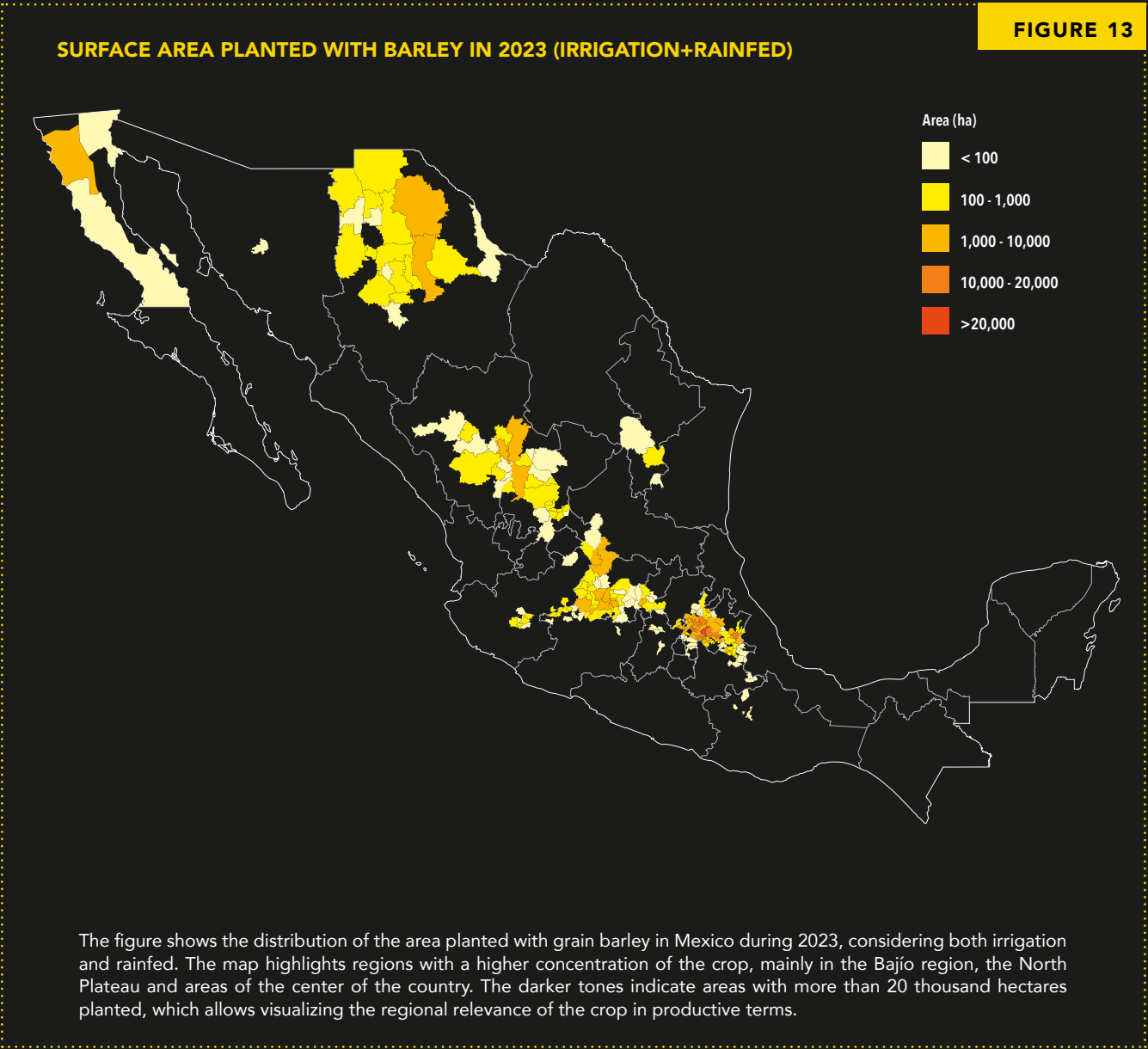
2. In order: Apan, Hidalgo; Cuyoaco, Puebla; Ahumada, Chihuahua; Valle de Santiago, Guanajuato; Calpulalpan and Tlaxco, Tlaxcala; Almoloya, Hidalgo; Axapusco, Mexico State; Singuilucan, Hidalgo; Chignahuapan, Puebla; Tepeapulco, Cuauhtemoc de Hinojosa and Zempoala, Hidalgo; Temascalapa, Mexico State; and San Felipe, Guanajuato.

In terms of production type, 83% of the planted surface is rainfed and 17% is cultivated under irrigation, reflecting a clear trend towards the use of rainwater. However, this proportion has not prevented exports from growing.

In 2022, Mexico exported barley worth US\$4 million, an 8,994% increase compared to 2010 and a 461,890%³ increase versus 2015. Despite this growth, the country ranks 42nd among exporters worldwide. Their main destinations are the United States, France, Peru, and the Netherlands, according to data from Chatham House (2024).

The use of barley in Mexico is primarily for brewing: 60% of domestic volume is destined for beer production (National Institute for Forestry, Agriculture and Livestock Research, INIFAP. 2020), 30% for livestock feed, and the remaining 10% for other food and health-related uses.

Despite its importance as a strategic input for one of the most dynamic industries in the country, the cultivated area has decreased by 1% since 2010 and 6% since 2015. This contrasts with the 72% increase in imports since 2015, which in 2022 reached one million tonnes, mainly from Australia, France and the Netherlands.



3. The value for 2022 was US\$4,328 million, while for 2010 and 2015 it was US\$48 and US\$1 million, respectively.

WATER FOOTPRINT OF BARLEY CULTIVATION

Barley production in Mexico involves significant water consumption, which varies according to the cultivation method. The rainfed barley has an average water footprint of 173.4m³ per tonne, while the irrigated one rises to 774.2m³/t, more than four times greater.

The distribution by type of water also shows important differences:.

In irrigated barley: 45% of the water footprint is blue, 43% green and 12% grey.



In rainfed barley: green water (65%) predominates, followed by blue water (28%) and grey (7%).



Overall, the total water footprint of barley in Mexico amounts to 396 cubic hectometres (hm³). Of this figure, 72.5% corresponds to irrigated agriculture and 27.5% to rainfed. In terms of color, 49% is green water, 40% blue and 11% grey.

	Irrigation	Rainfed
Blue	345.7	48.9
Green	333.5	113.3
Grey	95	11.3
Total	774.2	173.4

Table 15. WF of Mexican barley

The table shows the water footprint of Mexican barley expressed in cubic metres per tonne, distinguishing between irrigated and rainfed crops. Barley under irrigation has a significantly higher footprint (774.2m³/t), highlighting the intensive use of blue and green water. In contrast, rainfed barley has a lower footprint (173.4 m³/t), reflecting less dependence on surface and groundwater.

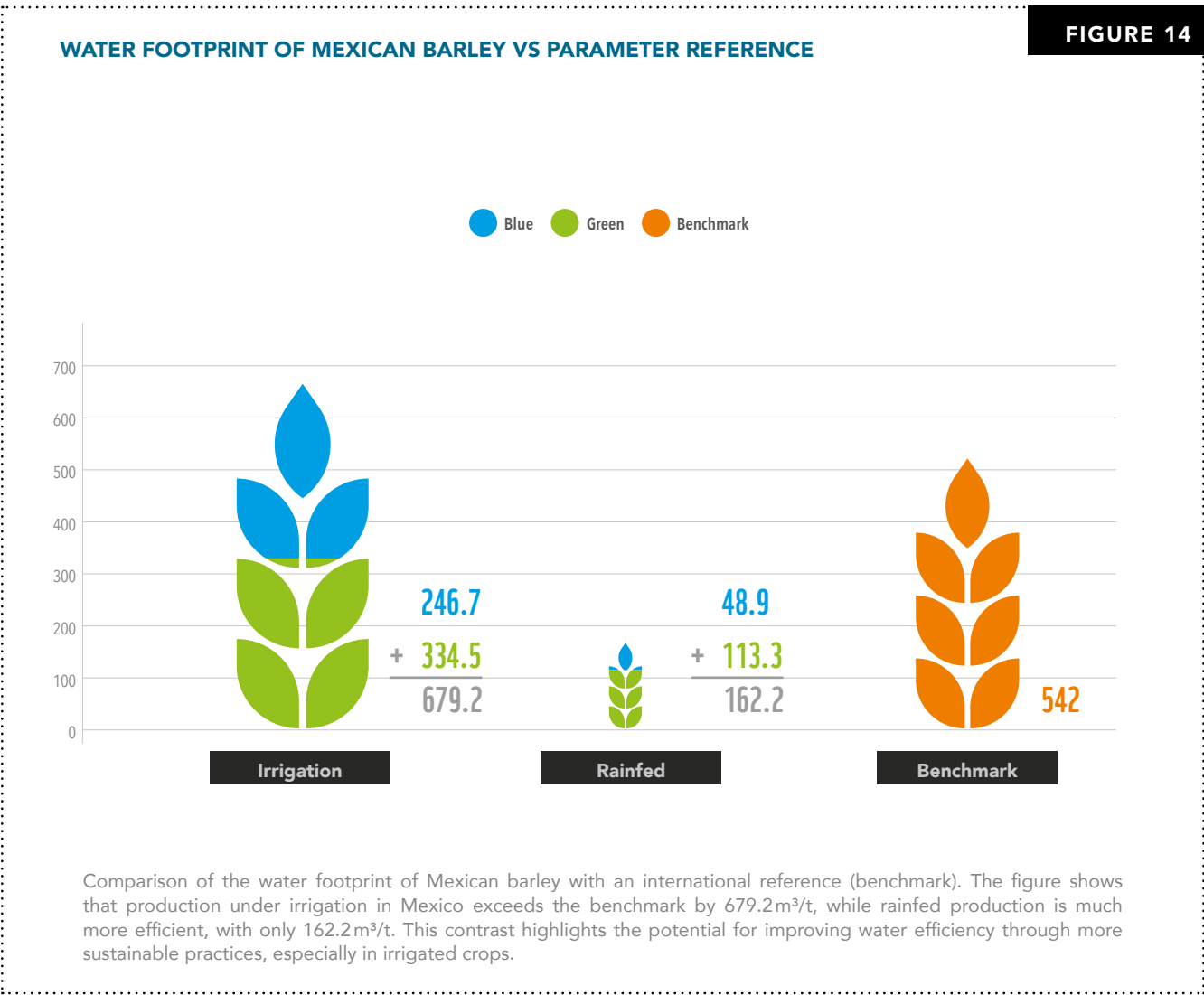
	Irrigation	Rainfed	Total
Blue	106.8	25.5	132.4
Green	103.1	59.2	162.3
Grey	29.4	5.9	35.3
Total	239.2	90.7	330

Table 16. WF of barley production in Mexico

The table shows the total water footprint of barley production in Mexico, broken down by water type (green, blue and grey) and cropping system (irrigated and rainfed). In total, 330 hm³ is used for its production, with irrigation being the main contributor. Green water represents the largest volume used, followed by blue, while grey takes up a smaller proportion.

EFFICIENCY PARAMETERS

Compared to international benchmark parameters, Mexican rainfed barley is more efficient in terms of water footprint per tonne. Instead, irrigated barley has a 25% higher footprint than the international standard, indicating areas for improvement to achieve greater sustainability.



CHALLENGES TOWARDS SUSTAINABILITY

Faced with an expanding market, barley production faces several challenges related to efficient water management and sustainability throughout its value chain. This includes not only cultivation, but also processing, especially in the brewing industry.

The heavy reliance on blue water poses a risk for the regions where it is produced, making it a priority to:

- Improve irrigation systems.
- Promote the treatment and reuse of water.
- Promote the transition to upgraded rainfed cultivation systems or systems that make better use of green water.

A prominent response to these challenges has been the promotion of regenerative agriculture, driven largely by the brewing industry. This strategy seeks to reduce the environmental impact of barley cultivation through practices such as:

- Reduced tillage.
- Implementation of crop rotation.
- Use of drip irrigation.
- Improved plant nutrition schemes and technical assistance.

This approach seeks not only to improve water efficiency, but also to generate ecological and economic benefits for producers.



Corn

THE HEART OF MEXICAN AGRICULTURE

Corn is the most important and widespread crop in Mexico. It is planted on 6.9 million hectares distributed across 2,347 municipalities, although only 82 of them generate 50% of the production value. The predominant variety is white corn, which accounts for 86.94% of all national production.

In addition, our country is the main consumer of corn per capita in the world. This grain represents 20.9% of Mexicans’ annual spending on food and beverages, with an average per capita consumption of 196 kg per year (SAGARPA, 2017).

Equivalencies	Irrigation	Rainfed	Total
ha	1,580,365.5	5,360,665.7	6,941,031.1
t	14,426,711.9	13,123,205.6	27,549,917.5
Yield t/ha	9.1	2.5	4

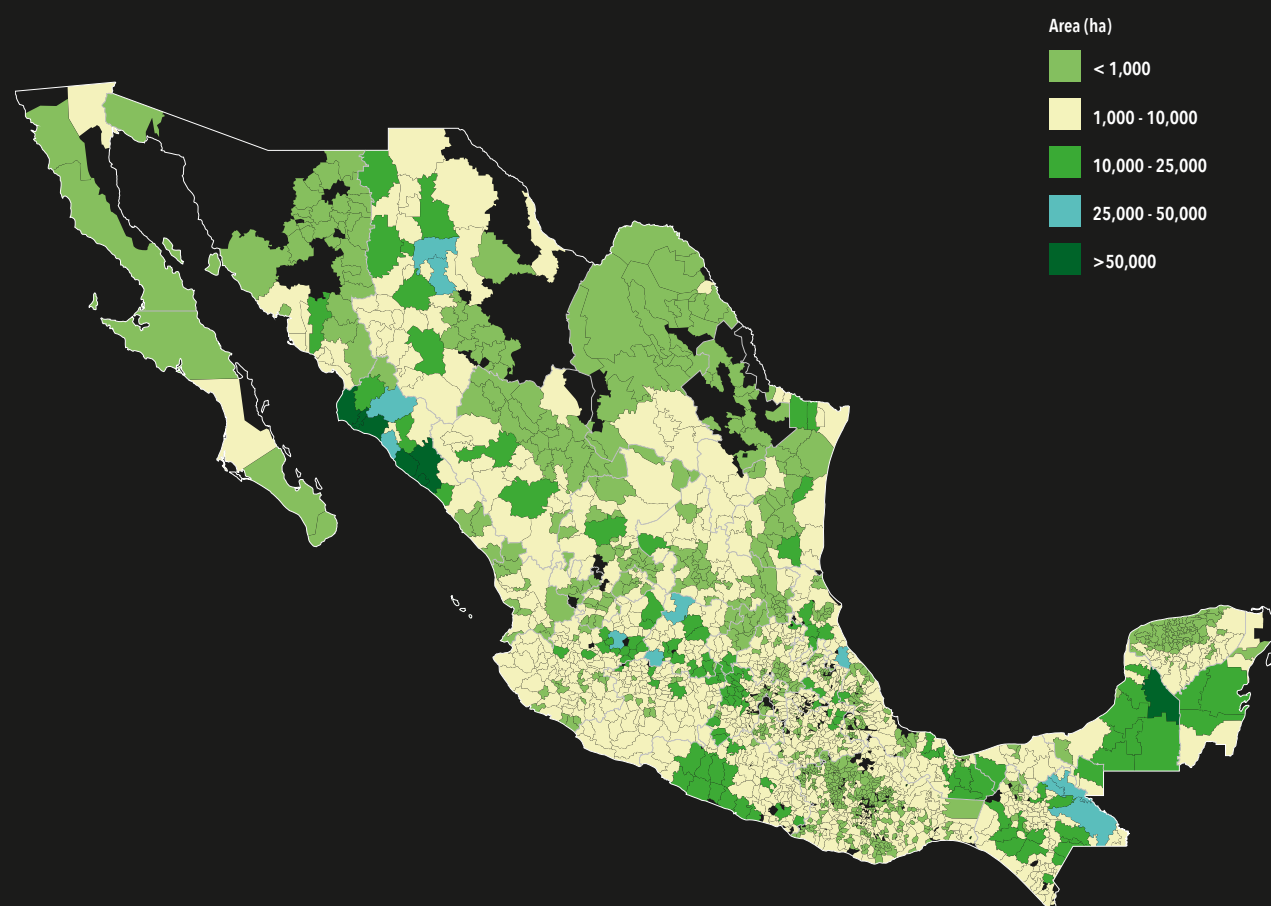
Table 17. Corn production in Mexico

Corn production in Mexico during 2023, distinguishing between irrigated and rainfed crops. More than 6.9 million hectares were planted, with a total production of over 27.5 million tonne. The yield per hectare was notably higher in irrigation (9.1 t/ha) than in rainfed (2.5 t/ha), which demonstrates a strong difference in productive efficiency according to the type of management.



PLANTED AREA OF GRAIN CORN IN 2023 (IRRIGATION+RAINFED)

FIGURE 15



The figure shows the planted area of grain corn in Mexico during 2023, considering both irrigated and rainfed crops. The map highlights that the greatest concentration of plantings is located in the center-south and southeast of the country, with some regions exceeding 50,000 hectares. This territorial distribution reflects the importance of corn in national food security and its weight in the country's water footprint.

PRODUCTION AND TRADE

In 2023, the area planted with corn was 6.9 million hectares: 77.2% was grown under rainfed conditions and 27.8% under irrigation. Both modalities show marked differences in terms of yield.

In terms of exports, Mexico generated US\$278 million in corn sales abroad in 2022, 25% more than in 2010, although 19% less than in 2015. Despite this, the cultivated area has decreased. 12% less since 2010 and 9% less since 2015.

Given the high domestic consumption, the country depends on imports to meet internal demand. In 2022, Mexico imported 16.4 million tonnes of corn, mainly from the United States, which positions it as the main global importer.

WATER FOOTPRINT OF CORN

Corn production in Mexico has a total water footprint of 48.1hm³ per year. This is mostly composed of green water (50.3%), followed by blue water (37.5%) and grey-water (12.2%), considering both rainfed and irrigated crops.

	Irrigation	Rainfed
Blue	215.7	-
Green	864.2	838.3
Grey	229.5	180.4
Total	1,309.4	1,018.7

Table 18. WF of Mexican corn

Water footprint of Mexican corn, measured in cubic metres per tonne produced, distinguishing between irrigated and rainfed crops. Irrigated corn has a total footprint of 1,309.4m³/t, while rainfed corn reaches 1,018.7 m³/t. The use of blue water in irrigation stands out, absent in rainfed, reflecting different pressures on water resources according to the type of crop.

When analyzing the footprint per tonne, irrigated corn generates 1,309m³/t, while rainfed corn accounts for 1,018.7 m³/t. This means that irrigation has a 28% higher footprint per unit produced. Although only 27% of the planted area is irrigated, this method accounts for 58% of the crop's total water footprint.

	Irrigation	Rainfed	Total
Blue	3,111.8	-	3,111.8
Green	12,467.6	11,001.1	23,468.6
Grey	3,310.9	2,367.3	5,678.2
Total	18,890.3	13,368.3	32,258.7

Table 19. WF of corn production in Mexico

Total water footprint of corn production in Mexico, broken down by water type and farming system. A total of 32,258.7 cubic hectometres (hm³) are used, with irrigation being the system with the highest consumption (18,690.3hm³). The largest proportion corresponds to green water use, followed by the gray component, which represents the water needed to dilute pollutants, and finally the blue component.

Within the agricultural sector, corn is the main contributor to the water footprint: it accounts for 21% of the total sectoral footprint, including 22% of the green footprint, 9% of the blue, and 40% of the grey one. Nationally, corn contributes 16% of the total production of water footprint.

	Blue	Green	Grey	Total
Agricultural	9%	22%	40%	21%
Total	8%	17%	20%	16%

Table 20. Participation of corn in the national agricultural water footprint and total

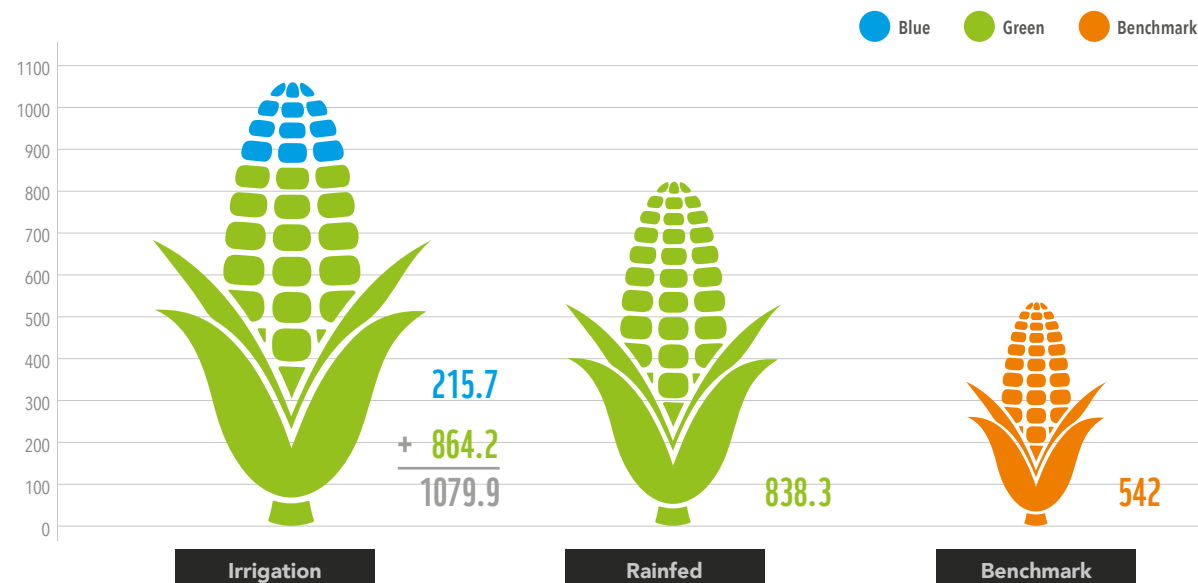
Corn share in the national water footprint, both within the agricultural sector and in the national total. In the agricultural sector, corn represents 21% of the total footprint, standing out for its high proportion of grey footprint (40%). At the national level, corn cultivation concentrates 16% of the total water footprint, with green water being the most representative component.

EFFICIENCY PARAMETERS

Compared to international standards, Mexican corn shows significant margins of inefficiency: its rainfed production is 54% less efficient, and in irrigation, it is 99% below the global benchmark.

FIGURE 16

WATER FOOTPRINT OF MEXICAN CORN VS BENCHMARK



The figure compares the water footprint of Mexican corn against the international benchmark value. It can be seen that irrigated production has a higher footprint (1,079.9 m³/t) compared to the benchmark (542 m³/t), while rainfed corn (838.3 m³/t) also exceeds this value. This highlights opportunities to improve the crop's water-use efficiency in Mexico, especially in irrigated systems.

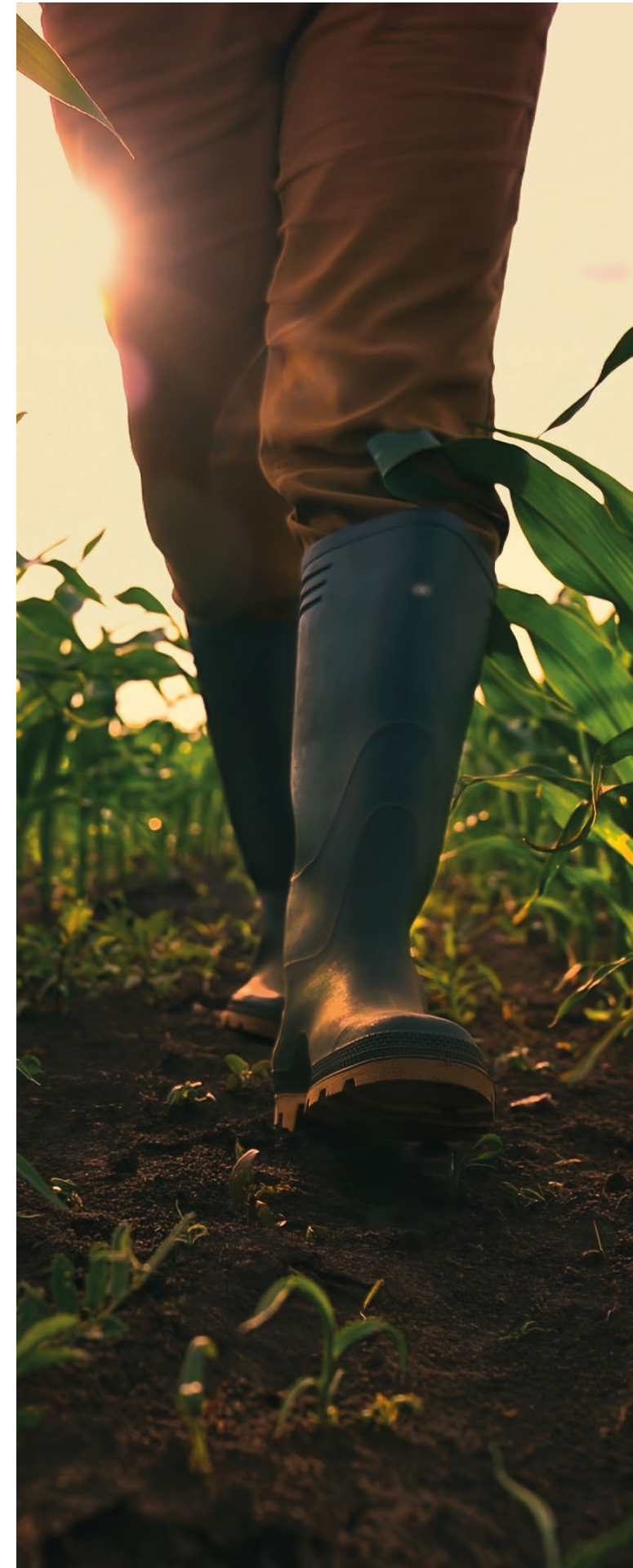
“Corn is a staple of traditional Mexican cuisine, which has been declared Intangible Cultural Heritage of Humanity. Humanity's Intangible Heritage by UNESCO.”

CHALLENGES TOWARDS THE SUSTAINABILITY

Corn faces multiple challenges to be sustainable. It is a crop of low commercial value and high vulnerability to abiotic stress, such as climate change and water scarcity, factors that directly affect its yield. It is often grown in degraded soils and requires chemical pesticides, which increases its grey footprint.

Faced with this scenario, some regions have begun to implement regenerative agriculture practices. These include improving soil health, reducing the use of agrochemicals, capturing more water and using livestock to enrich soil biota.

According to the International Maize and Wheat Improvement Center (CIMMYT), between 2017 and 2022, 21 thousand tonnes were added to the national production through these sustainable practices in eight production cycles. Although they are still isolated experiences, their increasing adoption could make a significant difference in reducing the national water footprint associated with corn.



Regenerative agriculture: cultivating healthy soil and making good use of water

Regenerative agriculture is based on practices that seek to transform the way we produce food, promoting a model that is more in balance with nature. Its core principle is to reduce the use of chemical inputs, minimize tillage, incorporate polycultures and service or cover crops, and introduce livestock species into cropping systems.

These actions, when implemented together, contribute significantly to improve soil health and to optimize the use of water on the plots, both that from rain (green water) and that used for irrigation (blue water). In addition to these benefits, this production approach fosters a more sustainable and resilient vision in the face of climate and environmental challenges.



Milk

VARIABLE EFFICIENCY IN A GROWING MARKET

Mexico produces 13 million litres of milk per year, which represents a 15% increase compared to 2015. Per capita milk consumption in Mexico is 124kg equivalents per year, a figure that has increased by 17 litres per person since 2010, although it remains below FAO recommendations, which suggest a consumption of 188 litres per person per year (SENASICA, 2023).

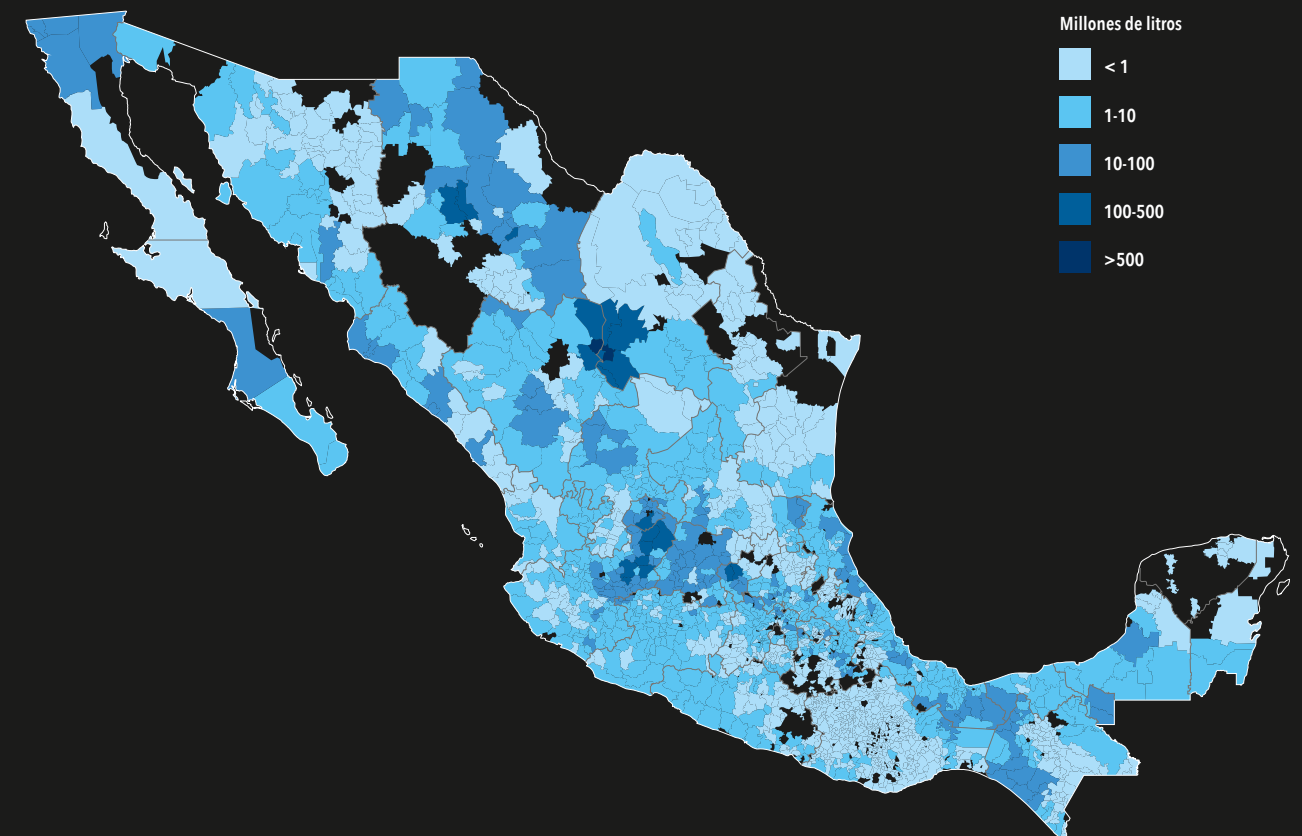
National milk production, 2023 (millions of litres)									
	2015	2016	2017	2018	2019	2020	2021	2022	2023
Milk	11,395	11,608	11,768	12,006	12,276	12,564	15,852	13,105	13,333

Table 21. National milk production in 2023

National milk production in Mexico between 2015 and 2023, expressed in millions of litres. Over this period, there has been steady growth, with production increasing from 11,938 million litres in 2015 to 13,533 million litres in 2023. This increase reflects a higher demand and expansion of the sector, which has important implications for the sustainable use and management of water.

BOVINE MILK PRODUCTION IN MEXICO DURING 2023

FIGURE 17



The figure shows the distribution of bovine milk production in Mexico during 2023, expressed in millions of litres per municipality. Darker shades indicate higher production volumes, concentrated mainly in the northern, central-western and south-eastern regions of the country. This visualization allows identifying the areas with the highest dairy activity and its possible impact on water use, key to evaluating its water footprint.

DISTRIBUTION OF PRODUCTION

Milk production is concentrated in 546 municipalities of the country.

Only 15 municipalities account for 52% of the total national production value.

In 2023, 13 million litres were produced, representing an increase of 15% compared to 2015.

MAIN PRODUCING REGIONS

The entities with the highest milk production are:

La Laguna Region (Coahuila and Durango): more than 3 million litres.

Jalisco: 2.8 million litres.

Chihuahua: 1.2 million litres.

Veracruz: 0.8 million litres.



These five states account for 61% of national production.



	Blue	Green	Grey	Total
Laguna	176.9	1,814.8	158.1	2,149.8
Jalisco	162.8	1,739.2	144.5	2,046.5
Chihuahua	120.3	1,512.3	103.8	1,736.5
Veracruz	127.4	1550.2	110.6	1788.2
National Average	124.9	1,590.2	135.6	1,850.6

Table 22. Average water footprint per litre of milk (m³/t)

Average water footprint per litre of milk in four key regions of the country: La Laguna, Jalisco, Chihuahua and Veracruz, compared to the national average. It can be seen that La Laguna has the highest footprint (2,149.8m³/t), while Veracruz has the lowest (1,768.2m³/t). The national average is 1,850.6m³/t, highlighting regional differences in water efficiency.

	Blue	Green	Grey	Total
Total	1,714.8	21,829.6	1,861	25,405.4
%	6.7%	85.9%	7.3%	100%

Table 23. Water footprint of milk production in Mexico (hm³)

Total water footprint of milk production in Mexico, amounting to 25,405.4hm³. Most of it corresponds to the use of green water (85.9%), followed by grey water (7.3%) and blue water (6.7%). This indicates that production depends mainly on soil moisture from rainfall, with lower pressure on surface or groundwater sources and moderate levels of associated pollution.

The water footprint of milk amounts to 25,405hm³, distributed in 86% green, 7.3% grey and 6.7% blue. This value represents 12.3% of the national livestock water footprint. Efficiency depends on the type of production system (extensive, intensive or mixed), the type of cattle feeding (grazing or forage), the water source (rainfed or irrigated) and the level of technology adopted.

CHALLENGES TOWARDS SUSTAINABILITY

The dairy sector faces important challenges. Challenges include soil degradation, climate variability and water availability, the use of antibiotics and growth promoters, ethics in production systems, and the need to close technological gaps to reduce losses between production sites and processing and final consumption.

Mexico’s National Chamber of Dairy Industry (CANILEC) as the main organization in the sector, has promoted measures to increase efficiency and reduce environmental impact, such as:



Usage of sustainable and regenerative agriculture practices in the supply chain.



Design of packaging and containers that promote the circular economy.



Coordination in the field to optimize the use of natural resources.



Berries

MEXICAN BERRIES

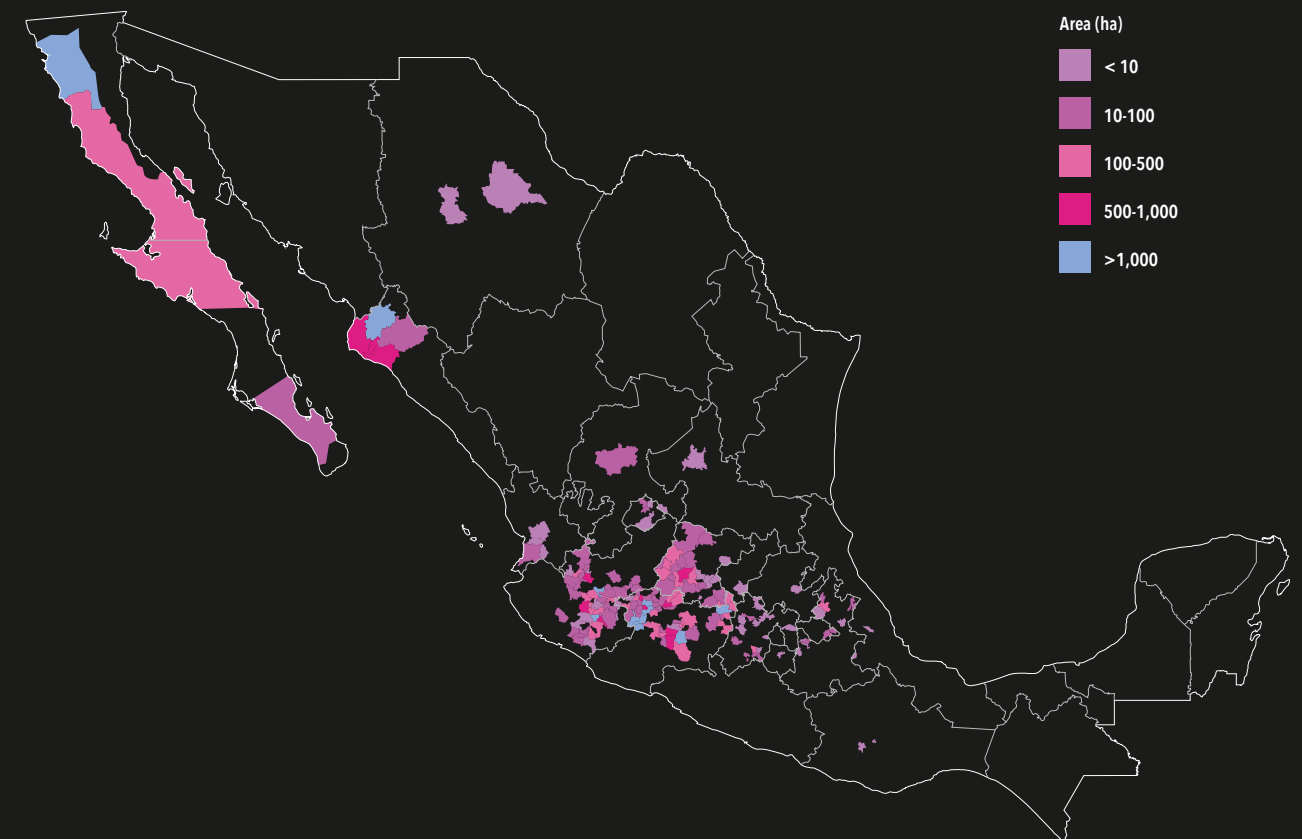
Over the past seven years, the global berry market has doubled in value, driven by favorable production conditions, a sustained increase in international demand, technological advances, and strong institutional support. Mexico has established itself as the world's leading supplier of these fruits. In 2022, the value of its exports exceeded US\$1.5 billion, a figure five times higher than the one recorded in 2015. 90% of these exports are destined for the United States and 8% for Canada.

To meet this growing demand, Mexico has significantly increased its cultivated area. Currently, 41,000 hectares of berries are being planted, representing a 41% increase compared to 2015. Although these crops are found in 181 municipalities in the country, production is highly concentrated: five states account for 97% of the planted area. Michoacán leads the list with 48%, followed by Jalisco with 25%, Baja California with 11%, Guanajuato with 6%, and Sinaloa with 5%. It is worth noting that 38% of the municipalities that currently produce berries were not growing them in 2015.

Berries are high-value commercial crops, whose production cost per cycle can reach one million pesos per hectare. They are highly laborintensive and especially vulnerable to pests and diseases,

which increases the need for inputs for their protection. They also depend almost exclusively on irrigation: 98% of the area is cultivated under this modality and only 2% in rainfed conditions.

BERRIES PRODUCTION IN 2023



The figure shows the distribution of the berry-planted area in Mexico during 2023, considering both irrigation and rainfed. It can be seen that the states with the highest concentration of area, especially those with more than a thousand hectares, are located in the west and center of the country. This visualization allows identifying the regions with the greatest presence of this crop, key to analyzing its water footprint and guiding sustainable strategies.

Equivalencies	Blueberry	Raspberry	Strawberry	Blackberry
Production (t)	79,101	190,367	640,162	221,727
Area (ha)	5,710	10,296	15,241	10,685
Yield t/ha	13.8	18.4	42	20.7

Table 24. Production of berries in Mexico

Data on berry production in Mexico, broken down by type: blueberry, raspberry, strawberry and blackberry. Strawberry leads with over 620 thousand tonnes produced and the highest yield (42 t/ha), followed by blackberry and raspberry. These data reflect the importance of each crop in terms of volume and efficiency, key elements for evaluating their water footprint.



	Blueberry	Raspberry	Strawberry	Blackberry
	323.2	200	200	158.7
	318.5	197	197	156.4
	154.2	95.4	95.4	75.7
	796	492.5	492.5	390.8

Table 25. Average water footprint per each berry (m³/t)

Average water footprint per tonne for four berries in Mexico. Blueberry has the highest footprint (796 m³/t), mainly due to the use of blue water. In contrast, raspberry and strawberry have a similar footprint of 492.5 m³/t, while blackberry shows the lowest value. This data helps to understand the water impact of each crop and its relative efficiency.

In terms of their water impact, berries present a significant footprint. The total water footprint of their production in Mexico amounts to 558.6 cubic hectometres annually. This is mainly distributed among four types of berries: strawberry accounts for 56% of the total, followed by raspberry with 17%, blackberry with 16% and the blueberry with 11%.

At the unit level, blueberries have the highest water footprint per tonne produced (796 m³/t), while blackberries have the lowest (390.8 m³/t). Although their contribution at the national level is relatively low — they account for 0.4% of Mexico's agricultural water footprint — their impact in producing regions is considerable due to the intensive use of water and land.

	Blueberry	Raspberry	Strawberry	Blackberry	Total
Blue	25.6	38.1	128	35.2	226.9
Green	25.2	37.5	126.1	34.7	223.5
Grey	12.2	18.2	61.1	16.8	108.3
Total	63	93.7	315.3	86.7	558.6
% of WF	11%	17%	56%	16%	
% of the area	14%	25%	36%	25%	

Table 26. Water footprint of berry production in Mexico (hm³)

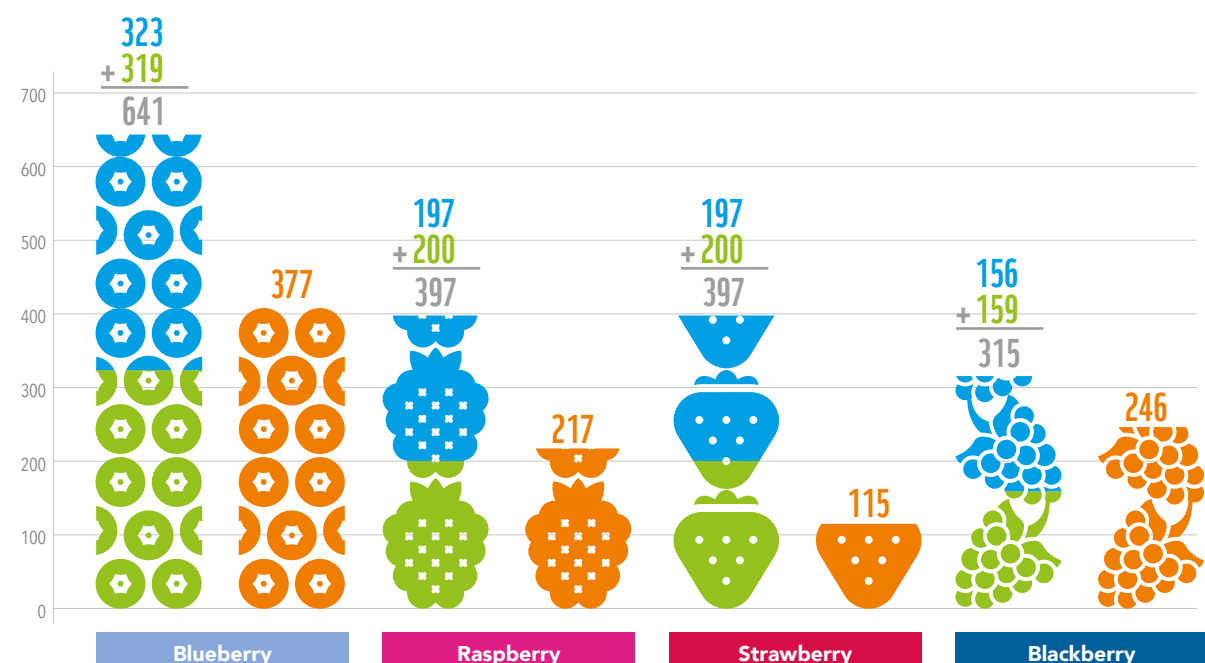
Total water footprint of berry production in Mexico, broken down by type of water and fruit. Strawberries consume the most water, accounting for 56% of the total, despite occupying only 36% of the surface. In contrast, blueberries and blackberries use less water, with a lower share in both surface and water footprint.

EFFICIENCY PARAMETERS

Mexican berries also face important challenges in terms of water efficiency. All of them show indicators above the international benchmark, reflecting opportunities to improve water resource management.

WATER FOOTPRINT OF MEXICAN BERRIES VS BENCHMARK

● Blue ● Green ● Benchmark



Comparison of the water footprint of Mexican berries with international benchmark values, measured in cubic metres per tonne. It can be seen that Mexican blueberries significantly exceed the benchmark, while raspberry and strawberry are above, but to a lesser extent. In contrast, Mexican blackberry has a lower footprint. This reflects areas of opportunity to improve water efficiency in some crops.

CHALLENGES TOWARDS SUSTAINABILITY

In terms of sustainability, these crops represent an increasing challenge. Despite its low impact in the national water footprint, its expansion accelerated has transformed usage patterns of resources in many regions. The high dependency on irrigation, the inputs for controlling the pests —many of which are linked to their grey footprint— and the demand for labor generate pressure on productive and social systems. In several areas, the difficulty in finding sufficient workforce is exacerbated by competition between legal and illegal markets.

Faced with these challenges, some of the main producer associations have begun to push for a transition towards more sustainable production. These actions, in many cases motivated by the demands of the international market, include more responsible practices in the use of chemicals and natural resources such as soil and water. However, the adoption of these practices is still limited and their progress depends on both the willingness of producers and the pressure of the market.



Beef, pork and poultry

GROWING CONSUMPTION AND WATER IMPACT

In Mexico, per capita meat consumption has doubled since 1980, reaching 75 kilograms per person in 2022. Not only has the quantity grown, but the preference has also changed: while beef consumption predominated four decades ago, today poultry meat is the most in-demand.

Over the past 12 years, this trend has intensified. Poultry consumption increased by 21%, reaching 38.8kg per inhabitant per year. Pork registered an increase of 33% in the same period, while beef consumption decreased by 11%.

	2010	2022	Variation
 Beef	32	38.83	0.21
 Poultry	16.5	21.96	0.33
 Pork	17.1	15.27	-0.11

Table 27. Per capita meat consumption in Mexico (kg/person/year)

In the evolution of per capita meat consumption in Mexico between 2010 and 2022, an increase in the consumption of poultry and pork stands out, with increases of 6.83kg and 5.36kg per person per year, respectively. In contrast, beef consumption decreased by 1.63kg, reflecting changes in the population's dietary preferences.

To meet this growing demand, especially for poultry and pork, Mexico relies heavily on imports. These represent 48% of the apparent national consumption in the case of pork and 23% in the case of poultry.

Type of meat	Production	Exports	Imports	Apparent consumption	Relevance of imports
	3,800	8	1,158	4,950	23%
	1,730	274	1,344	2,800	48%
	2,176	366	138	1,948	7%

Table 28. Apparent consumption (thousand tonnes) and share of imports

In the apparent consumption of meat in Mexico, as well as the participation of imports, poultry is the most consumed with 4.95 million tonnes, and 23% comes from abroad. Pork has the greatest dependence on imports, with 48% of consumption. In contrast, beef has a much lower imported participation, representing only 7% of the total.

On the other hand, Mexican exports of beef, pork, and poultry represent 22.7% of the total virtual water flow that the country allocates to exterior trade. Of that percentage, beef is the most relevant with 13.8%, followed by pork with 8.8%.

					
	2.5	33	2.8	38.3	0%
	215.5	2,236.4	195.1	2,647	9%
	240.7	3,746.5	147.7	4,134.9	14%

*% of virtual water total exports

Table 29. Virtual water exports

In virtual water exports associated with meat production in Mexico, beef tops the list with 4,134.9hm³ exported, followed by pork with 2,647 hm³. In contrast, poultry presents a minimal amount (38.3hm³). These data show that 14% of the virtual water exported comes from the bovine sector, 9% from the porcine sector and 0% from the poultry sector.

As for the impact of domestic consumption, animal proteins are responsible for 56% of the Mexican's water footprint, being this the most significant component of water consumption associated with diet. A part of this footprint comes from water used in other countries, since some of these meats arrive in the country through imports.

	Blue	Green	Grey	Total
 Poultry	308	4,130	352	4,790
 Pork	787	8,162	712	9,661
 Beef	658	10,236	404	11,298

Table 30. Weighted water footprint (m³/t) of meat in Mexico

Weighted water footprint by type of meat in Mexico, expressed in cubic metres per tonne (m³/t). Beef has the highest footprint at 11,298m³/t, followed by pork at 9,661m³/t and poultry at 4,790m³/t. These figures reflect the high water requirement, especially green, for the production of animal protein.

The national production of meat from these three species also reflects important differences in their water impact. On a unit basis, beef has the largest weighted water footprint, at 11,298m³/t, followed by pork at 9,661 m³/t and poultry at 4,790m³/t. Although Mexico produces more poultry (3.8 million tonnes per year) than beef (2.1 million) or pork (1.7 million), beef still has the largest total water footprint, due to its high footprint per tonne. Poultry ranks second in total footprint, driven by its high production volume, despite having the lowest unit footprint.

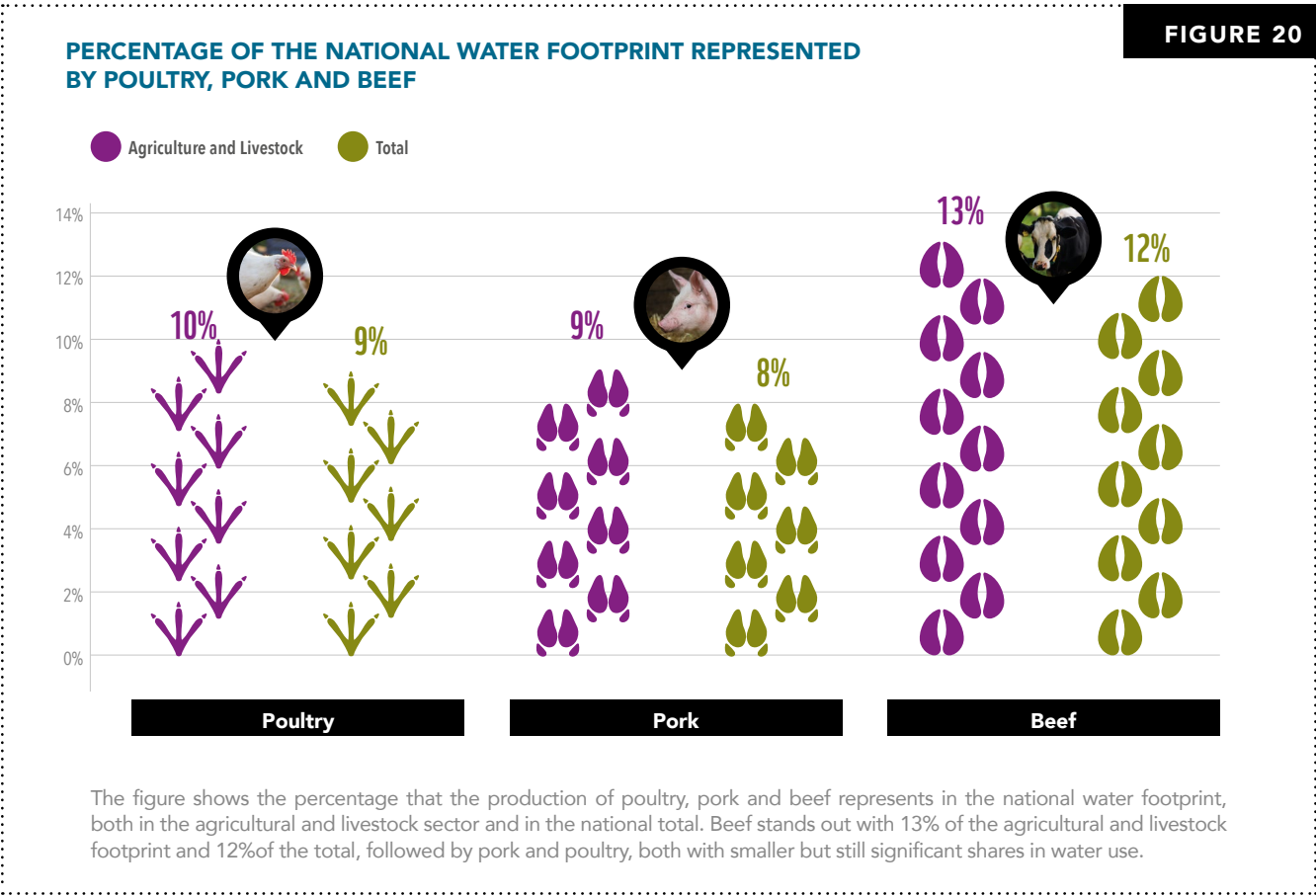
	Production (thousand tonnes)	Total water footprint (hm³)			
		Blue	Green	Grey	Total WF
Poultry	3,800	1,168.8	15,695.3	1,336.2	18,200.3
Pork	1,730	1,360.9	14,120.4	1,231.8	16,713.1
Beef	2,176	1,431.3	22,274.3	878	24,583.6

Table 31. Water footprint of meat production in Mexico

Total water footprint associated with meat production in Mexico, differentiated by type of meat and color of the water. Beef, with lower production than poultry, concentrates the largest total water footprint (24,582.6hm³), due to the high use of green water. Followed by poultry and pork, both with significant footprints that also include blue and grey water.

Taken together, the three species account for a total water footprint of 59,497 cubic hectometres per year, equivalent to 29% of the country's total water footprint and 32% of the primary sector's footprint.

Consumption projections indicate that the trend will continue to rise, particularly for poultry and pork. It is expected that a large part of this additional demand continues to be covered through imports, which also implies an increasingly dependence on water of other regions of the world.



CHALLENGES TOWARDS SUSTAINABILITY

The challenges surrounding the sustainability of meat production in Mexico are broad and complex. They involve the entire value chain, from the way inputs for animal feed are grown —mainly fodder crops and balanced feed— to the intensive and semi-intensive systems in which livestock are raised. Proper management during confinement, the slaughter process, and the transformation into carcasses and by-products must also guarantee the responsible use of natural resources, without compromising the safety and quality of food intended for human consumption.



Walnut in Mexico and the United States

CONTRASTS IN PERFORMANCE: EFFICIENCY AND SUSTAINABILITY

Walnut is a crop of productive relevance in both Mexico and the United States. Although it is the same fruit, there are important differences between the two countries in terms of yields, market conditions, and vulnerability to biotic stress. In addition to these variables, there is the water footprint, whose comparison reveals key aspects about the efficiency of their production models.

Equivalencies	Chihuahua	California
Area (ha)	104,088.2	154,999
Production (t)	100,190.48	670,000
Yield t/ha	0.96	4.32

Table 32. Production of walnut

The table compares walnut production between Chihuahua and California. Although Chihuahua has a considerable planted area (104,088 ha), its yield is low, with only 0.96 tonnes per hectare. In contrast, California produces much more (670,000 tonnes) on 154,999 ha, with a yield of 4.32 t/ha. This reflects a big difference in productive efficiency between the two regions.

The United States ranks second as the world’s largest walnut producer, with a cultivated area of 652,000 hectares, while Mexico ranks sixth globally, with 161,000 hectares planted. In both countries, the main production areas are California in the United States and Chihuahua in Mexico.

The differences in yield are striking: on average, the United States gets 4.32 tonnes per hectare, which is 440% more than Mexico, where productivity is 0.96 tonnes per hectare.

Despite the different contexts, both countries face common pests that affect the walnut, such as the New World Screwworm, aphids and mites. As for diseases, powdery mildew and anthracnose are the most frequent in both California and Chihuahua, and are treated using a combination of chemical and biological controls.

WF (m³/t)	Chihuahua	California
 Blue	2,578.7	588.3
 Green	3,264.4	952
 Total (m³/t)	5,843.2	1,540.3

Table 33. Water footprint of walnuts

The water footprint of walnut production in Chihuahua and California shows that Chihuahua uses 5,843.2 m³ of water per tonne, while California uses only 1,540.3 m³. This difference is mainly due to the more intensive use of green and blue water in Chihuahua, indicating lower water efficiency compared to the production model in California.

Walnut production is mainly developed under irrigation agriculture. In the United States, 85% of walnut area is grown under this system, while in Mexico the figure rises to 99%. However, the water management systems are different. In California, there is greater use of green water supplemented by auxiliary irrigation, whereas in Mexico production relies mainly on the direct use of irrigation water.

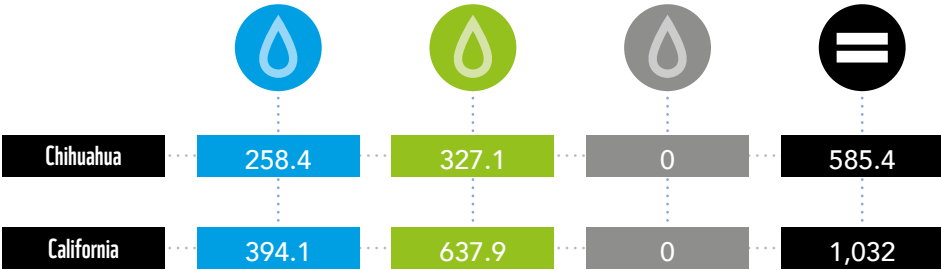


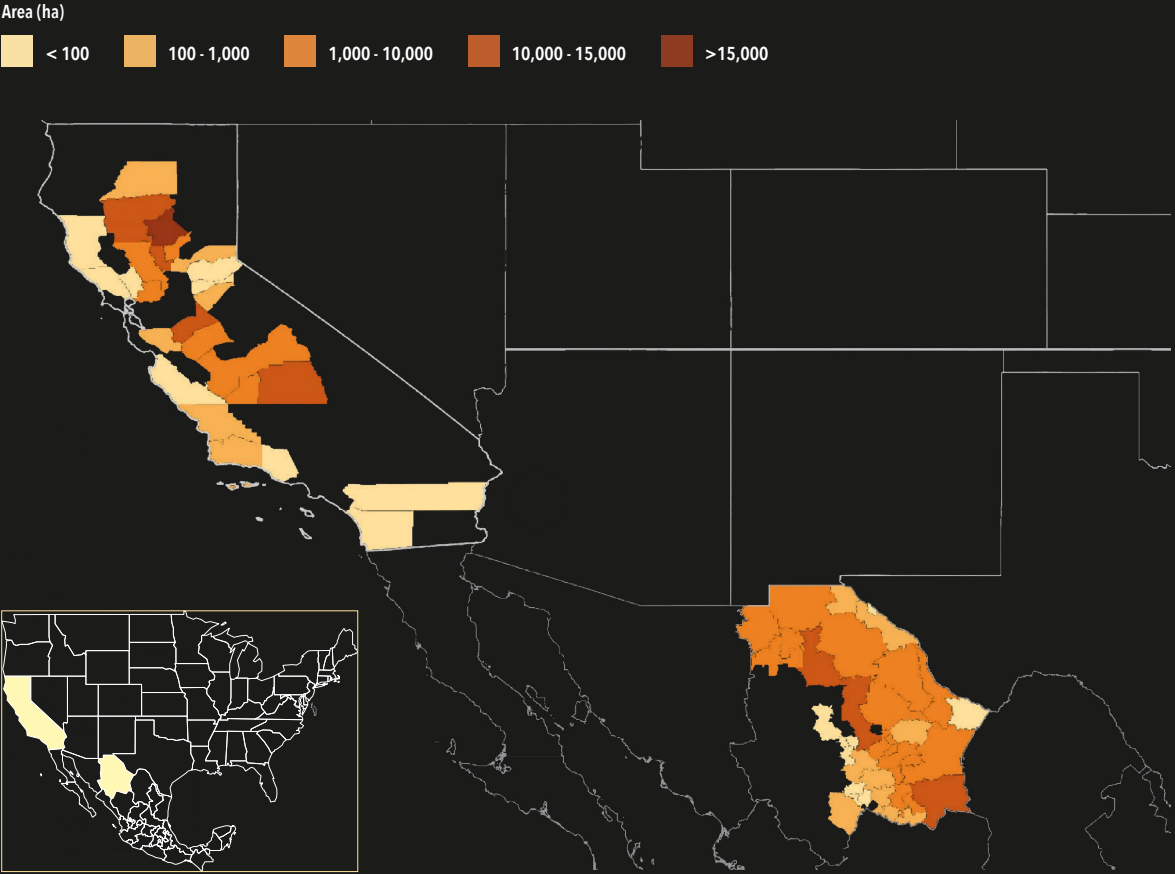
Table 34. Water footprint of walnut per color

The table compares the total water footprint of walnut production in Chihuahua and California, expressed in cubic hectometres (hm³). Although Chihuahua has a lower total volume (585.4 hm³), California reaches 1,032 hm³, with higher contributions from both green and blue water. In both cases, there is no record of grey water footprint, indicating the absence of significant pollution associated with the water used in production.

These differences in the production model have a direct impact on the water footprint. Walnut production in Chihuahua generates a total footprint of 585 cubic hectometres, while in California it reaches 1,032 cubic hectometres. Although California's figure is 76% higher, this state produces 660% more walnut than Chihuahua, reflecting a significant difference in terms of water efficiency. Walnut produced in Chihuahua represents 0.37% of Mexico's total agricultural water footprint.

AREA PLANTED WITH WALNUT IN CALIFORNIA AND CHIHUAHUA IN 2023

FIGURE 21



The figure shows the area planted with walnut in 2023, comparing the producing regions of California, USA, and Chihuahua, Mexico. The shades indicate the size of the cultivated area: from less than 100 hectares to more than 15,000. A high concentration of area is observed in specific zones of both territories, which highlights their importance in walnut production at a binational level.

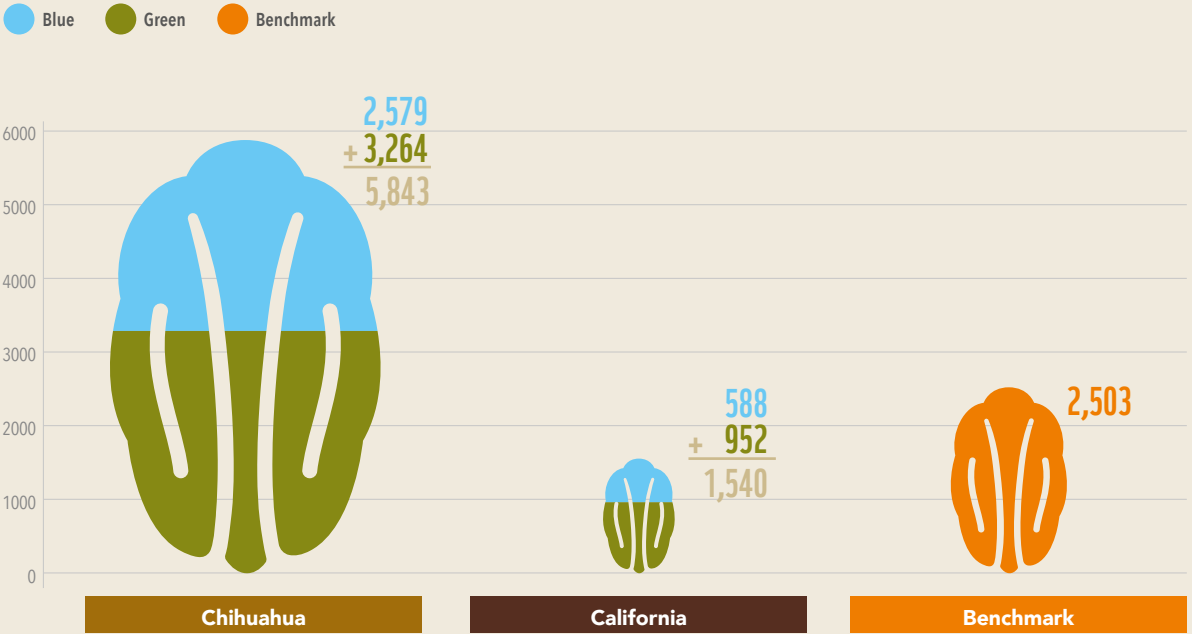
EFFICIENCY PARAMETERS

Compared to international standards, the Mexican walnut presents a major challenge: its water footprint is 133% above the benchmark, indicating a wide margin for improvement in terms of water use efficiency. On the contrary, the Californian walnut is 39% below this parameter, making it one of the most efficient in the world from a water perspective. 💧

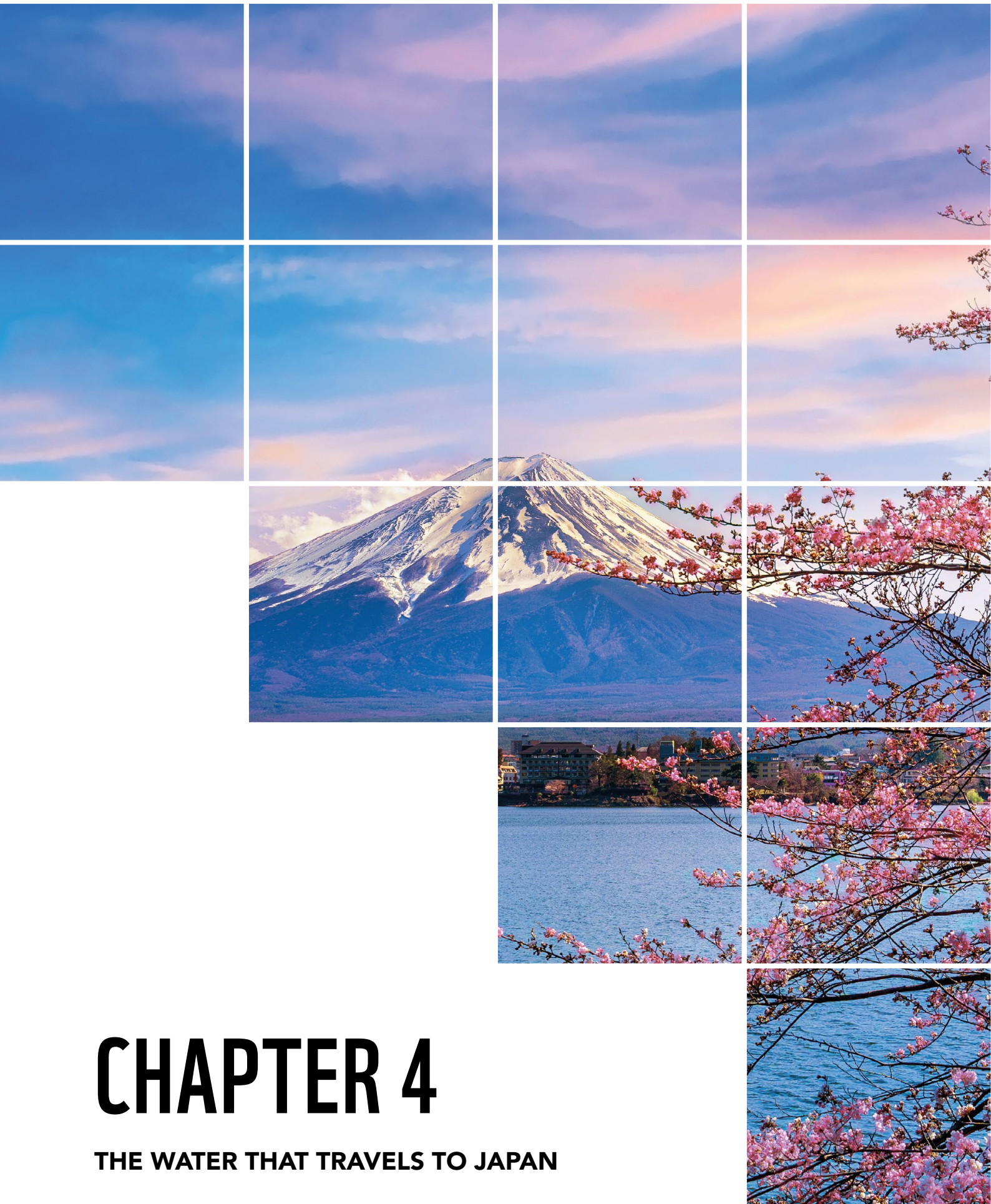


CHIHUAHUA AND CALIFORNIA WALNUT WATER FOOTPRINT VS BENCHMARK

FIGURE 22



The figure compares the water footprint of walnut cultivation between Chihuahua, California, and a benchmark value. Chihuahua shows a significantly higher footprint (5,843 m³/t) compared to California (1,540 m³/t) and the benchmark (2,503 m³/t), mainly due to the high use of green and blue water. This evidences opportunities for improvement in water efficiency for Mexican production.

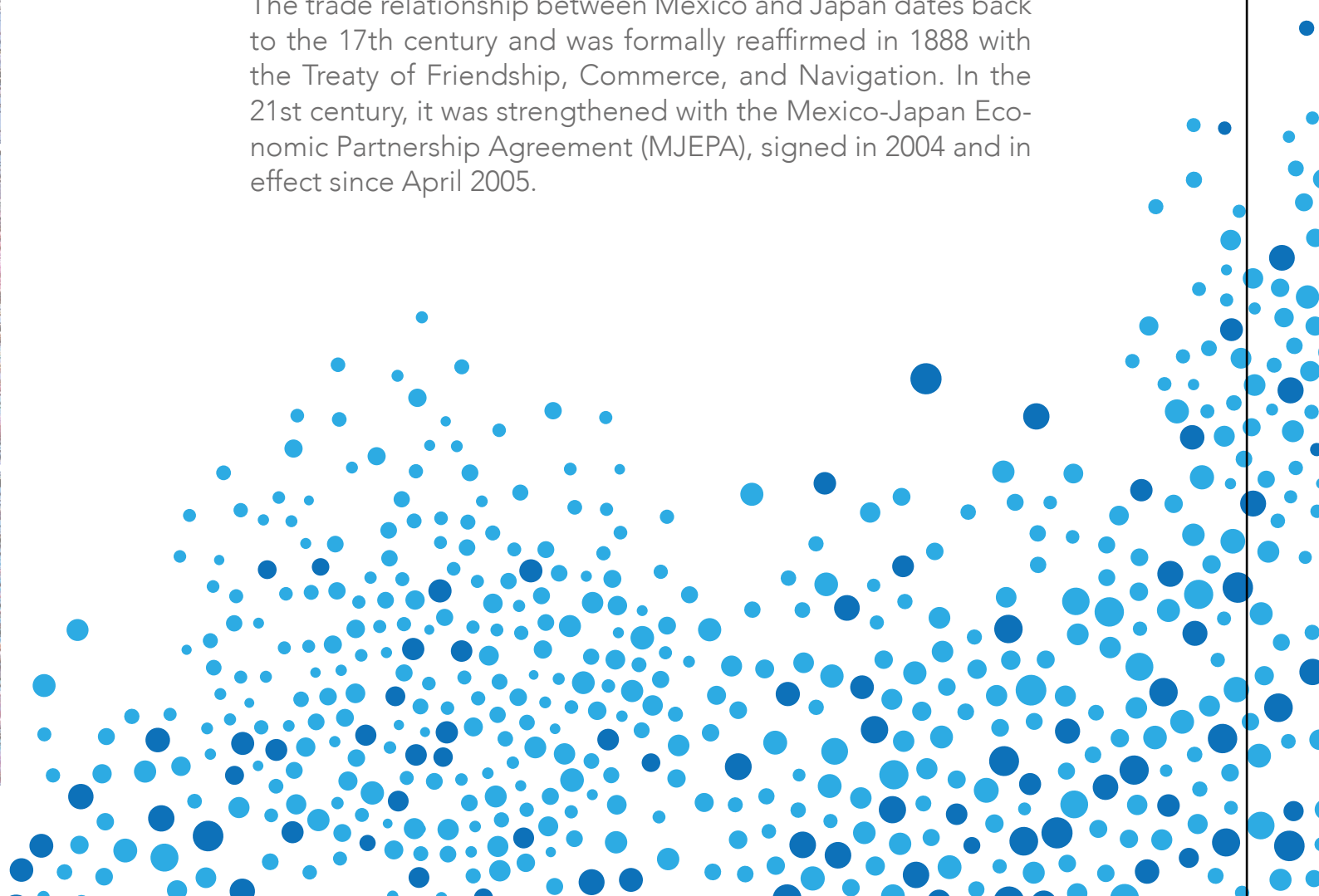


CHAPTER 4

THE WATER THAT TRAVELS TO JAPAN

Japan ranks second as a destination for Mexican virtual water, and although its role in foreign trade is often overlooked compared to the prominence of the United States, its relevance is on the rise. This ascent is in line with the volume of water involved in the commercial flow of the main agri-food products that Mexico exports to the Asian country.

The trade relationship between Mexico and Japan dates back to the 17th century and was formally reaffirmed in 1888 with the Treaty of Friendship, Commerce, and Navigation. In the 21st century, it was strengthened with the Mexico-Japan Economic Partnership Agreement (MJEPA), signed in 2004 and in effect since April 2005.



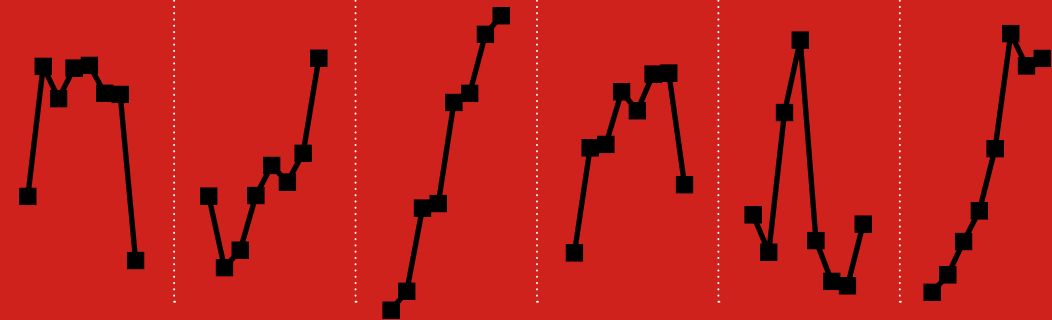
EXPORT VALUE FOR SELECTED COMMODITIES

FIGURE 23



Commodity	Avocado	Beef	Pork	Asparagus	Orange	Banana
2015	127,148	73,166	325,828	28,267	481	3,386
2016	186,724	47,144	342,993	37,814	255	7,609
2017	171,917	53,504	418,641	38,129	1,101	15,694
2018	185,935	73,373	422,713	42,909	1,540	23,112
2019	187,158	84,312	514,601	41,187	325	38,190
2020	174,399	78,284	522,874	44,523	78	66,089
2021	173,867	88,724	576,531	44,620	51	58,242
2022	97,762	123,292	593,404	34,466	425	60,072

2015-2022



The evolution of the export value of six Mexican commodities between 2015 and 2022 to Japan is shown in millions of dollars (USD million). Avocado stands out with increasing figures, followed by beef and pork. Products such as asparagus, banana and orange also maintain their relevant contributions. The information allows to identify trends and the economic importance of these products in the foreign trade of Mexico.

An expanding business relationship

Bilateral trade between Mexico and Japan amounts to US\$4.7 billion. Japan exports goods worth US\$2.3 billion to Mexico, while Mexico sends products worth 2.4 billion, of which 1.1 billion is in the agri-food sector. In return, Mexico imports only US\$55.6 billion worth of Japanese food, showing the disproportionate weight of the Mexican countryside in this trade relationship.



Japan imported 43,800 tonnes of avocado in 2022, of which 30,700 tonnes (70%) came from Mexico. This volume represents 3% of the total exported by Mexico, which is the world's leading supplier, with 1.1 million tonnes. The value of these exports to Japan was USD\$98 million.



Japan is one of the largest global importers of beef, with purchases of 667,000 tonnes worth USD\$4.9 billion. Mexico exports 19,900 tonnes, equivalent to 3% of the volume and USD\$123 million, positioning itself as the fifth most important supplier. In the case of Mexico, Japan is the second most relevant destination market for this meat.

PORK



Japanese imports of pork reach one million tonnes, with a value of US\$4.9 billion. Mexico exports 136,000 tonnes to this country, representing 13.6% of the volume and US\$593 million, making it the fourth largest supplier. Japan is also the main destination for Mexican exports of pork, receiving 66% of the total volume.

ASPARAGUS



Mexico leads the supply of asparagus in Japan, with 84% of the total imported volume (6,400 tonnes), worth US\$41 million. This flow represents 3.2% of Mexico's total asparagus exports, whose main market remains the United States (80.5%).

ORANGE JUICE



Of the 21,700 tonnes of orange juice imported by Japan, Mexico contributes 32% (7,100 tonnes), worth US\$18.7 million. Although this flow represents only 3.7% of Mexican exports of this product, Japan ranks third as a destination market.

BANANA



Japan imports 957 thousand tonnes of bananas per year. Mexico contributes 7.5%, becoming its third supplier, after the Philippines and Ecuador. Of the 540,000 tonnes of bananas that Mexico exports, 71,700 are destined for Japan, with a value of US\$60 million. Japan is the second most relevant market for this Mexican fruit, after the United States.

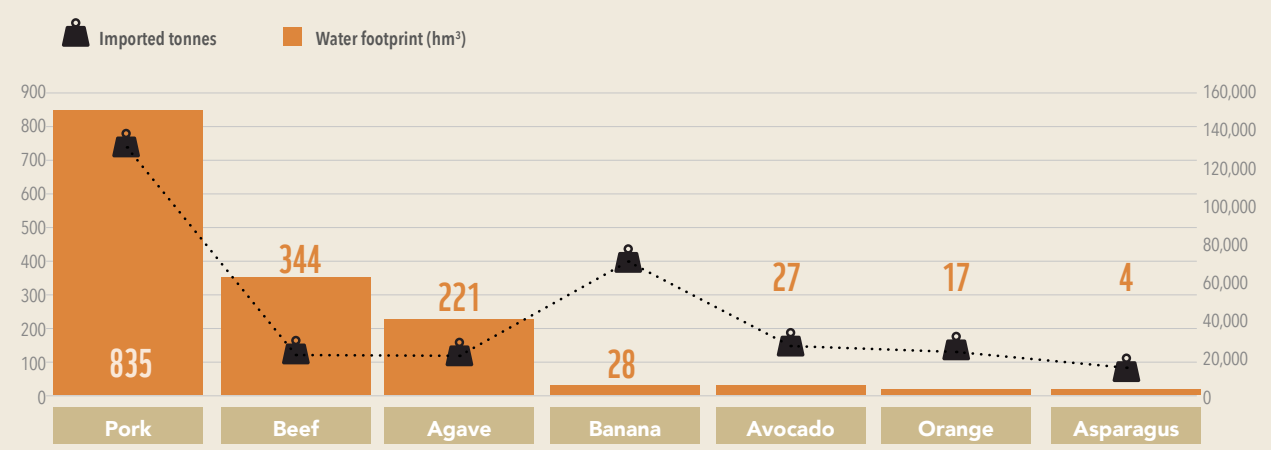
AGAVE (TEQUILA)



Tequila, made from agave with a designation of origin recognized in five Mexican states is one of the most representative products of national agrifood exports. Although the United States is the main market with 338 million litres, Japan ranks tenth, with 2.5 million litres per year, equivalent to 17,500 tonnes of agave.

MAIN PRODUCTS EXPORTED TO JAPAN: WATER FOOTPRINT AND VOLUME

FIGURE 24



The figure shows the relationship between the water footprint and the volume of imports of Mexican products to Japan. The product with the highest water footprint is pork, followed by beef and agave. Although some products like bananas have lower water impact, they have high export volumes, which allows us to observe differences between environmental impact and commercial demand.

Water footprint of exports to Japan

The seven products analyzed add up to a water footprint of 1,475.4 cubic hectometres annually, which represents 72% of the virtual water exported from Mexico to Japan in 2022. The highest figures correspond to pork (834 hm³), agave (734 hm³) and beef (343.5 hm³).

Commodity	Blue	Green	Grey	Total m³/t	t	Total hm³
Avocado	524	268.6	97.7	1,128.6	30,700	27.3
Agave	61.4	12,098.9	488.7	12,649	17,500	221.4
Asparagus	245.4	344.5	74.6	664.6	6,400	4.3
Banana	78.4	280.7	24.8	384	71,700	27.5
Orange	321.7	382.4	74.7	778.7	21,300	16.6
Pork	836.8	6,858.9	653.3	8,349	136,000	834.8
Beef	801.5	15,843.3	617.7	17,262.5	19,900	343.5
Total	2,869.2	36,077.3	2,031.6		303,500	1475.4

Table 35. Virtual water imports from Japan to Mexico

The table shows Japan’s imports of virtual water from Mexico, broken down by water type (blue, green and grey) and by product. The main commodities exported are pork, beef and agave, with high volumes of water footprint per tonne. In total, Japan imports more than 1,475 hm³ of virtual water associated with Mexican products, highlighting the environmental impact of international agri-food trade.

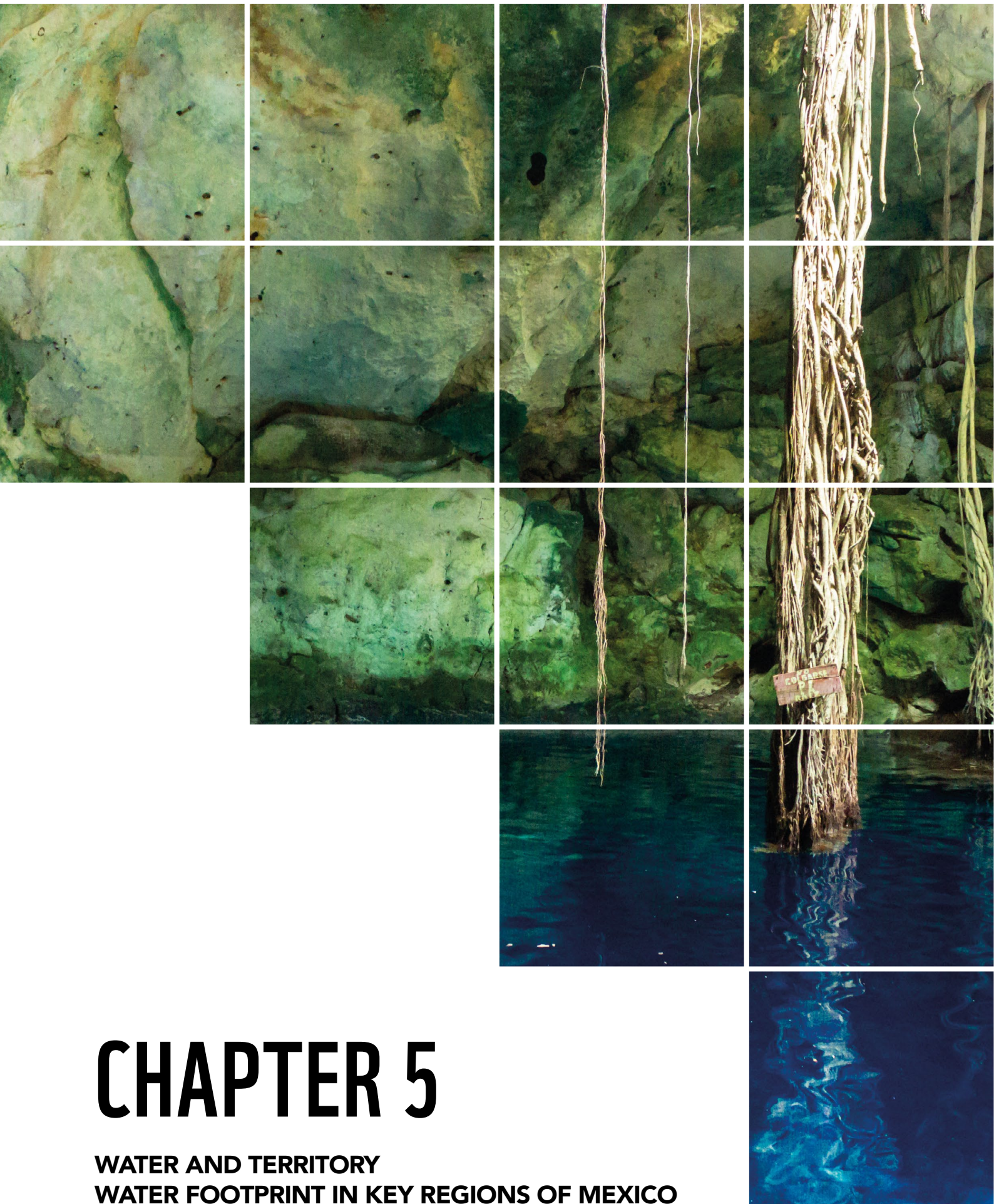
CHALLENGES TOWARDS SUSTAINABILITY

The continuity of these Mexican exports is closely linked to the availability and sustainable use of water. Mexico is the main or one of the main suppliers of key products for the Japanese diet, such as avocado, asparagus, orange juice, banana and tequila. Pork and beef also represent an important fraction of Japanese consumption.

Therefore, it is crucial to ensure water security in Mexican producing regions. Water scarcity in quantity, quality or seasonality could translate into shortages and higher prices for the Japanese consumer. To avoid this, a transition towards more resilient production models is required, with efficient water use, less dependence on intensive irrigation (blue water) and reduction of grey water generation by pollutants. Only in this way can the presence of Mexican products in the demanding Japanese market be maintained in the medium and long term. 💧

CHAPTER 5

WATER AND TERRITORY WATER FOOTPRINT IN KEY REGIONS OF MEXICO



The productive dynamics in Mexico are not homogenous. There are regions with a leading role in the production of high commercial value foods, whose agricultural expansion has brought with it a significant increase in the use of the water resource. In this section, two emblematic cases are analyzed: honey in the Yucatán Peninsula; and berries and avocado in Michoacán. Both reveal how production decisions, agricultural practices and territorial policies affect the regional water footprint, the sustainability of ecosystems and the economic health of communities.

Yucatán Peninsula: A sweet glimpse of honey

In this region of southeastern Mexico, 16,784 tonnes of honey are currently produced annually, distributed in 125 municipalities. However, 80% of this production is concentrated in just 44 municipalities. Although the volume of national production has increased slightly —4% more than in 2010— the trend has not been linear. In 2010, 55,684 tonnes were produced, reaching a peak of 61,881 in 2015, and then decreasing to 58,033 tonnes in 2023.

Geographical region	2023
National	58,033
Campeche	4,605
Quintana Roo	2,728
Yucatán	9,450

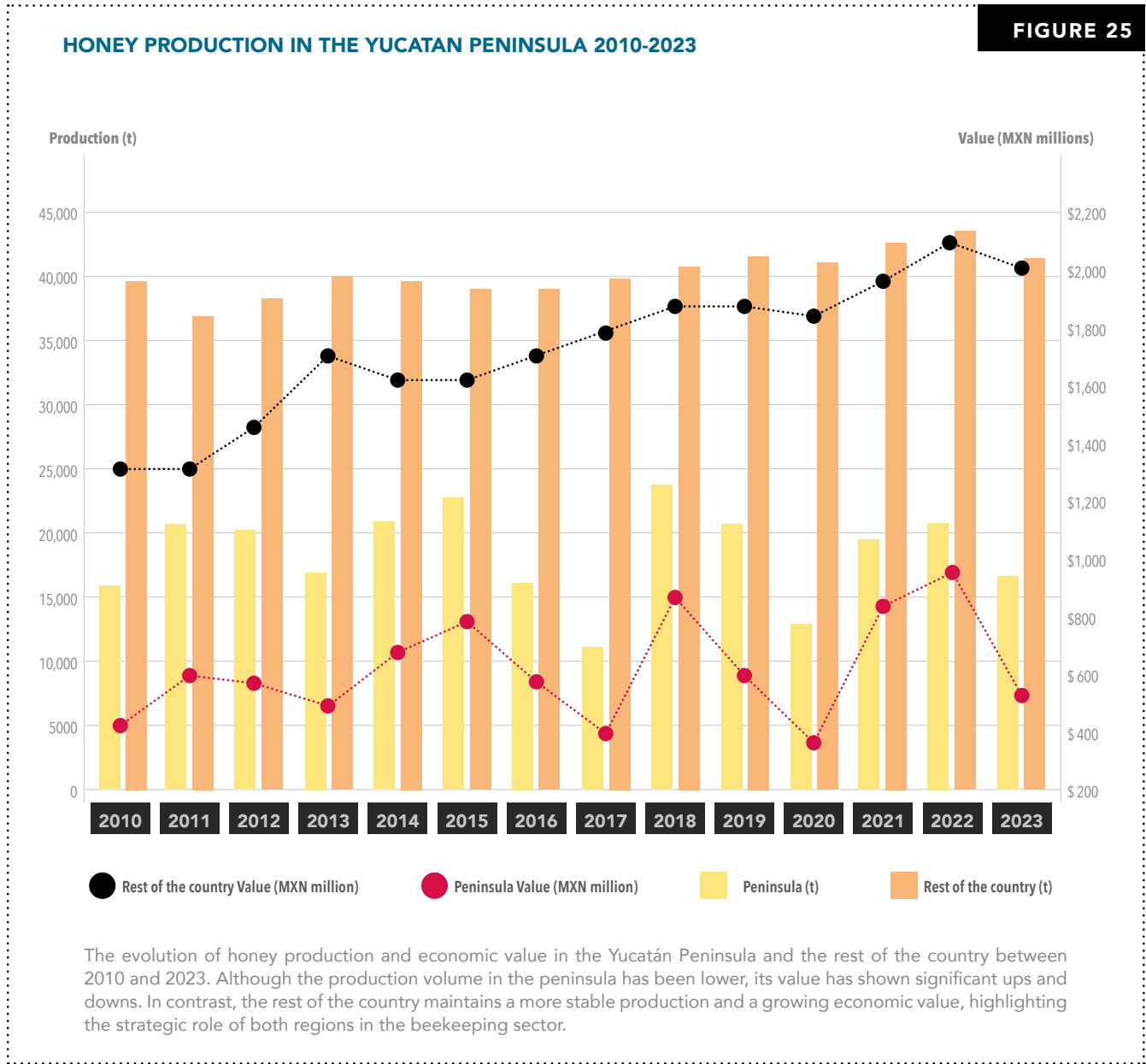
AgroDer, 2024. With information from SIAP (SADER).

Table 36. Volume of honey production in 2023

The table presents the volume of honey production in Mexico during 2023. Nationally, 58,033 tonnes were produced. The states of the Yucatán Peninsula stand out for their contribution: Yucatán with 9,450 tonnes, Campeche with 4,605 and Quintana Roo with 2,728. This region is key to national apiculture, both for its production volume and its relevance in exports.



National honey exports in 2022 reached 31,000 tonnes, with a value of 127 million dollars. However, they have faced important challenges. Since the 2010s, producers from the Yucatán Peninsula have had difficulties complying with Codex Alimentarius standards, required by the European Union, due to the presence of glyphosate in export samples. This contamination does not come from the beekeepers, who in many cases maintain organic practices, but from the proximity to transgenic soy crops introduced in the region since 2008, whose management includes the use of agrochemicals that are dispersed by air or by groundwater.



In terms of water footprint, honey is one of the most efficient livestock products: it requires only 0.18m³ of water per tonne produced. Of this total, 98% is green water, 1.5% is blue, and only 0.5% is gray, with minimal regional variations. The national total water footprint of honey is just 0.01 hm³, of which 31% corresponds to the Yucatán Peninsula. (0.003hm³).

				
National	0.003	0.176	0.001	0.180
Campeche	0.004	0.230	0.001	0.236
Quintana Roo	0.003	0.204	0.001	0.208
Yucatan	0.003	0.149	0.001	0.153

Table 37. Water footprint of honey (m³/t)

The table presents the water footprint of honey in Mexico, broken down by type of water and by state. Nationwide, the total value is 0.180m³ per tonne, with most of it being green water. Campeche records the highest footprint (0.236m³/t), while Yucatán has the lowest (0.153m³/t), reflecting regional differences in the use of water resources for their production.

Despite their efficiency and low impact, producers face risks derived from the shared use of water, air, and soil. When these common goods are compromised by nearby intensive agricultural activities, even the most sustainable production systems can be affected.

CHALLENGES TOWARDS SUSTAINABILITY

Among the main challenges of the apiculture sector is the need to involve themselves in decision-making processes regarding the use of shared resources. It is crucial to establish monitoring and early warning systems to detect the presence of highly dangerous pesticides, as well as to promote neighboring agricultural practices that do not compromise the purity of apiculture products. Only in this way can the viability of the apiculture sector, which is an economic and cultural driver of the region, be guaranteed.



Michoacán: berries and avocado, commercial treasures

Michoacán is one of the states with the greatest agricultural dynamism in the country. In 2023, its cultivated area exceeded 1.2 million hectares, distributed in 116 commercial crops. The state has eight irrigation districts, with the most important being the 097 Lázaro Cárdenas (51% of production) and the 087 Rosario-Mezquite (16%).

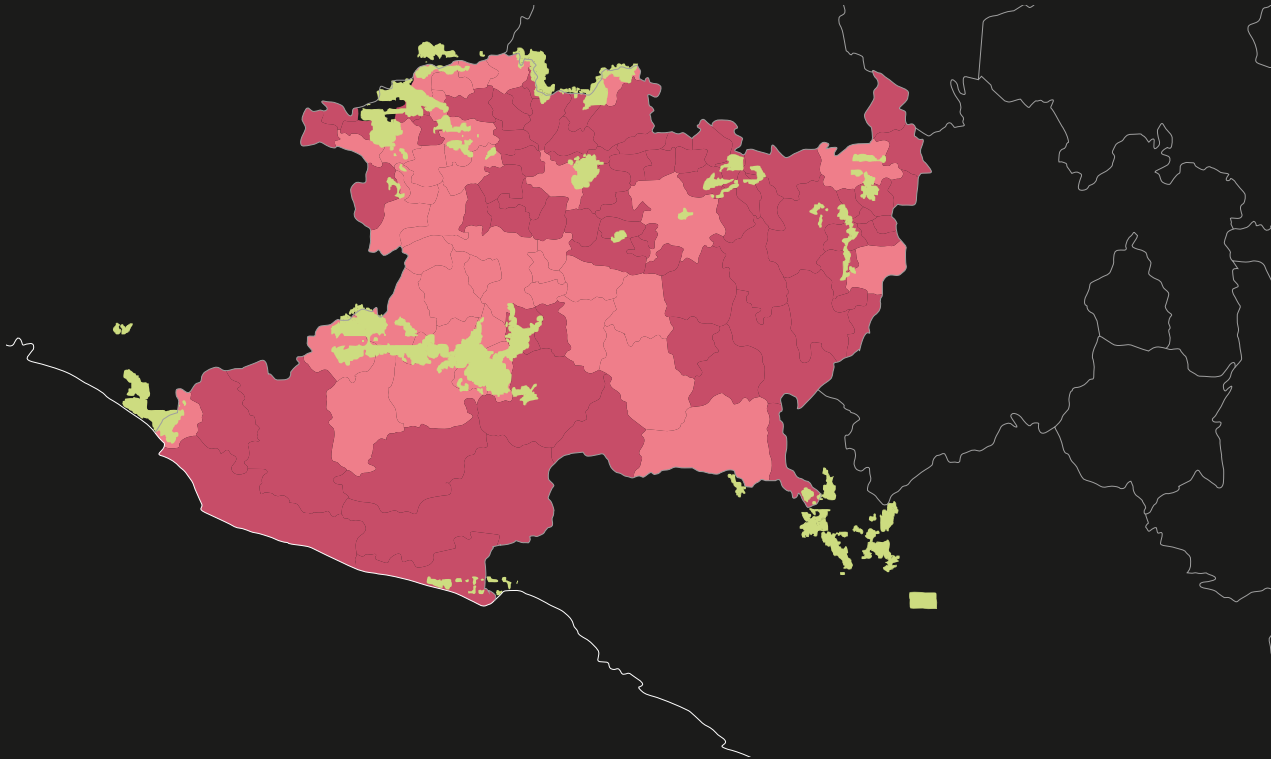
Five crops account for 52% of the value of state agricultural production:avocado (38%) and berries —cranberry, raspberry, strawberry and blackberry— (14%) they are the protagonists. The total value of Michoacán’s agricultural sector amounts to MXN\$115,748 million.

MICHOACÁN: VALUE OF AGRICULTURE AND LIVESTOCK PRODUCTION AND IRRIGATION DISTRICTS IN 2023

FIGURE 26

Production value (MXN million)

< 1,000 1,000 - 10,000 Irrigation districts



The figure shows the value of agricultural production in Michoacán in 2023, along with the location of the Irrigation Districts. A significant concentration of value is observed in municipalities in the western and southern parts of the state, where the main irrigation districts are also located. This reflects the close relationship between water infrastructure and agricultural productivity in the region.

AVOCADO

In 2023, Michoacán produced 2,253,783 tonnes of avocado in 66 municipalities, of which 11 generate 82% of the production. Avocado exports in that year reached 3,385 million dollars, 349% more than in 2010. In the last decade, the planted area increased by 74%.

Equivalencias	Irrigation	Rainfed	Total
ha	70,496	116,218	186,713
t	929,114	1,323,669	2,252,783
Yield t/ha	13.2	11.4	24.6

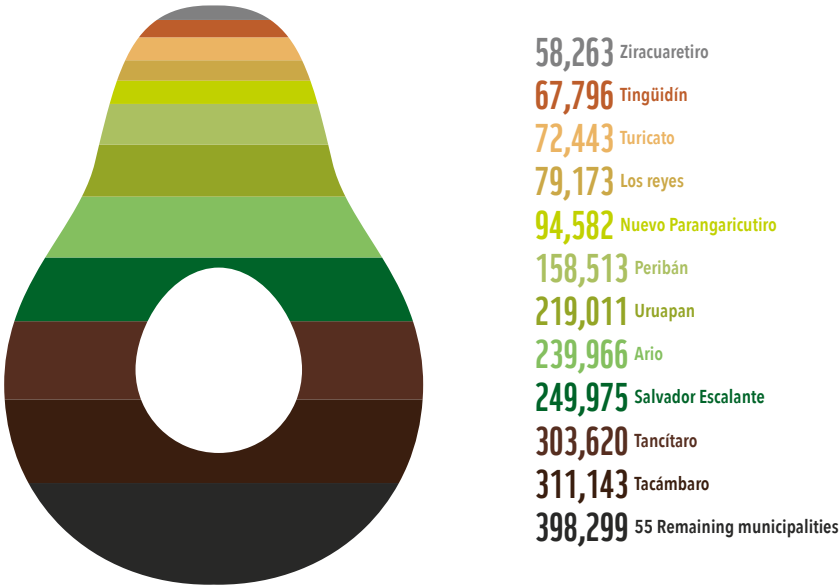
Table 38. Avocado production in Michoacán

Avocado production in Michoacán during 2023, differentiating between irrigated and non-irrigated rainfed areas. A total of 186,713 hectares were planted, with production exceeding 2.25 million tonnes. The yield was higher in irrigated areas, with 13.2 tonnes per hectare, compared to 11.4 in rainfed, highlighting the importance of access to water for improving productivity.

Currently, 38% of Michoacán avocados are grown under irrigation and 62% in rainfed. The unitary water footprint is 874m³/t for irrigation (lower than the national average) and 884m³/t for rainfed (slightly higher). The total water footprint in the state is 1,938hm³, of which 61% is green water, 28% blue and 11% grey. This figure represents 74.9% of the total water footprint of avocados produced throughout Mexico.

AVOCADO PRODUCTS IN MICHOACÁN BY MUNICIPALITY 2023

FIGURE 27



In the production of avocado by municipality in Michoacán during 2023, Tacámbaro, Tancítaro and Salvador Escalante stand out as the main producers, with over 300 thousand tonnes each. Together, these municipalities lead the avocado activity in the state. In addition, another 55 municipalities contribute significantly, reflecting the widespread geographical distribution of this key agricultural activity in the region.

	Michoacán		National	
	Irrigation	Rainfed	Irrigation	Rainfed
	328.4	186	345.7	202.2
	448.4	601.8	467.1	573.1
	97.8	97	95	100
	874.7	884.8	907.8	875.3

Table 39. Water footprint of Michoacán's avocado and national avocado (m³/t)

The table compares the water footprint of avocado produced in Michoacán with the national average, differentiating between irrigation and rainfed systems. In both cases, green water represents the greatest proportion. Michoacán shows figures similar to the national average, although with slight variations depending on the type of water and production system, reflecting relatively efficient water use in this major producing state.

	Water footprint of avocado production in Michoacán (hm³)		
	Irrigation	Rainfed	Total
	305.1	246.2	551.3
	416.7	796.5	1,213.2
	90.9	128.4	219.3
	812.7	1,171.2	1,983.8

Table 40. Water footprint of avocado production in Michoacán (hm³)

The table shows the total water footprint of avocado production in Michoacán, broken down by type of water and cultivation system (irrigation and rainfed). Most of the water use corresponds to green water, followed by blue and grey. In total 1,983.8hm³ was used, with the rainfed system being the one that generally requiring the most water.



BERRIES

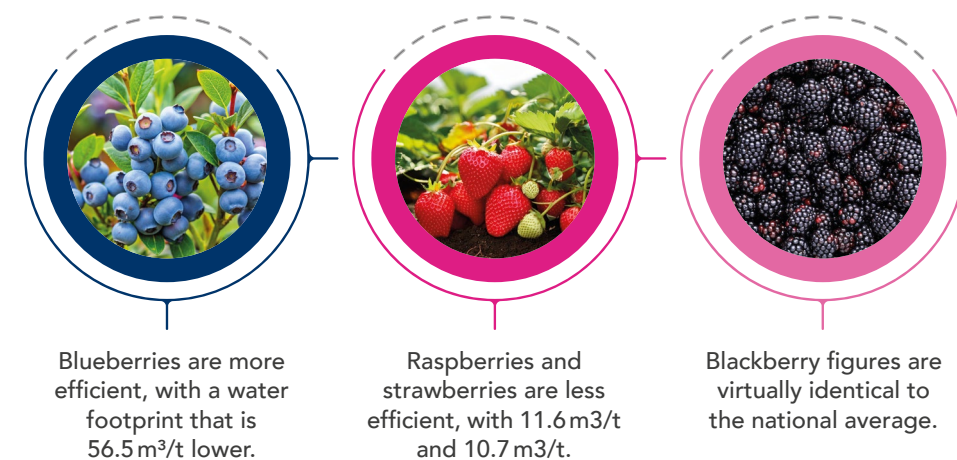
The production of berries in Michoacán reached 658,969 tonnes in 2023, concentrated in 51 municipalities, of which 12 represent 80% of the total. Of the total planted area, 46.2% is blackberry, 45.5% strawberry, 5.6% raspberry and 2.6% blueberry.

Equivalencies	Blueberry	Raspberry	Strawberry	Blackberry
t	12,110	30,354	401,800	214,706
ha	557	1,185	9,572	9,711
Yield t/ha	21.8	25.6	42	22.1

Table 41. Production of berries in Michoacán

The table shows the production of berries in Michoacán during 2023, detailing the volume harvested, the planted area and the yield per hectare. Strawberry stands out as the fruit with the highest production (401,800 tonnes) and the best yield (42 t/ha), followed by blackberry. Although blueberry has a lower volume, its productivity per hectare is also significant, reflecting efficient land use.

Compared to national averages, the water footprint per tonne in Michoacán shows variations:



Crop	Blueberry		Raspberry		Strawberry		Blackberry	
Región	Michoacán	National	Michoacán	National	Michoacán	National	Michoacán	National
Blue	273.9	318.5	204.9	197	193.1	197	142.3	15-
Green	300.6	323.2	198	200	208	200.6	169.8	15-
Grey	165.5	154	102.1	95.4	102.4	94.5	78.8	-
Total	739.5	796	504.1	492.5	503.2	492.1	390.9	39-
The total water footprint of berry production in Michoacán is 310hm³, of which 65% corresponds to strawberries, 27% to blackberries, 5% to raspberries, and 3% to blueberries.								

Table 42. Average water footprint for each fruit in Michoacán and the national average (m³/t)

The table shows the average water footprint of berries produced in Michoacán and compares it with the national average. It can be seen that the values are similar, although slightly lower in Michoacán. Strawberries account for 65% of the total water footprint of berries in the state, followed by blackberries (27%), raspberries (5%) and blueberries (3%), totaling 310hm³.



	 Blueberry	 Raspberry	 Strawberry	 Blackberry	 Total
	3.6	6	83.6	36.5	129.7
	3.3	6.2	77.6	30.6	117.7
	2	3.1	41	16.9	63
	9	15.3	202.2	83.9	310.4
% of the WF	3%	5%	65%	27%	100%
% of the surface	14%	25%	36%	25%	100%

Table 43. Water footprint of berry production in Michoacán (hm³)

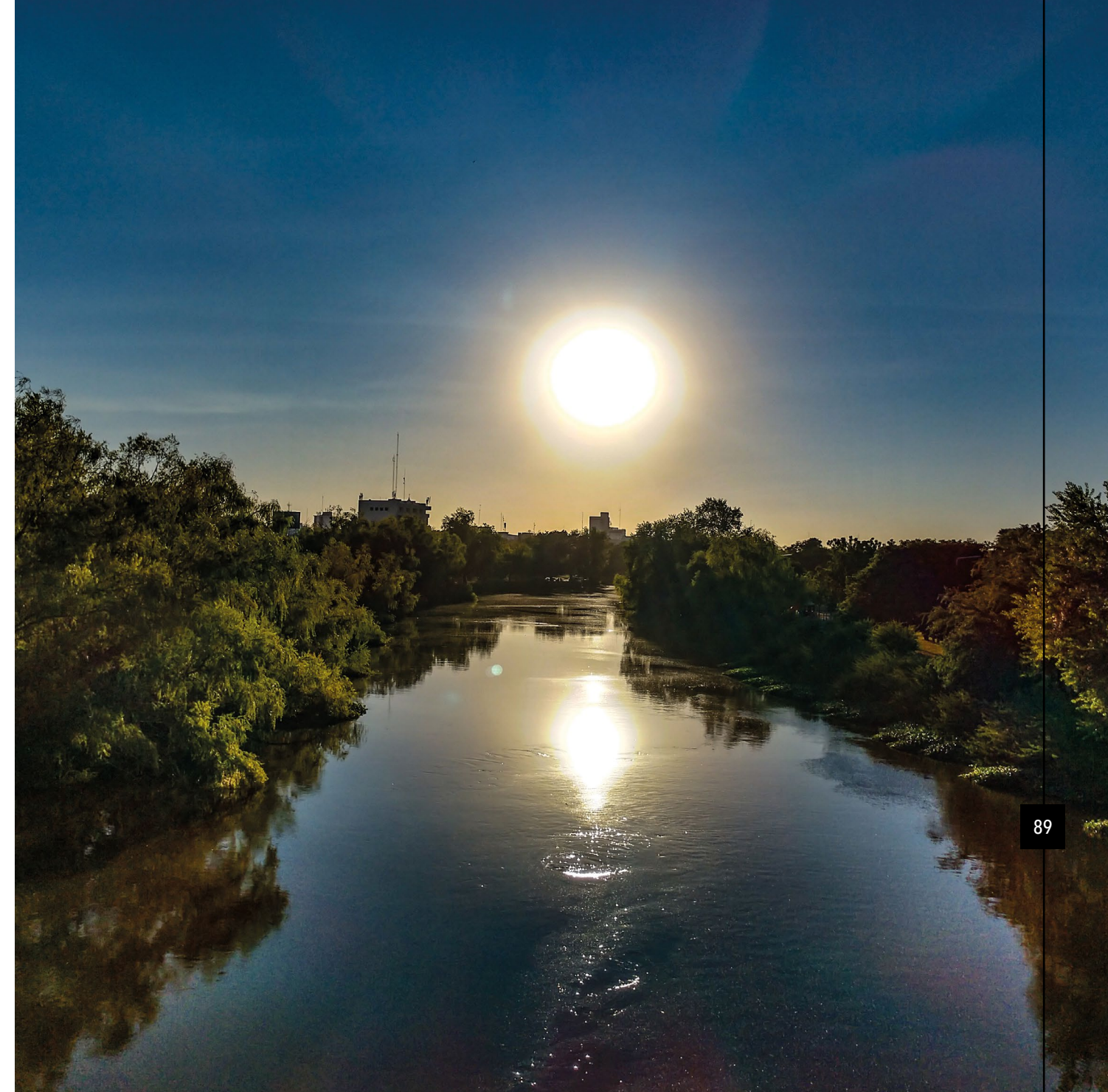
The total water footprint of berry production in Michoacán amounts to 310.4hm³. The strawberry concentrates the largest part (65%), followed by blackberry (27%), raspberry (5%) and blueberry (3%). Moreover, it is observed that the use of blue water is the highest, at 129.7 hm³. On the surface, strawberries represent 36% of the total planted in the state.

The total water footprint of berries in Michoacán amounts to 310hm³, equivalent to 56% of the total water footprint of berries in the country. Strawberry (65%) and blackberry (27%) lead in participation.

CHALLENGES TOWARDS SUSTAINABILITY

The rapid growth of agriculture in Michoacán —a 21% increase in agricultural area between 2020 and 2023— has brought economic benefits, but also environmental challenges. In irrigation area alone, it went from 454,192 hectares to 509,880 in the same period.

Since much of this production is destined for international markets demanding high sustainability standard, it is essential to drift towards more responsible agricultural models. This involves replacing chemical inputs with biological alternatives, reducing the grey water footprint, protecting soils from abiotic stress, and improving water use efficiency. Territorial planning that takes into account the productive vocation and the actual water availability of the regions is also required, thus avoiding putting even more pressure on the local systems.



Intensive and sustainable agriculture: case studies in Culiacán and the Bajío region

Agriculture in Mexico is marked by great contrasts, with regions that have achieved high levels of productivity and technification. At the same time, it faces important challenges in the sustainable use of water resources. Below are two representative cases: Culiacán, as a reference for open-field agriculture, and Culiacán, as a reference for open-field agriculture, and the Bajío (Guanajuato and Querétaro), as a leader in protected agriculture.



CULIACÁN: AGRICULTURAL POWERHOUSE FACING WATER CHALLENGES

Culiacán is one of the epicenters of Mexican agriculture. It not only supplies a significant part of the domestic market, but it also exports a wide range of products, mainly to the United States. This agriculture is not only technologically advanced, it also has a strong social component, promoting the well-being of the families that are part of its production chain.

In 2023, the planted area in Culiacán reached 252,800 hectares. Of that extension, corn accounts for 78%, while the most prominent vegetables, such as red tomato and green chili pepper, occupy 1% each. In this region is located the Irrigation District 010 Culiacán- Humaya, the second most important in the state in terms of volume of production.

Sown area in Culiacán		
Crop	Area	% of total
Grain corn	196,162	78%
Sugar cane	7,822	3%
Chickpea	7,196	3%
Peanut	6,195	2%
Grain sorghum	5,842	2%
Red tomato (jitomate)	3,609	1%
Beans	3,237	1%
Grain corn seed	3,178	1%
Safflower	2,383	1%
Green chili pepper	2,469	1%
34 other crops	14,771	6%

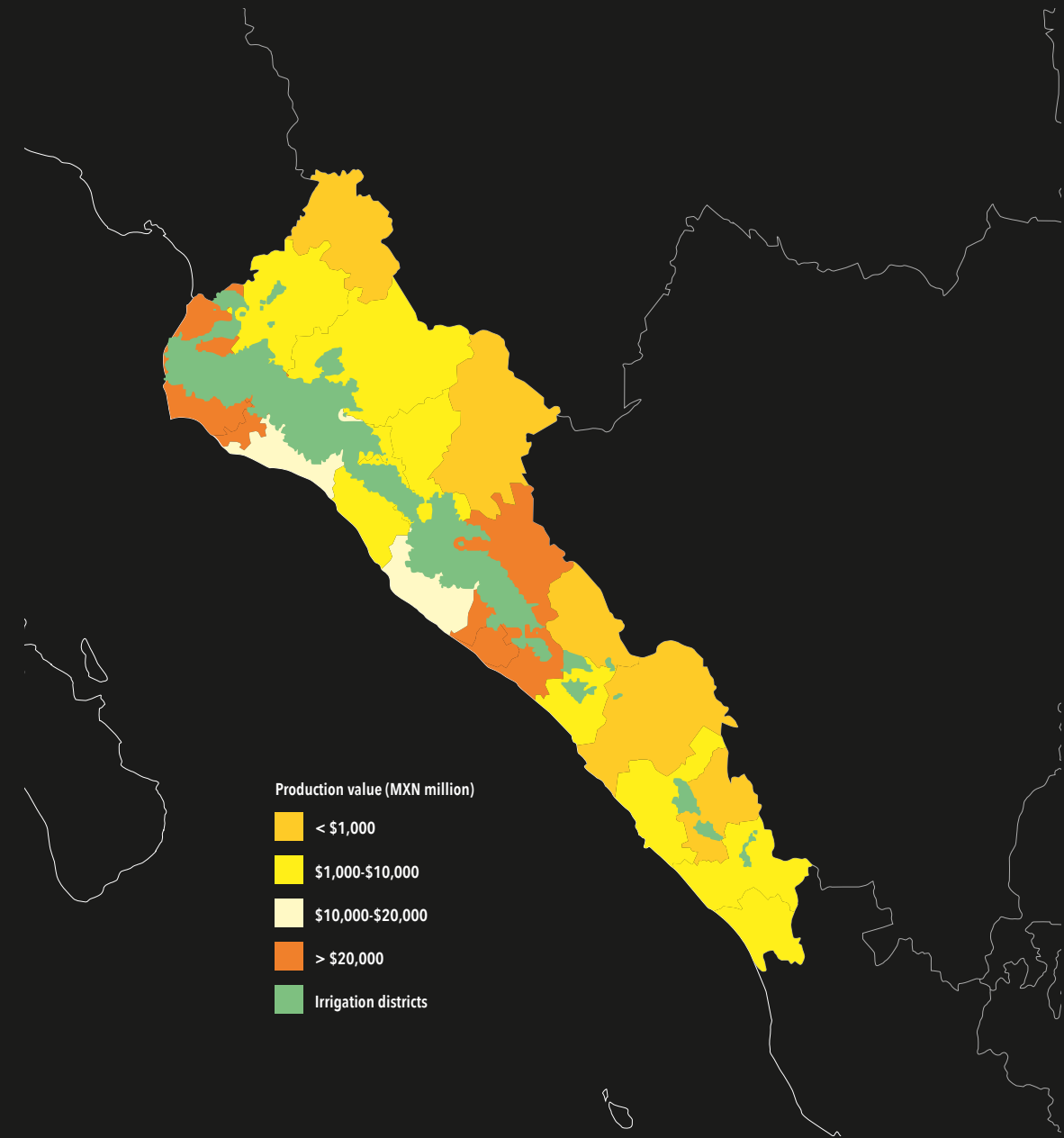
(Taking into account the municipalities of Mocorito, Navolato y Culiacán)

Table 44. Sown area in Culiacán

The table shows the distribution of the cropped area in Culiacán, including the municipalities of Mocorito, Navolato and Culiacán. Grain corn stands out by far, occupying 78% of the total. It is followed by crops such as sugar cane, chickpea and peanut, with smaller shares. Together, 34 additional crops represent only 6% of the sown area, reflecting a strong productive concentration in corn.

SINALOA: VALUE OF AGRICULTURE AND LIVESTOCK PRODUCTION AND IRRIGATION DISTRICTS IN 2023

FIGURE 28



The figure exposes the value of agricultural production in Sinaloa during 2023, along with the location of the irrigation districts. It is observed that the areas with the highest production value, greater than MXN\$20 billion, are concentrated in the center of the state, especially in areas with irrigation infrastructure. This reflects the high productivity linked to access to water for agricultural use.

From a water footprint perspective, Culiacán has some crops with particularly high indicators. Sesame has the highest unit water footprint, at 8,675 m³/tonne, followed by beans (4,688 m³/t) and safflower (4,584 m³/t). However, the largest

cumulative impact falls on corn, which accounts for 81% of the region's total water footprint. The green chili pepper, despite taking up only 0.9% of the surface, it concentrates 13% of the water footprint due to its high water demand.

Water footprint of the main crops in Culiacán (m³/t)				
	Blue	Green	Grey	Total
 Corn	272	1,287	325	1,884
 Chili pepper and bell pepper	1,113	2,845	192	4,150
 Sugar cane fruit	73	54	10	138
 Tomato	64	46	33	143
 Corn seed	367	1,613	403	2,384
 Green beans	296	1,792	285	2,373
 Beans	488	3,743	457	4,688
 Cucumber	15	69	45	128
 Chickpeas	61	1,096	165	1,323
 Sorghum	226	334	25	585
 Mango	523	759	98	1,380
 Safflower	699	3,850	35	4,584
 Eggplant	25	135	28	187
 Orange	189	414	79	682
 Green forage sorghum	160	434	26	619
 Peanut	-	2,185	34	2,219
 Onion	126	207	62	395
 Lemon	157	355	74	586
 Sesame	623	7,952	99	8,675
 Zucchini	16	56	36	108
 Spinach	55	196	62	314
 Green tomato	62	34	35	130
 Avocado	368	640	80	1,088

Table 45. Water footprint of the main crops in Culiacán (m³/t)

The table presents the water footprint of the main crops in Culiacán, expressed in cubic metres of water per tonne produced. It is observed that crops such as chili pepper, beans, and safflower have a high demand for water, exceeding 4,000 m³/t. In contrast, others such as tomato, cucumber, and Mexican zucchini show much lower usage. This information is key to planning more efficient water management.

The total water footprint of agricultural production in Culiacán is 5,605 cubic hectometres (hm³) which is equivalent to 3.6% of the national water footprint of the agricultural sector.

Water footprint of agriculture in Culiacán (hm³)					
Crops	Tonnes	Blue	Green	Grey	Total
 Grain corn	2,398,442	651	3,087	780	4,519
 Green chili pepper	178,729	199	509	34	742
 Sugar cane	478,130	35	26	5	66
 Red tomato (jitomate)	296,844	19	14	10	42
 Grain corn seed	14,300	5	23	6	34
 Green beans	13,863	4	25	4	33
 Beans	6,543	3	24	3	31
 Cucumber	155,871	2	11	7	20
 Rest of crops	240,286	28	73	17	118

Table 46. Water footprint of agriculture in Culiacán (hm³)

Among the total water footprint of some crops in Culiacán, grain corn seed, green beans, and beans have similar values, between 31 and 34hm³, despite their lower production volumes. In contrast, cucumber, with more than 155 thousand tonnes, has a lower total footprint (20hm³), which reflects a higher water efficiency in its production.

CHALLENGES TOWARDS SUSTAINABILITY

Culiacán has begun to take steps towards a more sustainable agriculture. Technologies and good practices have been incorporated in the management of water and soil, although these actions have not yet permeated all producers. One of the main challenges is to reduce the use of harmful agrochemicals and promote more environmentally friendly practices, both at the plot level and at regional planning. The key will be to scale these initiatives and consolidate a production culture that maintains the region’s economic leadership without compromising its natural resources.



AGRICULTURE IN THE BAJÍO: INNOVATION UNDER ROOF

In the Bajío region, which mainly covers Guanajuato and Querétaro, a highly technological model of protected agriculture has been consolidated. This type of production is carried out in closed structures such as greenhouses, macrotunnels or shade nets, which allows for precise control of the environment, protects against weather phenomena and minimizes the risks from pests and diseases.

This area is one of the most advanced in the country in terms of agricultural infrastructure. Sensors, high-precision irrigation systems, drones, water treatments and specialized software for crop management are used. In addition, post-harvest facilities such as cold rooms, packaging centers and logistics platforms have been developed, which strengthen their competitiveness.

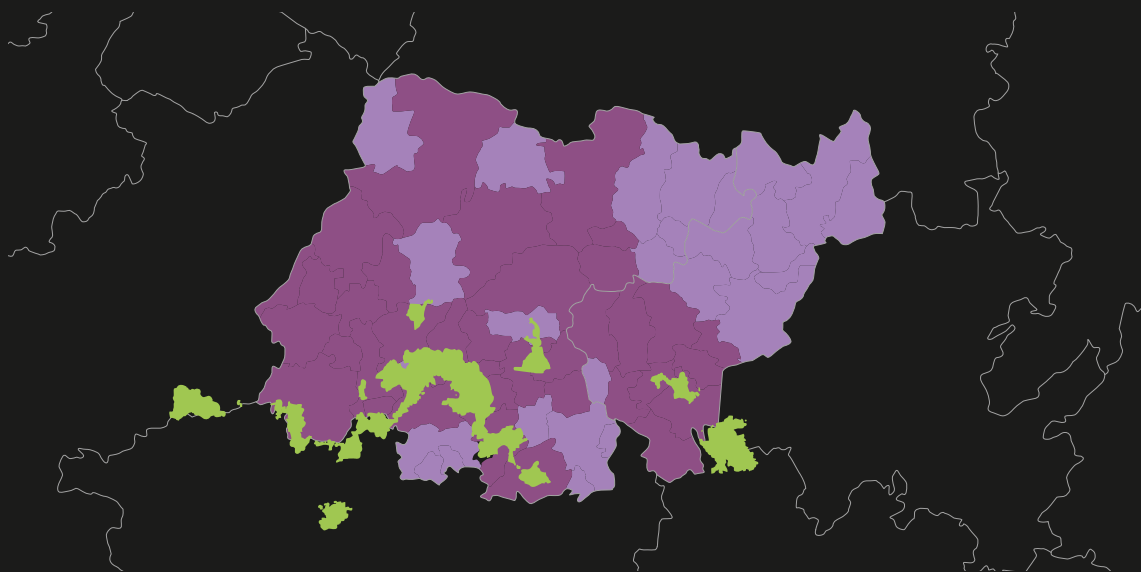
The predominant infrastructure in the region is the greenhouse (51% of the area), followed by the macro-tunnels (40%) and, to a lesser extent, the shade net (9%). In total, the protected area amounts to 4,024 hectares, representing a growth of 600% since 2010 and 175% since 2015.



THE BAJÍO: VALUE OF AGRICULTURAL PRODUCTION
AND IRRIGATION DISTRICTS IN 2023

Production value (MXN million)

< \$1,000 \$1,000-\$10,000 Irrigation districts

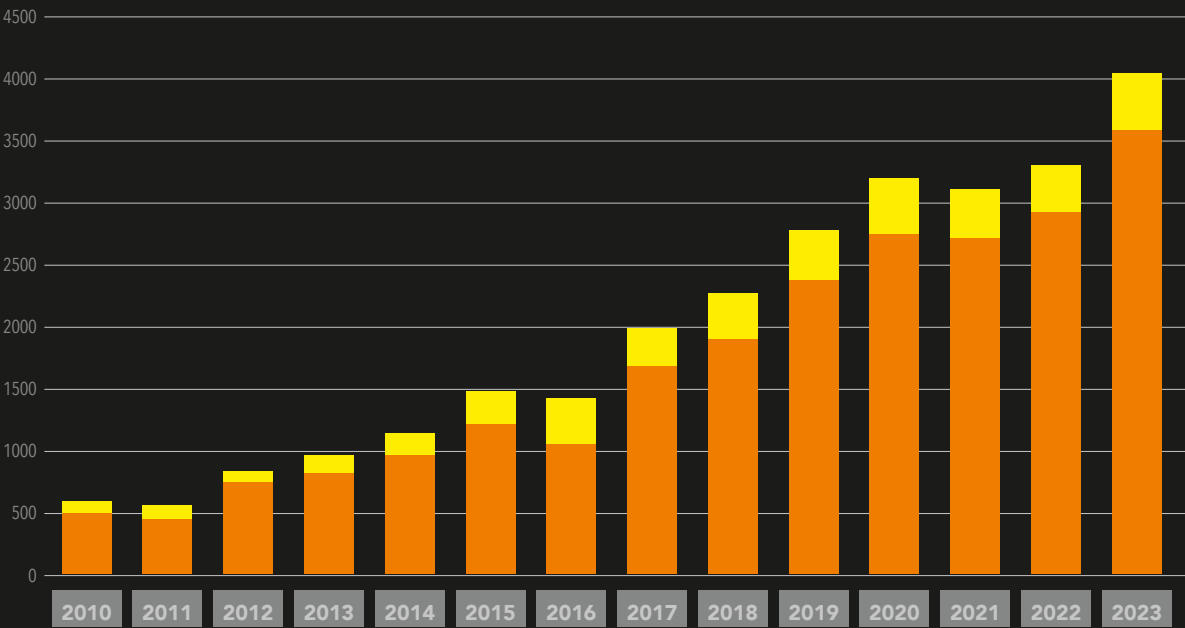


The figure shows the value of agricultural production in the Bajío, covering Guanajuato and Querétaro, during 2023. The areas with the highest incomes, which exceed MXN\$20 billion, are concentrated in regions with irrigation districts such as Alto Río Lerma, La Begoña and San Juan del Río. This highlights the close relationship between water infrastructure and agricultural productivity in the region.

FIGURE 29

PROTECTED AREA IN THE BAJÍO (2010-2023)

Guanajuato Querétaro



The figure shows the constant growth of the protected area in the Bajío (Guanajuato and Querétaro) between 2010 and 2023, destined for the use of greenhouses, macro-tunnels and shade net. This type of infrastructure went from less than 500 hectares in 2010 to more than 4,000 hectares in 2023, highlighting a strong boost to mechanized agriculture and greater water efficiency in the region.

FIGURE 31

“Green chili pepper is the crop that contributes the most to the water footprint within protected agriculture in the Bajío region, concentrating 81% of the total registered for this type of production.”

In 2023, 11 products were cultivated under protected agriculture. Four of them concentrate 87% of the total surface area: strawberry (39%), red tomato (21%), green chili pepper (18%) and blueberry (10%). These crops generated a combined value of MXN\$5,674 million.

Protected (Guanajuato and Querétaro), 2023			
Crop	Area	Tonnes	Value (MXN million)
 Strawberry	1,550	90,964	\$1,272
 Red tomato (jitomate)	830	190,278	\$1,802
 Green chili pepper	719	96,610	\$1,733
 Blueberry	386	2,878	\$181
 Raspberry	240	4,320	\$211
 Cucumber	209	31,913	\$341
 Lettuce	42	4,800	\$30
 Zucchini	27	1,902	\$9
 Blackberry	9	138	\$5
 Mushrooms, edible fungus and champignons	8	3,182	\$89
 Avocado	4	60	\$1
Total	4024.1	427,046	\$5,674

Table 47. Protected area in 2023 (Guanajuato and Querétaro)

Among the main crops in protected surface area in Guanajuato and Querétaro during 2023, strawberry, tomato and green chili pepper stand out, which concentrate most of the economic value and production volume. In total, more than 427 thousand tonnes were cultivated in 4,024 hectares, generating an estimated value of MXN\$5,674 million, reflecting the importance of this production modality.

From the water perspective, green chili pepper has the highest unitary water footprint (4,076 m³/t), followed by blueberry (1,310 m³/t) and avocado (1,192 m³/t). Blueberry is also the only crop where the use of blue water predominates, representing 52% of its total water footprint.

Water footprint of protected crops in the Bajío (m³/t)				
Crop	Blue	Green	Grey	Total
 Green chili pepper	313	3,501	262	4,076
 Blueberry	680	372	257	1,310
 Avocado	374	713	104	1,192
 Blackberry	312	171	128	612
 Red tomato (jitomate)	0	207	84	291
 Strawberry	87	169	35	291
 Mushrooms, edible fungus and champignons	70	106	45	221
 Cucumber	49	103	55	199
 Zucchini	37	96	66	199
 Lettuce	8	134	48	190
 Raspberry	87	53	40	179

Table 48. Water footprint of protected crops in the Bajío (m³/t)

The table shows the water footprint of protected crops in the Bajío region, expressed in cubic metres per tonne. Green chili pepper has the highest water consumption with 4,076 m³/t, followed by blueberry and avocado. In contrast, crops such as raspberry, lettuce, and zucchini have a significantly lower footprint, which allows for identifying opportunities for more efficient water use production.

Crop	Tonelada	Blue	Green	Grey	Total
 Green chili pepper	96,610	30.22	338.26	25.33	393.8
 Red tomato (jitomate)	190,278	0	39.37	16.03	55.4
 Strawberry	90,964	7.93	15.49	3.65	27.1
 Cucumber	31,913	1.56	3.29	1.17	5.8
 Blueberry	2,878	1.95	1.07	0.74	3.8
 Lettuce	4,800	0.04	0.64	0.23	0.9
 Raspberry	4,320	0.38	0.23	0.18	0.8
 Mushrooms, edible fungus and champignons	3,182	0.22	0.34	0.14	0.7
 Zucchini	1,902	0.07	0.18	0.12	0.4
 Blackberry	138	0.04	0.04	0.01	0.1
 Avocado	60	0.02	0.04	0.01	0.1
Total	427,046	42	399	48	489

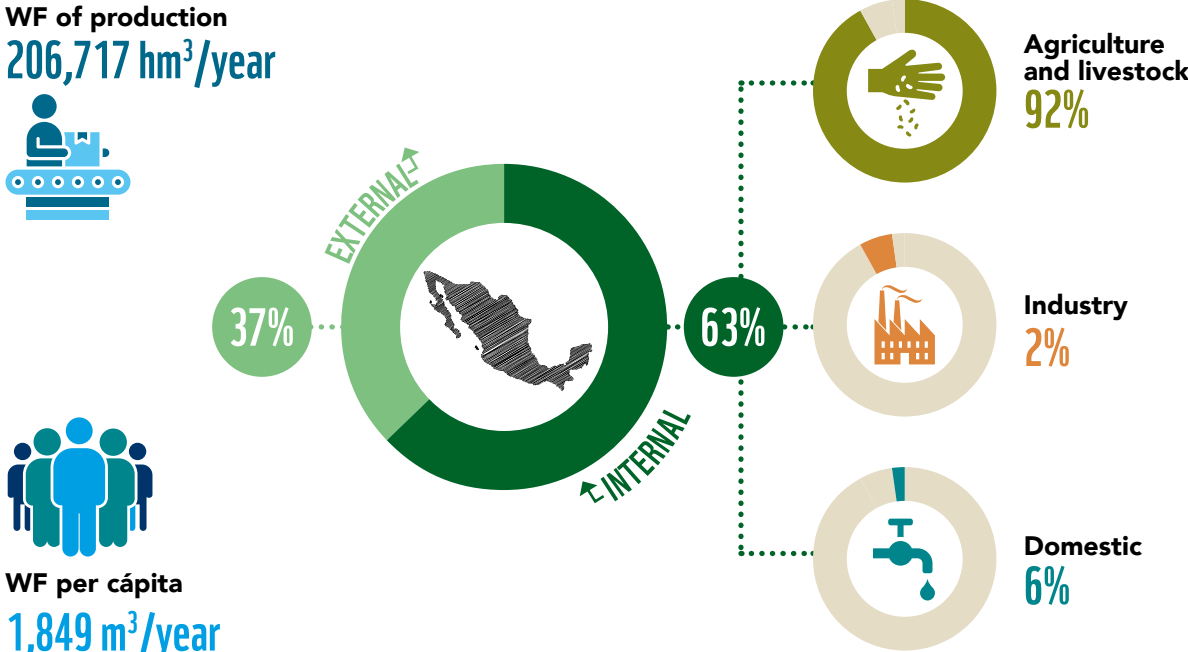
Table 49. Water footprint of protected crops in the Bajío (m³/t)

The table presents the total water footprint of protected crops in Bajío, considering the volume of production and the type of water used. Green chili pepper stands out for its high total water footprint, followed by tomato and strawberry. In contrast, crops such as zucchini, avocado and mushrooms present a much lower impact, which can guide decisions towards more efficient and sustainable production.

Overall, the total water footprint of protected agriculture in the Bajío is 489hm³, composed of 81.6% green water, 9.8% grey water and 8.6% blue water. The crop that contributes the most to this figure is green chili pepper, with 81% of the total, followed by red tomato (11%) and strawberry (5%). The rest of the crops represent only 3%.

FIGURE 31

MEXICAN WATER FOOTPRINT: KEY INDICATORS



In the overview of the Mexican water footprint, each inhabitant consumes on average 1,849 m³ of water per year. Of the national total, 63% comes from internal water and 37% is external. The agriculture and livestock sector concentrates 92% of the use, followed by domestic with 6% and industrial with 2%. The total annual WF amounts to 206,717 cubic hectometres.

CHALLENGES TOWARDS SUSTAINABILITY

Although the Bajío has demonstrated that it is possible to combine profitability with innovation, it still faces significant challenges to achieve a fully sustainable model. The region already has ideal technological conditions to promote water treatment and reuse. However, it is necessary to go beyond infrastructure: a widespread adoption of biological inputs and regenerative management practices that reduce the grey water footprint and improve soil health is required.

Since this form of agriculture will continue to grow as long as the market allows it, it is essential to establish clear limits based on regional water capacity, land use suitability, and current pressure on aquifers. Only in this way can it be ensured that the rise in protected agriculture does not compromise the ecological balance of the region.

Reflections Growth, consumption and challenges in Mexico's water footprint

The water footprint in Mexico has grown compared to previous measuring, both at the national and sectoral levels. This increase is due to various interrelated factors that need to be analyzed to understand their impact.

PRODUCTION WATER FOOTPRINT

Among the most important elements that explain this growth are:

- The expansion of irrigated agriculture, which grew from 5.6 million hectares in 2010 to 6.2 million in 2023.
- The increase in the volume of water allocated for agricultural use, from 57,381 cubic hectometres (hm³) in 2012 to 61,308 hm³ in 2023.
- The new agricultural areas are mostly intended for crops with high water demand and high water footprint.
- A growth in industrial activities and in the volumes of water granted for this sector: from 2,019 hm³ in 2012 to 2,786 hm³ in 2024.

These changes have not been sufficiently accompanied by practices that promote efficient management of the water footprint in the different sectors.

VIRTUAL WATER EXPORTS

The growth in Mexican exports has also had an impact. The total volume of exported products increased from 120 million tonnes to 160 million in 2022.

In particular, agricultural exports—which involve a high unit water footprint—have grown considerably. In 2010, 11.4 million tonnes of primary sector products were exported, and in 2024 this figure exceeded 18 million (Chatham House, 2024).

This increase reflects the growing presence of the Mexican countryside in international markets.

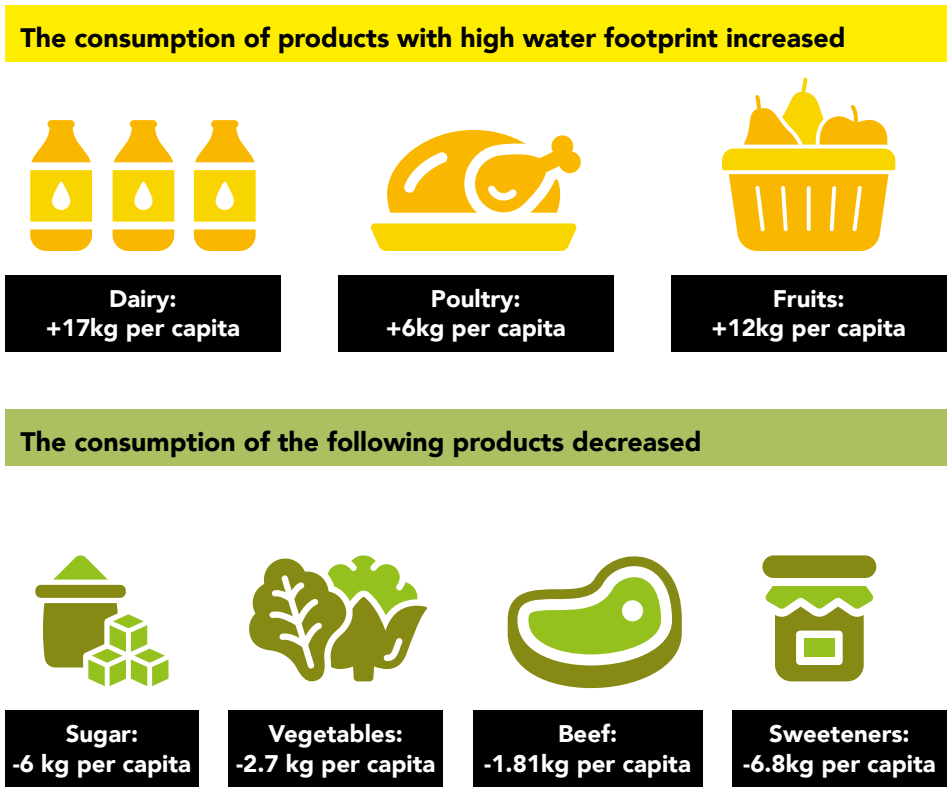
CONSUMPTION

Another key factor is the country’s population growth. The population increased from 112 million people in 2010 to 134 million in 2023 (INEGI), which naturally increases the demand for water.

CONSUMPTION PER CÁPITA

The per capita water consumption decreased slightly: from 1,978m³ per person per year (AgroDer, 2012) to 1,849m³ in recent years.

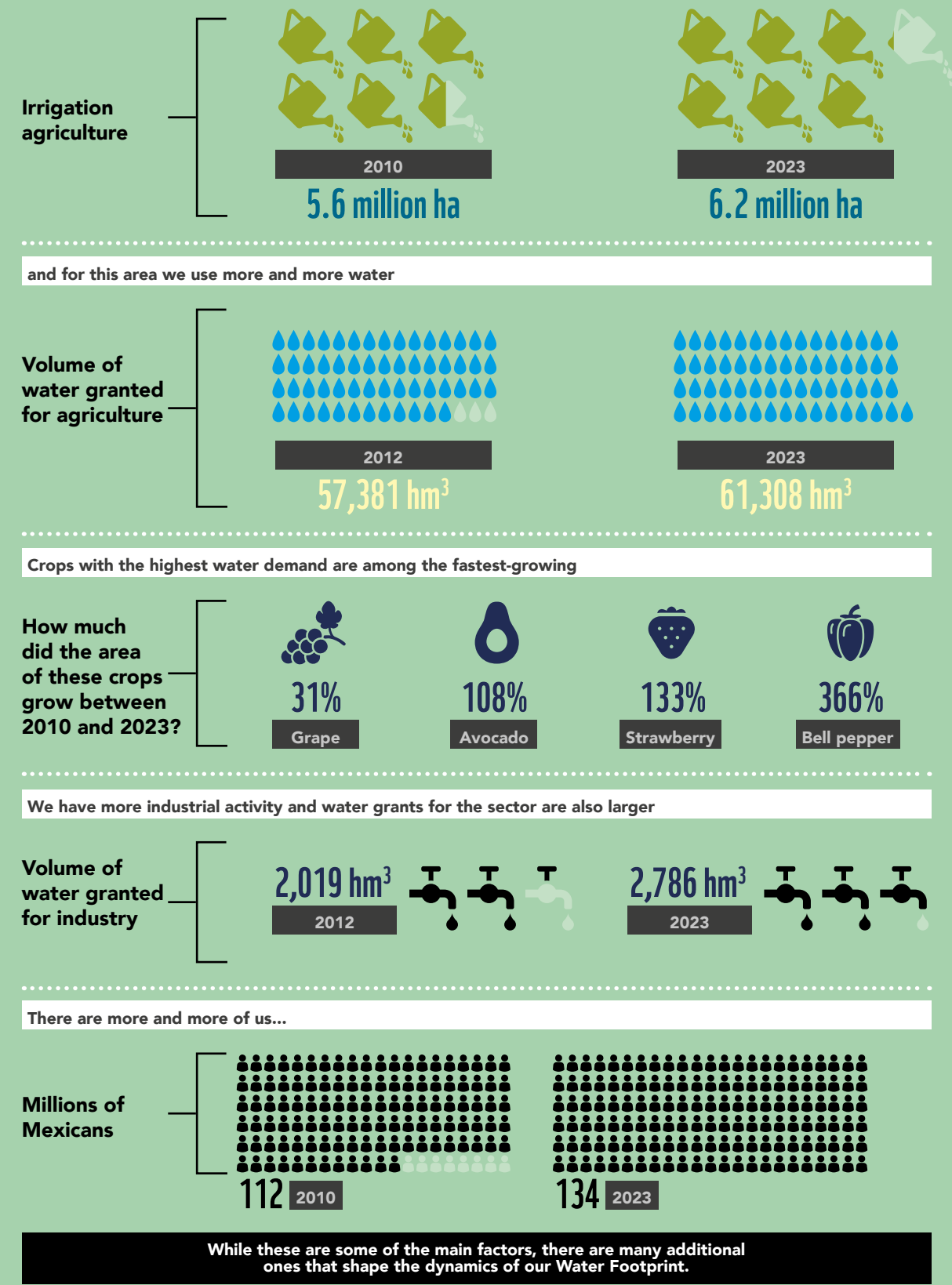
However, significant changes in the consumption patterns are detected in the food:



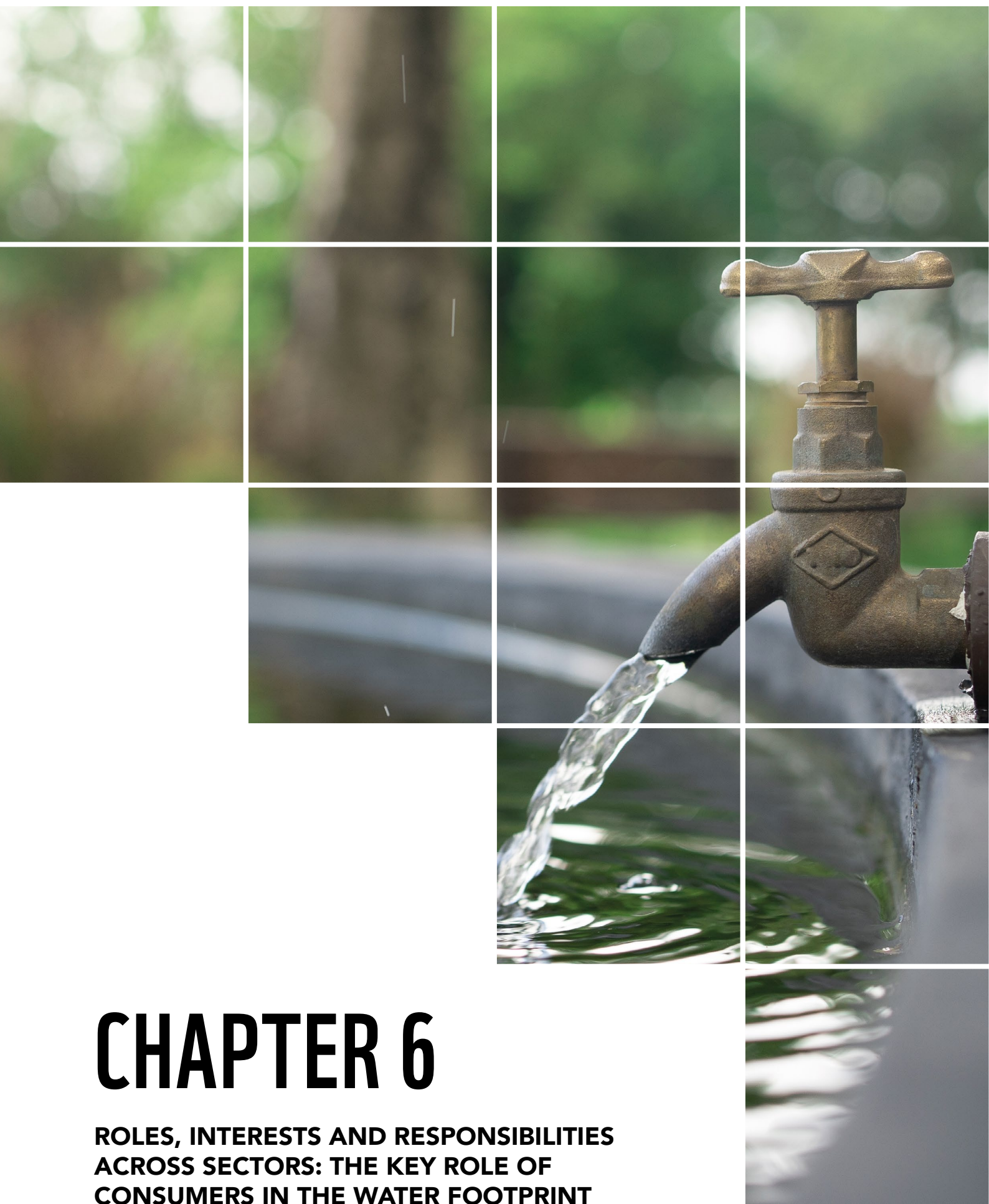
These data reflect a transformation in consumption habits that also impacts the country’s total water footprint.💧

FIGURE 32

WHY HAS OUR WATER FOOTPRINT INCREASED?



The figure explains why the water footprint has grown in Mexico. The increase in irrigation stands out. It went from 5.6 to 6.2 million hectares between 2010 and 2023, as well as the increase in the volume of water granted. High water demand crops also increased, such as bell pepper and avocado. In addition, there is the growth in population and the expansion of the industrial sector.



CHAPTER 6

ROLES, INTERESTS AND RESPONSIBILITIES
ACROSS SECTORS: THE KEY ROLE OF
CONSUMERS IN THE WATER FOOTPRINT

Consumers Decisions that transform

Consumers play a crucial role in reducing the water footprint, both through their daily habits and their purchasing decisions. There is a growing interest in practices that promote sustainability and water conservation, especially in the face of increasing global water scarcity.

More and more people are showing greater social responsibility by preferring sustainable agricultural products and those that minimize water use in their production. This awareness is also related to health, since opting for more sustainable diets—for example, with a greater presence of vegetables instead of meat—can significantly contribute to reducing the environmental impact.



Some recommended practices for consumers are:

REDUCTION OF DIRECT WATER FOOTPRINT:



Saving water at home: Taking shorter showers, fixing leaks, and using appliances (such as washing machines or dishwashers) only when they are fully loaded.



Rainwater harvesting: Using it for irrigation or other non-potable activities.

REDUCTION OF INDIRECT WATER FOOTPRINT:



Product substitution: Choosing products that have a lower water footprint, either because they are of a different nature, of more efficient origin, or because they are made in basins with less pressure on water.



Reducing food waste: Reducing food waste not only saves water, but also soil, inputs, workforce, and financial resources.



Avoiding products from unsustainable basins: This requires transparency from companies and an informed citizens about the water situation in the regions of origin.



Demanding information: Demanding transparency from companies and governments about the water footprint of products and the regulations that affect them.



Dietary changes: Adopting diets with a higher proportion of fruits and vegetables, which require less water than meat production.



Choosing responsible brands: Opting for products from companies that implement sustainable and environmentally friendly practices.



Informing ourselves and measuring: Using simulators and other tools to learn about the water footprint of the products you consume and make informed decisions.

The greatest power of the consumer lies in their ability to influence the decisions of brands. When people choose sustainable products, they motivate companies to integrate these practices throughout their entire supply chain.

Companies Innovation and commitment for responsible water management

Having an efficient and sustainable approach to water use is key for companies, not only from an environmental perspective, but also for their economic viability and its social impact. More and more, companies recognize the importance of adopting practices that minimize their water footprint, not only for reputational reasons, but also to reduce operational risks and costs.

Across the country, numerous companies are adopting international standards, certifications and strategies to improve their water efficiency. This responsible management not only enhances their reputation in front of consumers and authorities, but also improves their competitiveness in the market.

REDUCTION OF THE OPERATIONAL WATER FOOTPRINT

Among the most common and recommended actions are:



Assessment and monitoring: Conducting comprehensive diagnostics of water use in all operational areas, with continuous monitoring systems that detect leaks and inefficiencies.



Water saving in operations: Incorporating efficient technologies, such as aerated faucets and optimized irrigation systems.



Reusing and treating greywater: Implementing water recycling systems in industrial processes, promoting a circular economy model.



Better practices and technologies: Using advanced technologies to optimize processes, control temperature, treat water before discharge, and improve efficiency in the withdrawal and return of water, both surface and underground.



Staff education and involvement: Promoting an internal culture of responsible water use, motivating employees to apply good practices both at work and in their daily lives.



Community-impact initiatives: Developing projects that improve the conditions of the environment, including ecosystem restoration and strengthening of ecosystem services such as water supply.

REDUCTION OF THE WATER FOOTPRINT IN THE SUPPLY CHAIN

Each actor within a supply chain has the potential to reduce their water footprint, especially in non-sustainable or inefficient activities. This implies:



Evaluate water use not only within the company, but also in the processes of suppliers and at the origin of inputs and raw materials.



Positively influence suppliers to adopt efficient practices, thus ensuring future supply of water for the entire chain.

TRANSPARENCY IN PRODUCTS AND PROCESSES



Reports and disclosure: Publish reports on water use and the progress in the reduction of water footprint. This reinforces transparency and strengthens the trust of consumers, regulators and investors.



Certifications: Participate in national and international initiatives which require commitments to responsible water management. Certifications add value to products, which improves their access and permanence in increasingly demanding and aware markets.



Governments

Public policy for sustainable water management

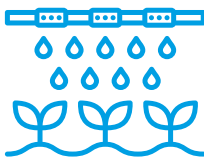
The government sector plays a key role in protecting water resources. It is their responsibility to establish a solid regulatory framework that regulates the use of water, limits excessive consumption and promotes sustainable practices in all sectors, from agriculture to industry.

REGULATIONS AND STANDARDS

Governments should update and enforce regulations such as the **NMX-AA-184-SC-FI-2021**, giving it a more rigorous focus on water footprint. It is fundamental to incorporate this concept into national water policies and ensure its coherence with other public policies (environmental, agricultural, energy, commercial and foreign).

INFRASTRUCTURE AND EDUCATION

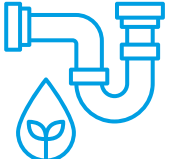
It is also crucial to invest in infrastructure for the supply, distribution and treatment of water, through:



Efficient irrigation systems



Wastewater treatment plans



Distribution networks that reduce leaks and losses

In addition, governments must promote education in the responsible use of water, both among citizens and in large-scale users. This includes public campaigns to promote sustainable practices in households and companies.

ASSESSMENT OF THE WATER FOOTPRINT AND STRATEGIC PLANNING

Leveraging the communicative power of the water footprint is essential. It is recommended to:

Include it as a basic tool in water planning and decision-making.

Strategically evaluate the location of public utilities with high water demand, promoting the use of alternative sources or their relocation if necessary.

Apply criteria **circularity** and water reuse in public services to reduce its own water footprint.



ENVIRONMENTAL FLOW AND WATER ALLOCATION

Water for the environment must be prioritized. Integrating flow rate analysis with water footprint assessment is key to a fair and sustainable allocation of concessions. In this context, instruments such as Water Reserves take on special relevance.

TRANSPARENCY AND CONSUMER INFORMATION

Transparency around consumer products must be promoted, allowing citizens to make informed decisions. While it would be ideal to label all water-intensive products, a more feasible approach is to highlight those that demonstrate water efficiency and local sustainability, encouraging their consumption.

ZONING BY BASINS AND USAGE LIMITS

It is necessary to establish limits on water use by basin, not only in numerical terms, but by evaluating the sustainability of use based on:

- The water regime
- The environmental flow
- Local efficiency and sustainability at production sites

This includes promoting the use of inputs that come from regions where water use is truly sustainable.

INTEGRATED MANAGEMENT AND APPLIED SCIENCE

Integrated Water Resources Management (IWRM) should coordinate all sectors and levels of government, considering the quality, quantity and distribution of water.

Finally, the state should actively support scientific research and the development of technologies that improve efficiency and reduce waste in all sectors.

NGOs

Strategic allies for fair and sustainable water management

Non-governmental organizations (NGOs) play a crucial role in promoting water sustainability and reducing the water footprint through multiple actions in various sectors.

These organizations:



RIGHT TO WATER

NGOs advocate for the recognition of access to water as a fundamental human right, working to ensure that all people have access to clean water and sanitation services, in accordance with existing regulatory frameworks.

WATER FOOTPRINT CERTIFICATION

They accompany companies and industries in their water footprint certification processes, providing them with advice on efficiency, compliance with standards and continuous improvement.

RESPONSIBLE LABELING

They promote the use of labels for water-efficient products sourced from sustainable basins. These labels allow consumers to make informed decisions, encouraging good production and consumption practices based on tools such as the water footprint.

SCIENCE AT THE SERVICE OF POLICY

They develop technical and scientific studies —on topics such as water footprint, environmental flow or hydrography— that generate solid information to support public policies and decisions regarding water management.

CONSERVATION AND SUSTAINABLE PRODUCTION

They promote practices for the conservation of ecosystems and sustainable production, especially in areas with high pressure or water scarcity (hot spots), contributing to a more balanced use of resources.

FINANCING AND CAPACITY BUILDING

They provide financing and training schemes to facilitate technological adoption among producers and companies, fostering innovation and efficient water use.

Specific actions by sector Keys to reducing the water footprint in Mexico

Based on the information presented, specific actions can be recommended to reduce the water footprint in different sectors and types of water (blue, green and grey), both in volume and in local impact, in pursuit of a greater sustainability.

DOMESTIC SECTOR



Blue water: Reduce use in everyday activities such as bathing, cleaning and food preparation. Reduce indirect consumption by avoiding waste and choosing products with a lower water footprint, preferably from local sources.



Green water: It is not relevant, except through the consumption of agricultural products.



Grey water: Improve the management of household waste. Avoid pouring oils, chemicals or toxic substances. Promote more efficient sanitary management.

INDUSTRIAL SECTOR



Blue water: Move towards a zero blue water footprint. This involves eliminating losses through evaporation and reusing water to the maximum extent, except for that which is directly incorporated into products.



Green water: It's not relevant, except for inputs from the primary sector.



Grey water: Transition to a zero grey water footprint, through the complete treatment of wastewater, its reuse and thermal control of discharges.

AGRICULTURE AND LIVESTOCK SECTOR



Blue water: Reducing the WF per tonne produced by increasing the yields through advanced irrigation methods (such as drip irrigation) and reducing the proportion of blue water in relation to green water.



Green water: Improve the productivity of green water in rain-fed agriculture and pastures, leveraging local rainfall patterns.



Grey water: Minimize the use of agrochemicals and apply inputs efficiently. Transition to regenerative and organic agriculture models. 💧

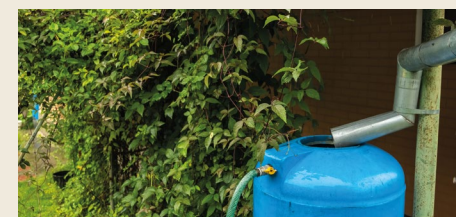
CROSS-CUTTING ACTIONS FOR WATER SUSTAINABILITY



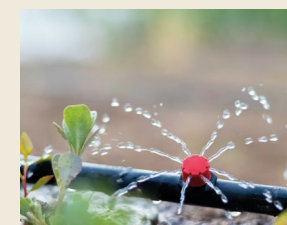
Avoid unnecessary agricultural expansion, opting for better yields on existing plots through regenerative practices and efficient irrigation technologies.



Disseminate the concept of water footprint, adapted to each sector and type of audience, to promote informed and collaborative decisions among consumers, companies, governments and communities.



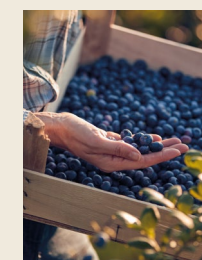
Promote rainwater harvesting rain, both in urban and rural environments. In cities, it reduces grey water and improves water efficiency. In the countryside, it boosts the productivity of green water. Its impact on urban and agricultural expansion should be considered.



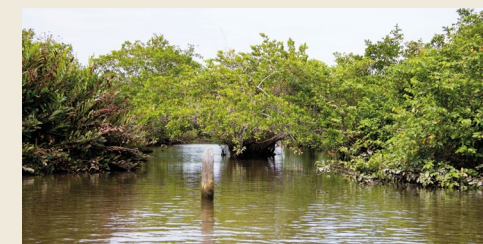
Investing in technology, such as moisture sensors, drip irrigation systems, and IoT-based smart water management, smart metres, and advanced treatments (membranes, oxidation) for water reuse.



Respect the regional productive vocation, adapting activities to water and ecological conditions locales, with clear regulations on concessions and mechanisms for transferring water between sectors.



Promote good practices in all sectors, linking sustainable production with market incentives.



Increase investment in green infrastructure, such as natural areas that promote aquifer recharge, reduce erosion, and help mitigate urban heat.



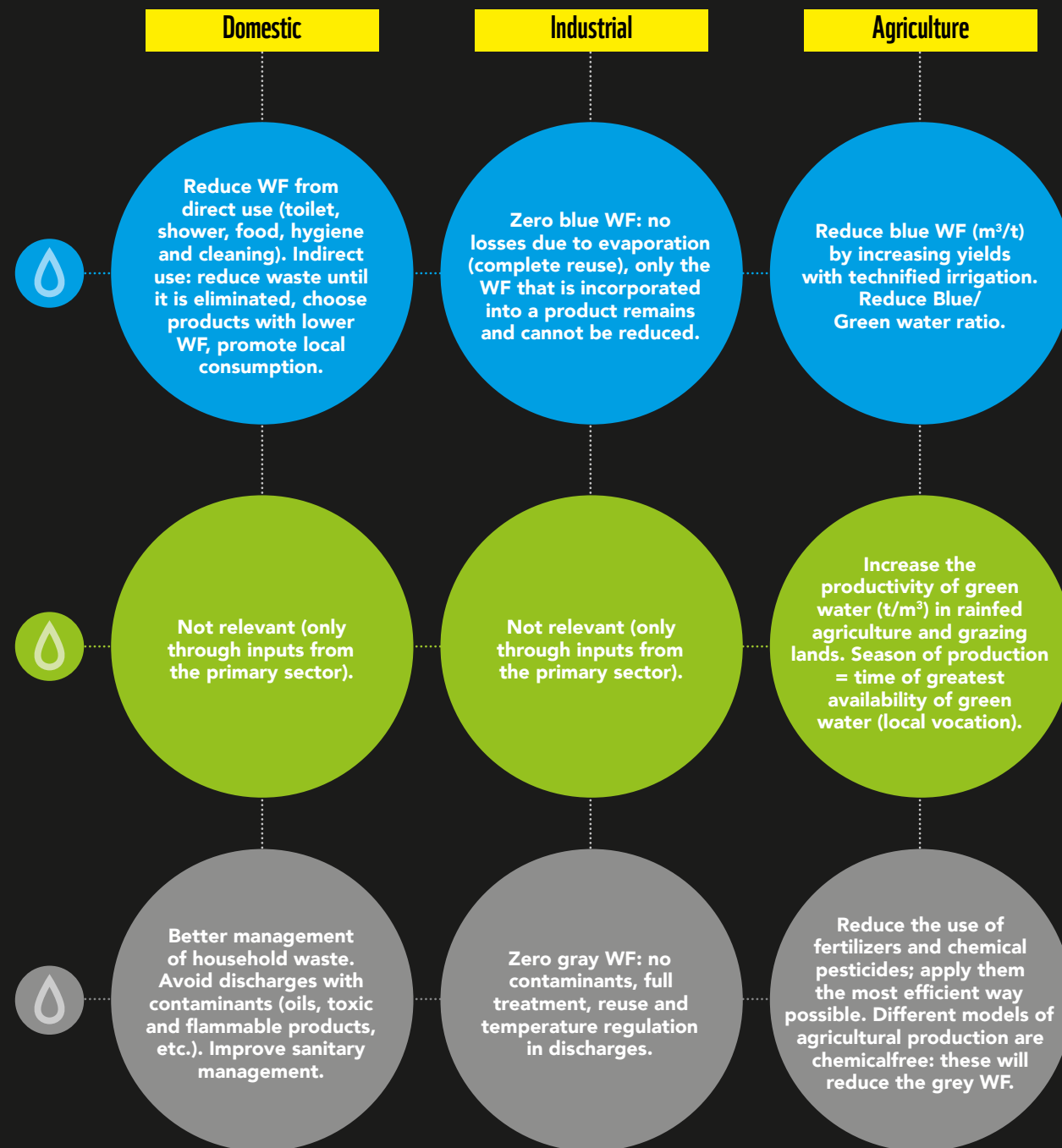
Reuse, treat, and harness water across all sectors, reducing the grey water footprint and ensuring new sources through technologies that allow the use of recycled water in agriculture, industry, and cities.



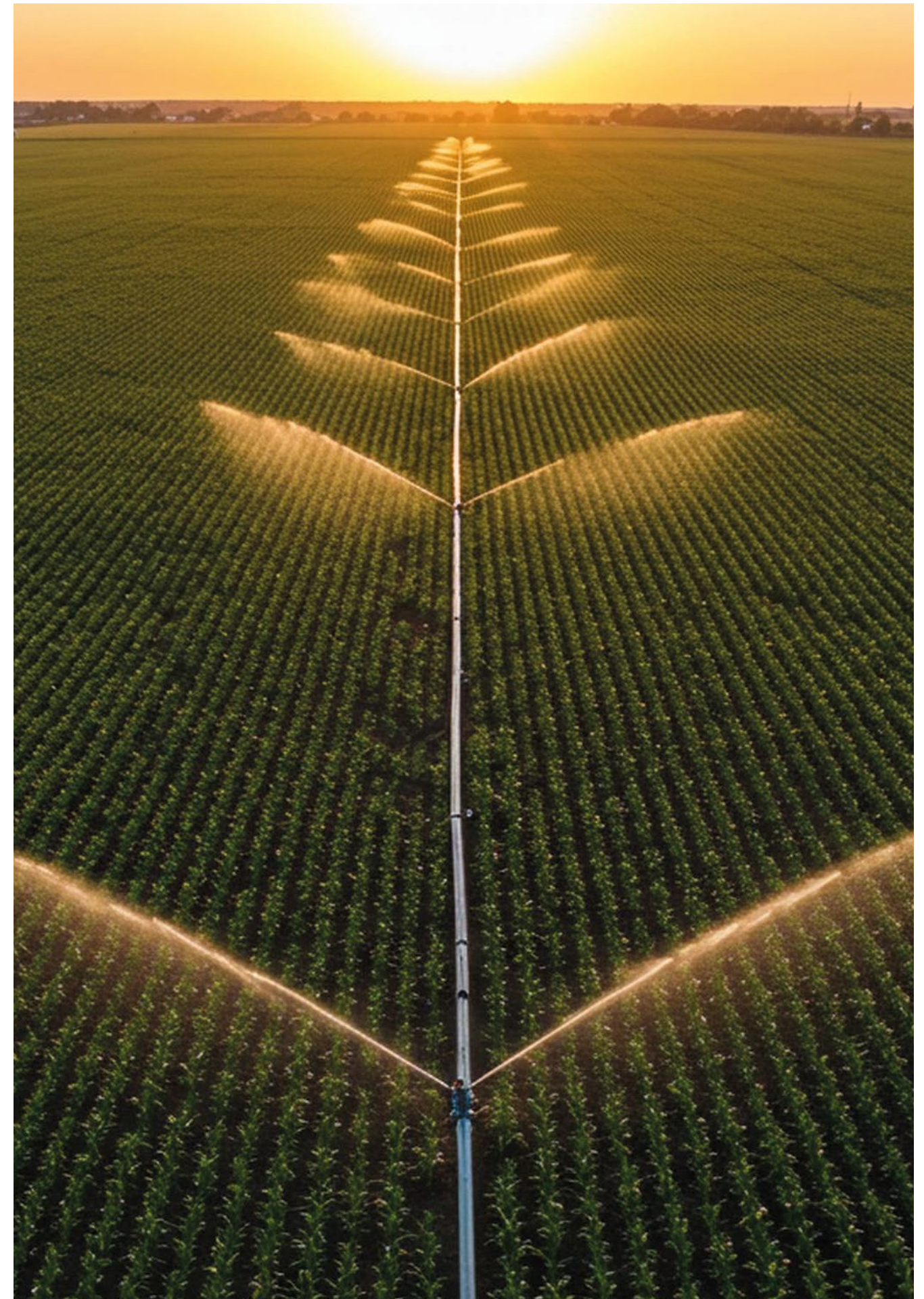
Drive science for policy, combining tools like environmental flow and water footprint to design innovative and sustainable policies.

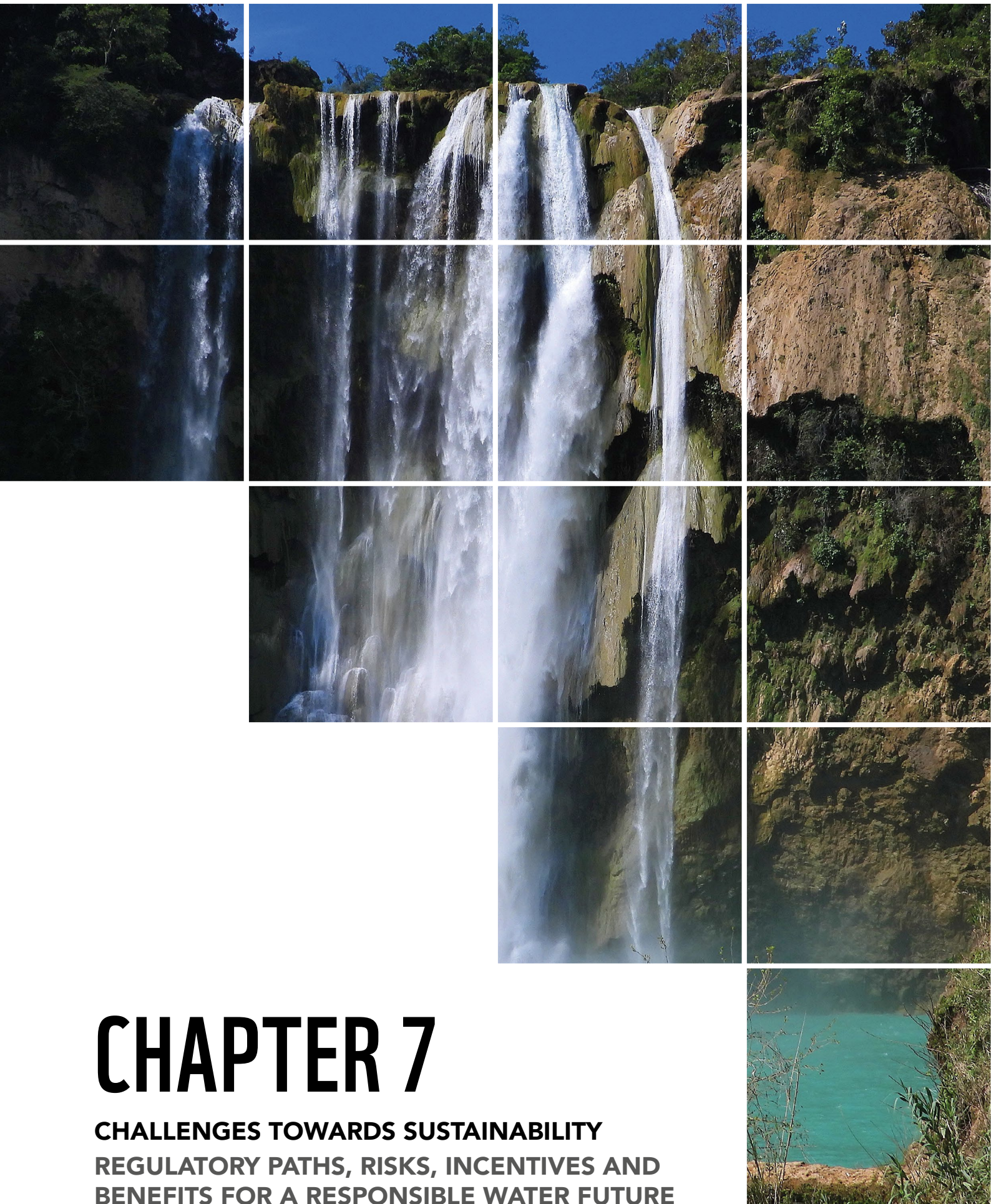
**SPECIFIC ACTIONS TO IMPROVE THE WATER FOOTPRINT
BY SECTOR AND TYPE OF WATER**

FIGURE 33



The figure presents concrete actions to improve the water footprint (WF) in the domestic, industrial and agricultural sectors. It proposes reducing blue water consumption and waste, as well as improving the management of waste that affects the grey WF. In agriculture, it suggests irrigation technology and better use of fertilizers. It also highlights that green WF can only be reduced from the primary sector.





CHAPTER 7

CHALLENGES TOWARDS SUSTAINABILITY
REGULATORY PATHS, RISKS, INCENTIVES AND
BENEFITS FOR A RESPONSIBLE WATER FUTURE

“It is important to promote responsible consumption practices, push education and public awareness, and create an enabling environment for innovation through policies and incentives.”

The sustainability of water use must consider the environmental, social, and economic aspects comprehensively, seeking to minimize the negative externalities and ensure real benefits at different levels of society.

An effective transition to sustainable models involves adopting approaches that rely more on green water —such as extensive or organic agriculture— and reduce stress on blue water. At the same time, minimizing or eliminating the use of chemicals in agriculture and livestock farming can significantly reduce the grey water footprint, especially in a context of increasing animal protein consumption.



Four key drivers for advancing towards sustainability

1. REGULATIONS

Regulations play a central role in setting mandatory standards that guide industries and communities towards more sustainable practices. These regulations:

- Set limits for withdrawal, quality and treatment of water.
- Demand energy saving and reuse technologies.
- Generate shared responsibility between sectors.
- Foster innovation by encouraging companies to develop new technological solutions.
- Protect ecosystems and ensure availability for future generations.
- Promote responsible practices throughout the productive chain.

Moreover, they can incorporate tools such as performance indicators or metrics like the water footprint, which allow for a more precise evaluation of the real impact of human use on water resources. This can be strengthened through benchmarking policies and analysis of critical stages in production processes.

2. QUANTITATIVE OBJECTS AND TOOLS ASSESSMENT

- The water footprint allows identifying the points of greatest vulnerability, either due to inputs originating from unsustainable areas (indirect water footprint), or due to inefficient processes (direct water footprint).
- In terms of grey water footprint, it is recommended to implement more stringent internal standards than those established in the current regulations, always prioritizing the highest possible technological level.
- The combined application of concepts such as water footprint and environmental flow allows for the construction of more robust public policies adapted to the hydrological context.

3. RISKS

Water risks, such as droughts, floods and pollution, force governments, industries and communities to take urgent measures:

- **Droughts:** They reduce availability and put at risk agricultural, urban and industrial supply.
- **Floods:** They affect infrastructures and contaminate drinking water sources.
- **Contamination:** For industrial, agricultural, and urban waste, it mandates the treatment and reuse of water to maintain its availability.

In the face of these risks, adaptive water planning, monitoring technologies, resilient infrastructure, and strategies for conserving and reusing the resource are required. Moreover, population growth and economic development require increased efficiency in all sectors to ensure future supply.

4. INCENTIVES

Economic and regulatory incentives are essential tools for encouraging action:

- **Financial incentives:** Subsidies, segmented pricing and fiscal support for the adoption of efficient technologies in agriculture, industry and households.
- **Regulatory incentives:** Recognition and certification for companies that reduce their footprint, work in sustainable basins or implement good practices.
- **Eco-certifications:** They improve the reputation and competitiveness of companies, provided there is interinstitutional coordination to avoid confusion from an excess of seals.
- **Innovation awards:** They stimulate research and development of technologies such as recycling, reuse, precision irrigation or advanced water treatment.

5. BENEFITS

Water sustainability is not only necessary, it also offers tangible benefits:

- **Environmental:** Pressures on aquifers, rivers and lakes are reduced; biodiversity is protected and ecosystem services are preserved.
- **Economic:** Costs of withdrawal, treatment and distribution are minimized; processes are optimized and access to new markets and financing is achieved.
- **Social:** Equity in access to water and public health is improved, along with the resilience of communities in the face of climate change.

Efficient water management not only protects ecosystems, but also drives profitability, social equity, and long-term water security.



Towards real water sustainability: efficiency, governance and policy for changeo

The transition to sustainability requires clear goals, efficiency parameters adapted to each context, and an approach that is participatory and inclusive. To achieve this, it is essential to establish coordinated policies that promote effective actions in all sectors involved.

EFFICIENCY

Promoting sustainable use of water is essential to ensure its future availability. This involves the promotion of responsible consumption practices, boosting education and public awareness, and creating an environment conducive to innovation through policies and incentives.

Understanding the main triggers of the use and expansion of water—such as intensive agricultural practices, industrial processes or domestic consumption patterns—allows for the design of specific strategies, more effective and with a smaller margin of error.

Working with the sectors that are most intensive in water consumption is key. Measuring its use, identifying areas for improvement and adopting technologies such as drip irrigation or industrial reuse can significantly reduce the blue and grey water footprint.

Investment in technologies and capacity development strengthen this path. From drip irrigation systems to industrial water recycling, through continuous staff training, these measures allow for better adaptation to water challenges.

Projects must consider the local context: productive vocation, climate, water availability and soil characteristics. Thus, it avoids compromising water resources

and promotes truly sustainable development. Increasing productivity is not enough. It is essential to consider the environmental and social impacts of water use. Evaluating these effects allows for the promotion of practices

that benefit both the economy and ecosystems and communities.

Reducing grey water footprint, particularly in agriculture and industry, helps improve water quality. Replacing agrochemicals with biological inputs, and properly treating wastewater, are essential steps towards this goal.

GOVERNANCE

Water sustainability requires active participation from governments, businesses, communities, farmers, and nonprofit organizations. Each actor brings valuable knowledge and can strengthen public policies if involved from design to implementation.

It is equally important to involve citizens. Consumption decisions and everyday behavior in households and workplaces can have a big impact on water footprint.

Incorporating economic, social, and environmental interests in decision-making is essential. While the former focus on productivity, the latter demand equity in access to water, and third parties are seeking ecosystem preservation.

Recognizing that nature has a central role implies respecting ecological cycles and restoring water systems—rivers, wetlands, basins—as a preventive and corrective measure against climate change.

Sustainable management must protect water as a common good. This requires ensuring environmental flows and requiring efficiency mea-

sures as a condition for new concessions, thus preventing growth from compromising environmental balance.

Educating the population and applying multi-criteria analysis for decision-making are fundamental practices. Considering economic, social and ecological variables allows for the development of more just and lasting policies.

The use of agreement scales—such as consensus, consent, or endorsement—helps to construct policies that are more robust, by ensuring that they reflect a support base between the actors involved.

POLICIES

Sustainability should be the central goal of every water policy. This implies not withdrawing more water than ecosystems can regenerate and maintaining the balance between flow, runoff and human use.

Promoting savings, efficient use and the adoption of new technologies is fundamental. At the same time, educating the population in the responsible use of water allows for lasting changes in habits.

In basins with water stress, any new concession must be conditioned to savings measures by existing users. This ensures growth that is compatible with resource availability.

Reducing grey water footprint to minimal levels, or even eliminating it, should be a realistic goal in all sectors. This requires policies that

“La sostenibilidad hídrica exige la participación activa de gobiernos, empresas, comunidades, agricultores y organizaciones civiles.”

promote reuse, water treatment, and improvement of industrial and agricultural processes.

Ensuring environmental flows and reserving water for the ecosystem should be a structural part of any water policy. Especially in times of scarcity, this measure protects biodiversity and the regenerative capacity of water bodies.

When defining flow policies, growth projections, sectoral use and climate variables should be considered. This will make it possible to anticipate future demands and ensure sustainable supply.

Water management is multidisciplinary. It involves science, economy, social justice, engineering and governance. Therefore, policies should promote collaboration between knowledge and sectors to achieve comprehensive solutions.

Science should guide decisions. Only with reliable data and rigorous analysis is it possible to design adaptive, effective, and resilient policies. This approach allows for adaptability to change and resource protection for the future generations.

Balancing economic (productivity), social (equity and access) and environmental (conservation) interests is essential. Only this way it is possible to build a water policy that is fair, efficient and sustainable over time.

Balanced sustainability: integrating economy, social equity and environmental health into water management

“The policies differentiated by sector, region and type of use should be supported by scientific evidence, prioritizing activities with greater water efficiency (in blue and green water) and less pollutant pressure (grey water).”

For a water management policy to be truly successful, it must integrate economic, social, and environmental interests in a balanced way. This means ensuring that industries and agriculture have sufficient access to water to operate efficiently, ensuring that the entire population has access to clean water and adequate sanitation, and protecting aquatic ecosystems and their biodiversity. Long-term sustainability is only possible if these three pillars are considered equally.

Recognizing that nature holds the key is essential for building sustainable water policies. This principle is based on understanding the natural water cycles and respecting their ecological limits. Applying nature-based solutions—such as restoring basins, conserving wetlands, and protecting aquifer recharge areas—improves resilience to extreme events and ensures ecosystem balance. Including these ecological approaches in policies allows for maintaining the capacity of ecosystems to provide essential services.

Protecting the common resource involves reducing the water footprint in all sectors—agricultural, industrial and domestic— and ensuring the necessary environmental flow to maintain the health of aquatic ecosystems. When the use is not sustainable, the relocation of certain activities can be an efficient alternative to alleviate the pressure on certain regions. Ensuring the environmental flow allows for conserving natural habitats and protecting biodiversity, benefiting both people and the environment.

Any new water use project must be conditioned on the prior implementation of water-saving measures by current users. This strategy avoids compromising the future availability of the resource and promotes efficiency before authorizing new withdrawals. In this way, economic growth and development do not jeopardize water sustainability.

Public awareness and multi-criteria analysis are fundamental tools for the development of effective policies. Education enables to modify consumption habits

“Applying nature-based solutions—such as restoring basins, conserving wetlands, and protecting aquifer recharge areas—improves resilience to extreme events and ensures ecosystem balance.”

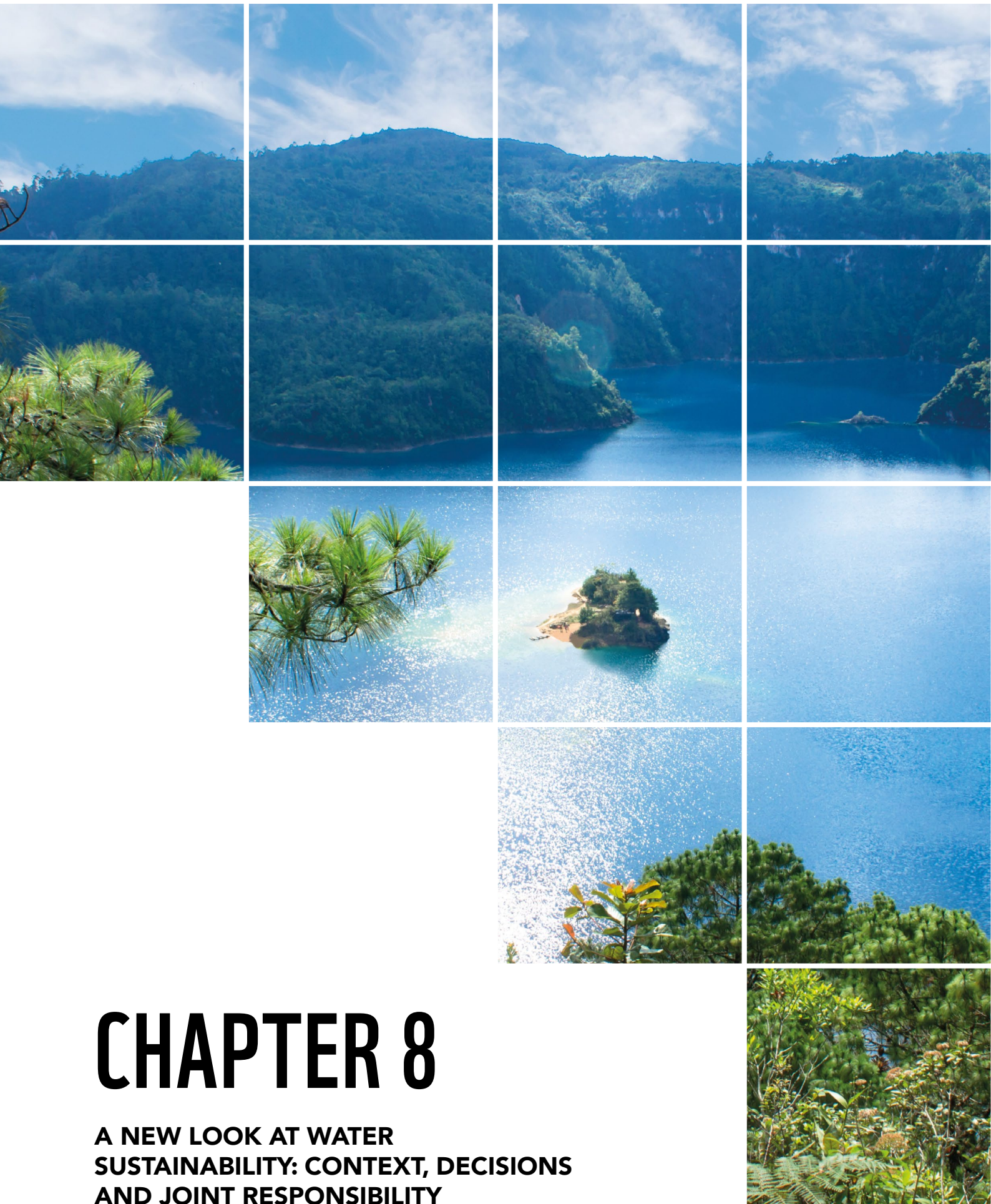
and promote sustainable practices. Whereas multicriteria analyses provide solid foundations for making informed decisions, by simultaneously considering economic, social and environmental impacts.

Having a new metric based on water footprint is key to efficient management. This metric should consider all water use in production and consumption, including withdrawals, concessions, rainwater use and pollutant discharge. It should reflect the impact of the entire production chain—from raw materials to exports—and evaluate the volume, type of water, pollutants and effects by region, time and quality.

Methodological standardization in the calculation of the water footprint (blue, green and grey water) will make it possible to trace the origin of water and evaluating the sustainability of each concession, use or activity based on its context. It is essential to establish mechanisms that ensure transparency, efficiency and responsibility in the use of the resource.

This metric should also integrate two essential elements: the natural hydrological regime (NHR) and the environmental flow (EF). Both are basic premises for determining the sustainability of water use in each activity or project. Incorporating the water footprint into the integrated management of water resources allows it to be used as a technical criterion for making decisions based on the impact and magnitude of use.

Finally, policies differentiated by sector, region and type of use must be based on scientific evidence, prioritizing activities with greater water efficiency (in blue and green water) and lower polluting pressure (grey water). These decisions must consider the productive vocation of the regions, to guarantee responsible and sustainable use of water at the national level. 💧



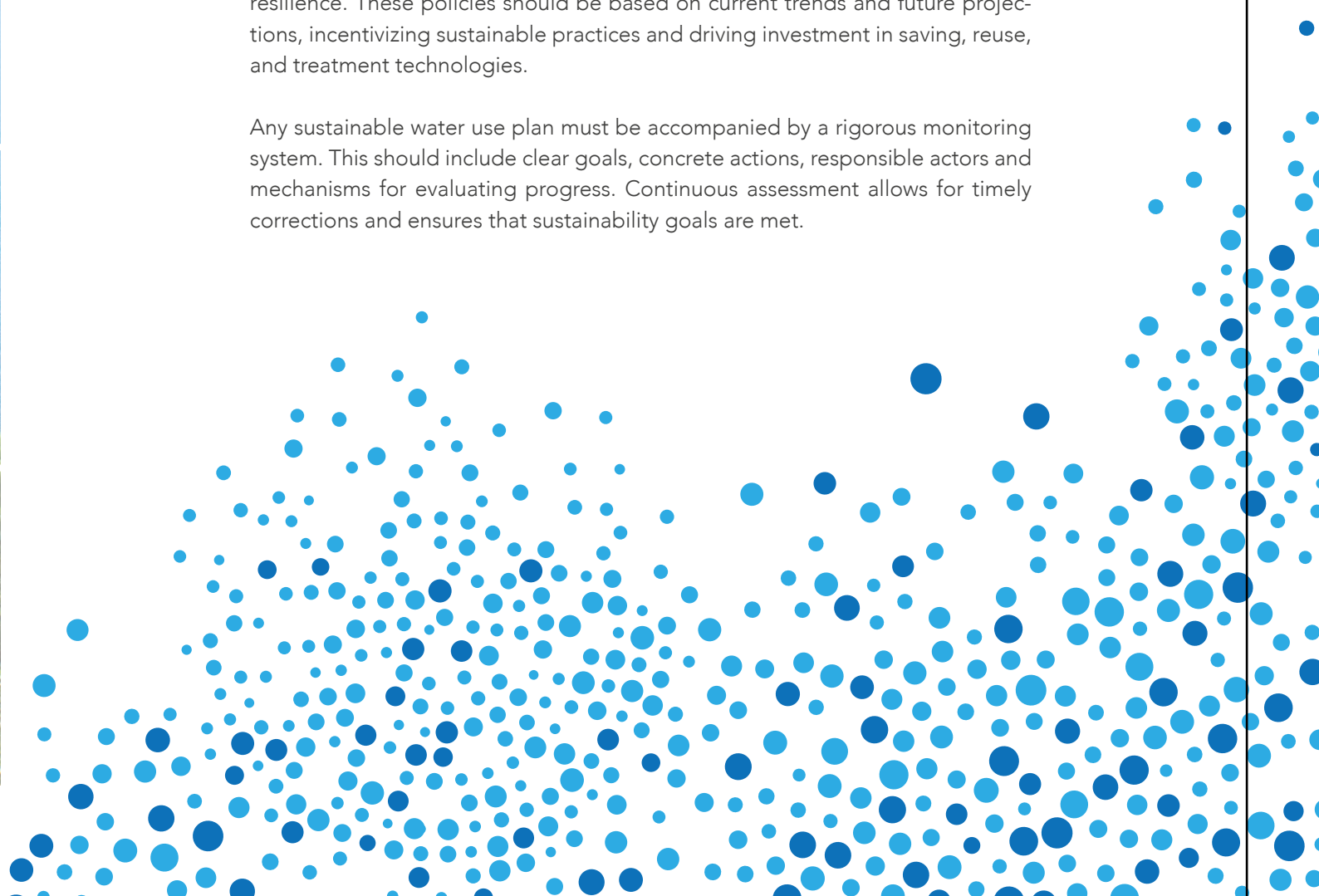
CHAPTER 8

A NEW LOOK AT WATER
SUSTAINABILITY: CONTEXT, DECISIONS
AND JOINT RESPONSIBILITY

Improving the measurement mechanisms is essential for efficient and sustainable water management. Having up-to-date and reliable data allows to identify critical areas, monitor progress and adjust policies based on evidence. Technological tools such as monitoring sensors and big data analysis provide detailed information about water use and the water footprint, strengthening decision-making.

Designing economic policies that consider water flow and water footprint scenarios in the medium and long-term is crucial for anticipating risks and fostering resilience. These policies should be based on current trends and future projections, incentivizing sustainable practices and driving investment in saving, reuse, and treatment technologies.

Any sustainable water use plan must be accompanied by a rigorous monitoring system. This should include clear goals, concrete actions, responsible actors and mechanisms for evaluating progress. Continuous assessment allows for timely corrections and ensures that sustainability goals are met.





The active participation of water users —farmers, industries, and communities — is fundamental for responsible management. Informing, training, and accompanying local actors on how to reduce their water footprint directly contributes to the protection of the resource and improves use practices at the basin level.

Achieving true sustainability requires aligning human well-being, economic viability, and ecological priorities. Policies must strike a balance between development, environmental conservation, and social equity, with a fair distribution of benefits and responsibilities.

Establishing alert thresholds for water use and quality makes it possible to prevent impacts before they become irreversible. These limits allow for anticipating crises and channeling resources to the areas with the greatest urgency, facilitating effective and timely responses.

Integrating water footprint into public policy is a key strategy for promoting a more equitable and conscious use of water. This metric should be used not only to identify opportunities for improvement, but also to guide incentives, regulations and sustainable development strategies.

CONTEXT MATTERS MORE THAN NUMBERS

While the water footprint of a product can provide valuable data, it is not always enough to make a decision. A single product can have different water footprints in different basins, and its impact will depend on variables such as resource availability, local pressure, ecological recovery capacities, and usage patterns.

Therefore, before making decisions based solely on indicators, it is necessary to consider additional factors: the local environment, the sustainability of use, the carrying capacity of ecosystems, and production alternatives. Only in this way can the best options be identified from a truly comprehensive perspective.

If there are more favorable conditions in other regions to produce the same thing, it is important to evaluate them. This does not mean automatically canceling activities, but rather redirecting efforts so that production takes place in more sustainable and less vulnerable scenarios.

Although unsustainable water use has marked many of the current challenges, we are still in time to make significant changes. The tools exist and the information is available. What is needed is determination, cooperation, and a shared vision. The water footprint should not be seen as a final judgment, but as a compass that guides actions towards viable and responsible scenarios.

TOWARDS A GRADUAL CHANGE WITH A NEW DESTINATION

Decisions must be adapted to different contexts, with differentiated thresholds and rhythms. In many cases, the benefits of responsible management will not be immediate or have direct economic return, but they will generate important environmental, social and reputational benefits.

The change will be gradual, but it must begin immediately. Sustainability is a collective construction that is achieved through concrete, realistic and progressive actions. If we act now, we can chart a new course for water, leaving a footprint that marks the right path. 💧

“Although the unsustainable use of water has marked many of the current challenges, we still have time to make significant changes.”

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METHODOLOGICAL NOTE

This document was developed using the Water Footprint Assessment Manual (Hoekstra, 2011) as a fundamental basis for accounting for green, blue, and grey footprints.

For its development, time series 2016-2023 were considered, from various sources included in the references section. Possible discrepancies in the totals between virtual water flows are due to the multitemporal nature of the analysis and the dynamics in water availability and use patterns, production patterns, and trade in the interannual series.

The case studies used local information, from organizations, producers, and production chains of each case study referred to.

The parameters or benchmarks are the ones used by the Water Footprint Research Alliance and the Water Footprint Assessment Tool.

WHAT IS THIS INFORMATION USEFUL FOR?

This tool is part of the innovations that allow us to get closer to the sustainability of water resource use. The water footprint is a very powerful tool in decision-making, which should not be seen as a set of isolated indicators: it acquires value and perspective by giving it a context.

The parameters indicated should serve as a reference for decision-making, always considering the various endogenous and exogenous factors that allow understanding the particular dynamics of each region, basin or aquifer, production chain or product, and social context. Among others, the pressure of use, the ecosystem needs (environmental flow), demographic dynamics, and patterns of economic development. Production or substitution alternatives and efficiency parameters are part of the latent consortium of indicators and contextual variables of necessary consideration.

This document is part of our contribution to the continuation of Arjen Y. Hoekstra's legacy, who generously shared his wisdom with us on countless occasions, providing an additional source of information to all enthusiasts who find in his reading and analysis an incentive to awaken the creativity and curiosity that leads us to find proposals and solutions for the best management of the water resource. 💧



