TEEB Implementation in Mexico: "Promoting biodiversity and sustainability in the agriculture and food sector project"

A background review of agriculture and biodiversity in Mexico

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List of Acronyms

BIOFIN	Biodiversity Finance Initiative
CBD	Convention on Biological Diversity
COP	Conference of the Parties
COUSSA	The Conservation and Sustainable Use of Soil and Water
ESMERALDA	Enhancing ecoSysteM sERvices mApping for poLicy and Decision mAking
EU	European Union
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GIZ	The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
INDC	Intended Nationally Determined Contribution
IPBES	Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services
NBSAP	National Biodiversity Strategy and Action Plan
PND	National Development Plan
PROCAMPO	The Program of Direct Rural Support
PRODEZA	The Strategic Development Project Drylands
PROMARNAT	Programa Sectorial de Medio Ambiente y Recursos Naturales
PSAGP	Sectoral Program for Agriculture, Livestock and Fisheries
SEMARNAT	The Ministry for the Environment and Natural Resources
TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UN-REDD	United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation

Executive Summary

1. BACKGROUND

With its GDP estimated at USS$ 2.4 trillion in 2017, Mexico is currently the second largest economy in Latin America, after Brazil, and the eleventh largest economy in the world. Over the past three decades, the country has struggled to significantly raise its trend growth rates. Notwithstanding various market reforms, including the North American Free Trade Agreement (NAFTA), which entered into force in 1994, Mexico's real GDP growth has lagged behind that of other similar developing nations, both in Asia and in Latin America. Consequently, GDP per capita and other improvements in living standards have stagnated.

The services sector (currently estimated at 64% of GDP) and manufacturing sector (currently estimated at 31.6% of GDP) have increasingly spearheaded the country's economic growth, while the agriculture sector's contribution has declined from around 13.7% of GDP in the 1965 to 3.8% in 2017. Despite being one of the cradles of human agriculture with the Mesoamericans (8000 – 2000 BC) developing domesticated plants such as maize, squash and beans, **Mexico is not a major player in the world agricultural economy. However, domestically, agriculture is an important sector, employing 13.4% of the 54.51 million people from the labour force.**

Mexico is **world's second largest producer of lemons and lime, fifth largest producer of maize and chickens, and tenth largest producer of beef.** In addition, a number of agricultural and food products (agrifoods) that are of strategic importance to the agricultural sector including barley, coffee, maize, dry beans, rice, sorghum, sugarcane and wheat, beef, eggs, milk, pork and poultry, and two fisheries products (shrimp and tuna).

2. PROBLEM DEFINITION: Challenges to sustainable agriculture and biodiversity in Mexico

Globally, food systems are now the source of 60% of terrestrial biodiversity loss, 33% of soil degradation and 61% of the depletion of commercial fish stocks. The situation in Mexico is largely consistent with these global statistics.

Mexico's agriculture has a very long history, stretching back to the Mesoamericans (8000 – 2000 BC) that developed domesticated plants such as maize, squash and beans. Farming became even more organized after the arrival of Spaniards in 1519. However, the boost in agriculture started in 1944 when an American biologist, Norman Borlaug, sponsored by the Rockefeller Foundation, started plant breeding and crop science which sparked what is known as the "Green Revolution". These reforms heightened the use of modern technology, high yielding crop varieties, chemical fertilizers, irrigation facilities, and improved farm implements and crop protection measures. Up to the 1960s, Mexico experienced dramatic improvements in agricultural production and productivity and the country grew most of the food it needed and became a net exporter of some agricultural products, particularly wheat. However, the drive to increase agri-food production has had a major toll on the environment including, *inter alia* **loss of soil fertility, soil erosion, diminishing water resources, and air, soil and**

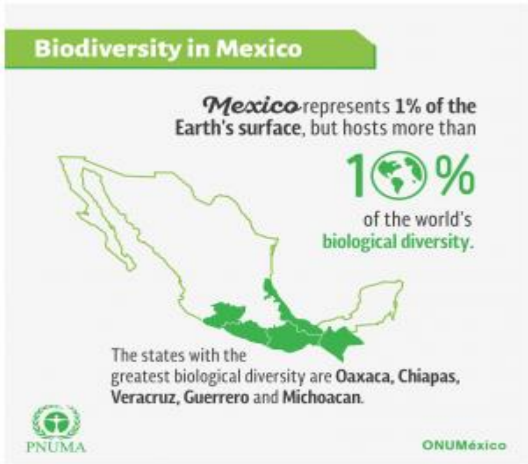
water pollution. Today, **Mexico is on position 11 on the list of countries with the highest rate of greenhouse gas emissions in agriculture.**

On the other hand, **water shortage is a serious threat to sustainable agriculture in Mexico**. By 2009, agriculture accounted for nearly 75% of the water usage in the country and there have be no significant changes over the years. However, its use is very inefficient, with almost 55% of the total usage being wasted, mainly due to leaking and excess irrigation. **The most vulnerable regions to water deprivation are the Northern and Central parts**, which are classified as arid and semi-arid.

Climate change impacts pauses another major threat to the sustainability of agriculture in Mexico. Over the last four decades, Mexico has proven to be most susceptible to extreme weather events in Latin America, including heavy rainfall and landslides. **Between 1970 and 1990, 18% of all disasters in the region affected Mexico**. The **country has also experienced droughts, floods, frost, and hail affecting 15% of farmers between 1980 and 2000**. According to the World Bank (2014) projections, precipitation is expected to decrease in most of the country with varying degrees. Such changes in weather patterns are expected to affect farmers in various ways mainly through reduction in average crop yields.

Challenges to Biodiversity in Mexico

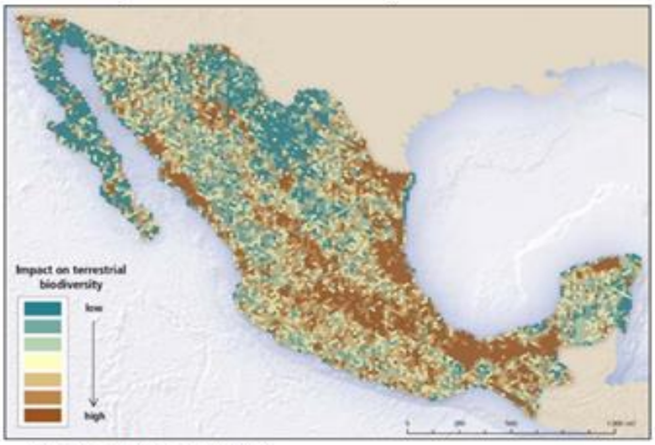
Mexico is one of the most megadiverse countries of the world, hosting more than 10% of the world's biological diversity. Its location, complex topography, climate and evolutionary history are a source of a great richness of environment, fauna and flora, and this has placed the country among the top five places in the world. **Of the 34-world biological 'hot spots'** (areas of greater biological endemism in the biosphere), **three are in Mexico**. These are: **The Pine-Oak Forests of the Sierra Madre** (including the Sierra Madre del Sur and the Neovolcanic axis)**; Mesoamerica** (including Southeast Mexico, the Atlantic and Pacific coasts and the Balsas river basin)**; and the southern portion of the California Floristic Province**.



Source: www.teebweb.org/teeb-mexico/biodiversity/

According to a report by TEEB Mexico, **30 – 35% of Mexico's national territory is covered by forests, jungle or other types of vegetation, placing the country at 12th position in terms of global forest area**. Furthermore, majority of Mexico's flora and fauna are endemic; and **between 50% and 60% of the known species of plants of the world are represented in Mexico**. The states with the greatest biological diversity are found in the south, with **Oaxaca being the biodiverse-richest State, followed by Chiapas, Veracruz, Guerrero and Michoacán.**

Map of threats to biodiversity in Mexico



Source: Febrero (2016)

In terms of drivers and pressures, **Mexico experiences threats to biodiversity from agricultural conversion, a major driver of deforestation in some regions**. Land use change, driven by agricultural expansion, is creating fragmentation and loss of forests, grasslands, wetlands and other habitats. For instance, between 1990 and 2000, Mexico lost roughly 1.1% of its forests annually, over half of which was attributable to agricultural expansion. Furthermore, **agricultural intensification, agrochemicals, and eutrophication from agriculture runoff are causing pressures on biodiversity both on terrestrial and marine habitats**. **The pressures of livestock grazing on forests and grasslands are severe**.

In addition to agricultural impacts, several other factors have been cited as leading causes of Mexico's biodiversity loss including **land use change for agriculture, urbanization, unsustainable tourism, pollution growth, climate change, invasive alien species and pertinent poverty leading to overexploitation of natural resources**.

3. CURRENT SITUATION: Mexico's national level strategies and policies

To address these challenges, Mexico has embraced sustainable agriculture and biodiversity conservation, through a variety of national level strategies and policies, which have evolved over time. Promotion of **sustainable agriculture landscapes and natural resource management** are enshrined within the **the National Development Plan 2013-2018** (Plan Nacional de Desarrollo 2013-2018)**.** It emphasizes**, "building a productive agriculture and fisheries sector to ensure food security of the country",** as its key strategy. This strategy is linked to the Conservation and Sustainable Use of Soil and Water (COUSSA) which was implemented in 2008 to promote sustainable practices in agriculture, livestock, fisheries and aquaculture activities.

In December 2013, the government of Mexico, through SAGARPA, unveiled a new six-year agricultural development plan called the **2013-2018 Agricultural, Fisheries and Food Development Program**, which is part of the **National Development Plan**. Under the Program, ten "Change Pillars" are proposed to create change in the agro-food sector including the optimal use, sustainable and modernization of water, and management and prevention of climate and market risks.

In addition, Mexico is committed to more sustainable production and consumption of goods and services through efficient practices in the use of water, materials, energy and elements of biological wealth. Specifically, the **National Strategy for Sustainable Production and Consumption** encourages and guides an inclusive and facilitating green growth that preserves our natural heritage, while generating wealth, competitiveness and creation of jobs.

Although Mexico's agricultural policy reforms started in 1917 when the Mexican Constitution was amended to recognize the land rights of the original occupants under their regimen of customary tenure, most current policies started in the mid-1990s following its implementation of the structural adjustment programs of the 1980s.

In 1994, Mexico launched a major direct support program known as **the Program of Direct Rural Support** or **PROCAMPO**, which was followed by another one called **the Alliance for the Countryside** or **Alianza Para el Campo**, in 1996. The main objective of both programs was to enhance investment and productivity in the agriculture sector without distorting production incentives, thus enabling the integration of agricultural producers into the market economy. **In 2014, PROCAMPO was widely reformed and renamed PROAGRO Productivo (Productive PROAGRO)** to reduce distortions and improve its effectiveness. From 2003, Mexico implemented a price support program called **Incentivo Complementario al Ingreso Objetivo (Target Income Programme)** to guarantee a minimum income to small- and medium-scale grain and oilseed farmers.

To conserve and protect its biodiversity, the Government of Mexico has defined an ambitious agenda in the preservation its biological diversity. This is envisioned in the National Development Plan 2013, which explicitly included the term “green growth” as one of its main objectives and stressed the importance of environmental sustainability in its objective.

For over 20 years, Mexico has also created and constantly improved its System of Economic and Environmental Accounting. Mexico regularly updates a national inventory of the damage to the environment and natural resources caused by human activities of production, distribution and consumption and publishes the book “The Natural Capital of Mexico” (El Capital Natural de México).

Besides, Mexico has implemented several policy instruments for the preservation of biological diversity and its natural resources. For example, **Mexico has 181 federal Protected Natural Areas; schemes for the Payment for Ecosystem Services (PES) covering almost 3 million hectares of the national territory; and operates over 12,000 Units of Wildlife Conservation and Management covering around 39 million hectares** (corresponding to over 19% of the national territory).

In December 2016, Mexico hosted the 13th Conference of the Parties to the Convention on Biological Diversity (CBD COP13) in Cancun, with the motto "Incorporating biodiversity for well-being". Together with the other members of the Convention, Mexico promoted the ambitious agenda of integrating biodiversity into four sectors: agriculture, forestry, tourism and fisheries.

At the international level, Mexico is party to a number of international conventions that promote forest and biodiversity conservation, including the ‘Convention on Biological Diversity (CBD), 1992’. **Mexico has also been actively involved in monitoring and implementing the objectives of the Convention on Biological Diversity**. Mexico has come up with various national strategies, legislation and administrative instruments to address the obligations under the conventions. For instance, under the CBD (1992), the country implemented its first National Biodiversity Strategy in 2000. **The current National Biodiversity Strategy and Action Plan (NBSAP) (2016-2030) is broadly aligned to the global Strategic Plan for Biodiversity 2011 – 2020 and its Aichi Targets as well as the United Nations 2030 Agenda for Sustainable Development**. The NBSAP (2016-2030) also presents **an important opportunity and framework to mainstream biodiversity criteria in such policies, plans and programs, within and across sectors, and at all levels of government**, to ensure the continued provision of ecosystem services necessary for the well-being of the Mexican people.

4. ACCOUNTING FOR ECOSYSTEM IMPACTS AND DEPENDENCIES

Despite well intended national policies and strategic plans, **challenges to conserve biodiversity and ensure sustainable agroecosystems still remain.** Many natural areas and habitats are threatened, for example, **it is estimated that Mexico lost 35% of its forest cover in the past 20 years. Furthermore, 2,606 species are in danger of extinction, threatened or subject to special protection.**

Within agricultural landscapes, land degradation is an important factor in Mexico's national economy impacting 65% of the national land area. By 2003, **it was estimated that losses of nutrients and productivity in agricultural and grazing areas cost over $2 billion a year**, **losses due to salinization approach $1 billion and the cost of deforestation are up to $0.5 billion**. It has also been shown that land degradation is an important contributing factor to rural-urban migration in Mexico.

There is a growing concern on the potential environmental effects from agricultural landscapes and agri-food systems, broadly. However, there is paucity of studies assessing environmental impacts of agri-food systems across the value chain in Mexico. A **few studies conducted mostly at farm gate points towards significant impacts including land degradation. Consequently, important ecosystem services including carbon capture, habitat provision as well as provisioning ecosystem services such as food and water are being negatively affected**. An example, demonstrating the extent of these impacts is provided below. The main report provides four such examples.

Case study ES 1: Agriculture and cattle raising are among the key drivers of soil degradation in Mexico

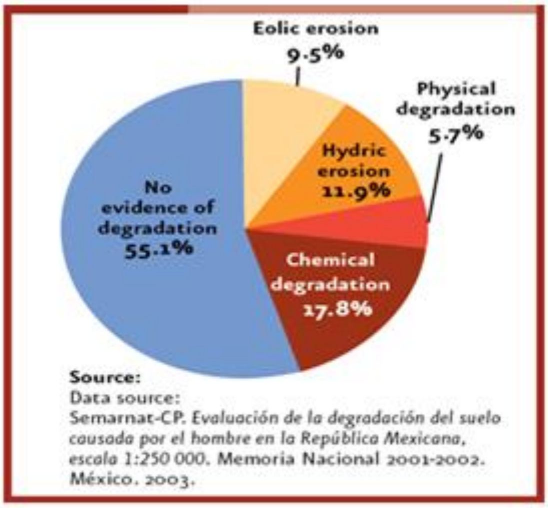
Soil degradation in Mexico is increasingly recognized as a serious problem of great concern. According to the Institut de recherche pour le développement (IRD, 2012), about 80% of the land is subject to erosion. **The central state of Michoacán is the most affected, with more than 2 million hectares affected, representing 70% of the surface area**. Soil degradation remains a key challenge for the sustainability of agriculture and biodiversity as it involves the loss of biological diversity and destruction of soil structure. It affects land productivity and therefore, a major threat to food security.

While soil degradation in Mexico can be attributed to an interlocking force of natural process including climate, rugged and changeable topography and fragile soils, **agriculture and cattle raising are considered to be the key driving factors**.

An investigation by SEMARNAT and the Colegio de Postgraduados (2003), entitled Assessment of soil degradation caused by man *(*Evaluación de la degradación del suelo causado por el hombre en la República Mexicana, escala 1:250 000, in spanish), gives the most comprehensive assessment of soil degradation in Mexico. The study considered four degradation processes namely, hydric and eolic erosion, and physical and chemical degradation.

It was found that, 44.9% of soils in Mexico showed some type of degradation. **Chemical degradation was found to be the dominant soil-degradation process in Mexico affecting 17.8% of the country land area,** followed by hydric erosion (11.9%), eolic erosion (9.5%) and physical degradation (5.7%).

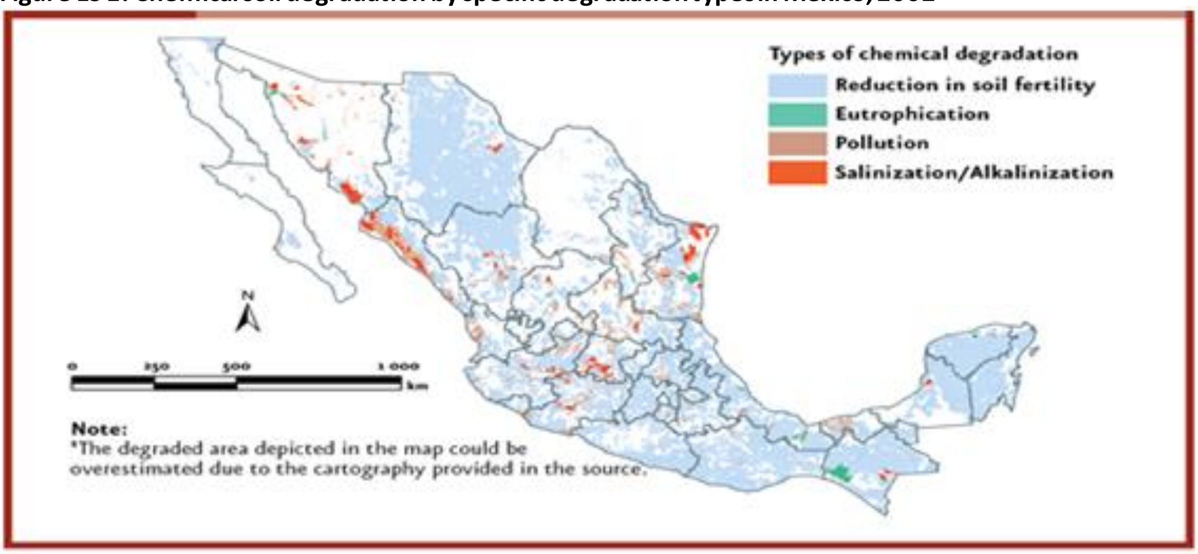
Relative area affected by soil degradation process in Mexico, 2002



The study results showed that chemical degradation occurred in all states, **the most affected being Yucatan (55.1%)** and the least being Baja California Sur, Coahuila, Baja California and Sonora, where the area evidencing chemical degradation represents 5.5% or less of the corresponding state territory. Chemical soil degradation could be attributed to a wide range of industrial and agricultural activities, including hydrocarbon spills, excessive fertilizer and pesticide application, poor materials management, hazardous and urban solid wastes.

The dominant chemical degradation type was the reduction in soil fertility, affecting 92.7% of the total country area, resulting from the decrease in the availability of soil minerals and organic matter (Figure ES 1).

Figure ES 1: Chemical soil degradation by specific degradation types in Mexico, 2002

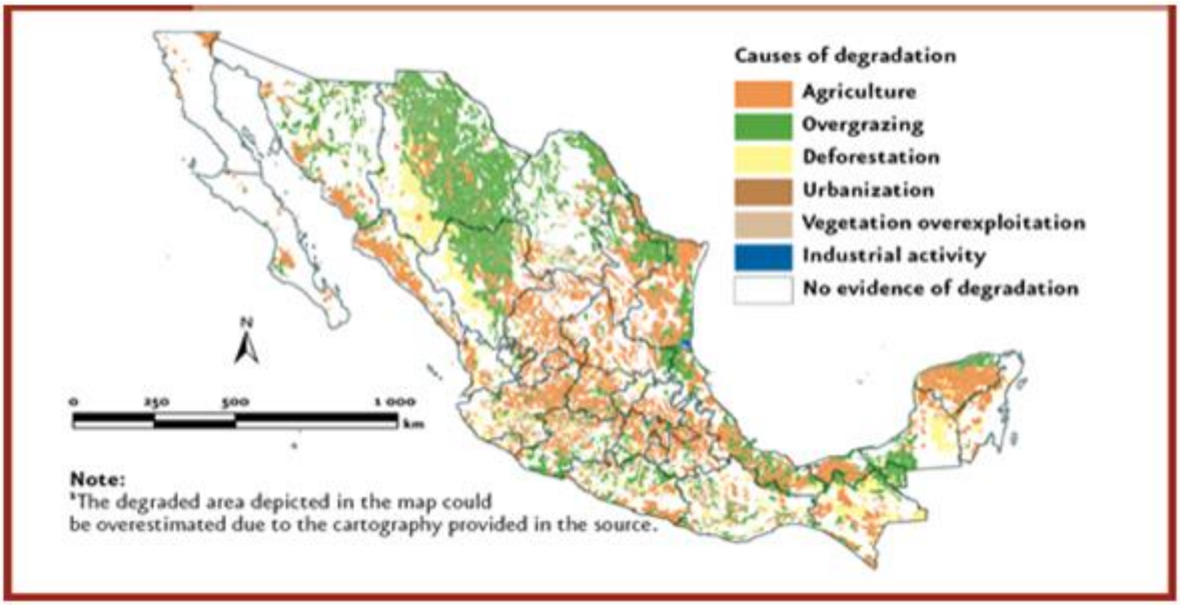


Source: SEMARNAT (2008)

It was found that this degradation type occurred in more than half of Yucatan and nearly one third of Tlaxcala, Chiapas, Morelos, Tabasco and Veracruz (Figure ES 1). The other specific chemical degradation types were pollution salinization and eutrophication which were far less widespread, altogether representing 7.3% of the chemically degraded area in Mexico.

Agriculture and cattle raising were found to be the major causes of soil degradation, altogether accounting for 35% of the country's degraded area (17.5 % each). This was followed by deforestation at 7.5% and the rest could be attributed to urbanization, vegetation overexploitation and industrial activities (Figure ES 2).

Figure ES 2: Main causes of soil degradation in Mexico, 2002



Source: SEMARNAT (2008)

5. PROJECT AIMS AND OBJECTIVES: TEEB Implementation in Mexico, "Promoting biodiversity and sustainability in the agriculture and food sector project"

1. To complement the Government of Mexico's initiatives for agriculture sustainability and biodiversity conservation, **the United Nations Environment (UN Environment), with the support of the European Union (EU), launched a four-year project for "Promoting biodiversity and sustainability in the agriculture and food sector in Mexico**.

2. This project is in line with the Cancun Declaration adopted at the 2016 December CBD COP13 in which governments committed to mainstream biodiversity across all sectors. The project would contribute to integrating biodiversity values into national accounting and reporting systems and will encourage sectors that depend or have an impact on biodiversity to adopt integrated approaches for its conservation and sustainable use. In line with the Declaration, the project will also contribute to supporting sustainable production and consumption throughout value chains, the safe and sustainable application of technologies, and the phasing out of harmful incentives and strengthening of positive incentives.

3. **The overall objective of this project is to protect biodiversity and contribute to a more sustainable agriculture and food sector with well-functioning ecosystems**. This will be achieved by:
    - developing and applying instruments to capture the value of ecosystems services across the entire life cycle in the agri-food and the non-food agricultural raw material sectors;

- identifying intervention options protecting biodiversity and promoting well-functioning ecosystems and by direct engagement with farmers, agri-businesses, government, and civil society (including consumers).

The example above – on the impact of a**griculture and cattle raising on soil degradation in Mexico** – has not been funded by the UN Environment/EU project, but **demonstrates the often-invisible externalities, impacts and dependencies between the agricultural sector and ecosystems and biodiversity**. This Executive Summary is limited to this one example, but the main report provides four such examples.

The studies presented are more limited in scope that the full TEEBAgriFood assessments that would be conducted under the current UN Environment/EU project. For instance, these analyses do not cover the **entire value chain** 'from farm to fork' (and including final waste management), does not consider all impacts such as **human health**, and do not present a **Theory of Change**, i.e. what can be done to intervene to switch away from the current business-as-usual scenario to an alternative – the sustainable management of agricultural landscapes.

Although 'partial' vis-à-vis the TEEBAgriFood Evaluation Framework, the studies described herein reveal the potential for **complex trade-off** between social- economic and environmental objectives in the Mexico's agri-food systems. Research into this area is still evolving, with an evaluation of possible trade-offs mainly focused at farm level or partial agri-food value chains. More comprehensive analysis of potential social- economic and environmental trade-offs is generally constrained by the complexity of the agri-food value chains and data availability. However, an understanding of these trade-off is crucial for the effective implementation of Mexico's green agricultural initiatives and biodiversity conservation, and this is the focus of the UN Environment/EU project.

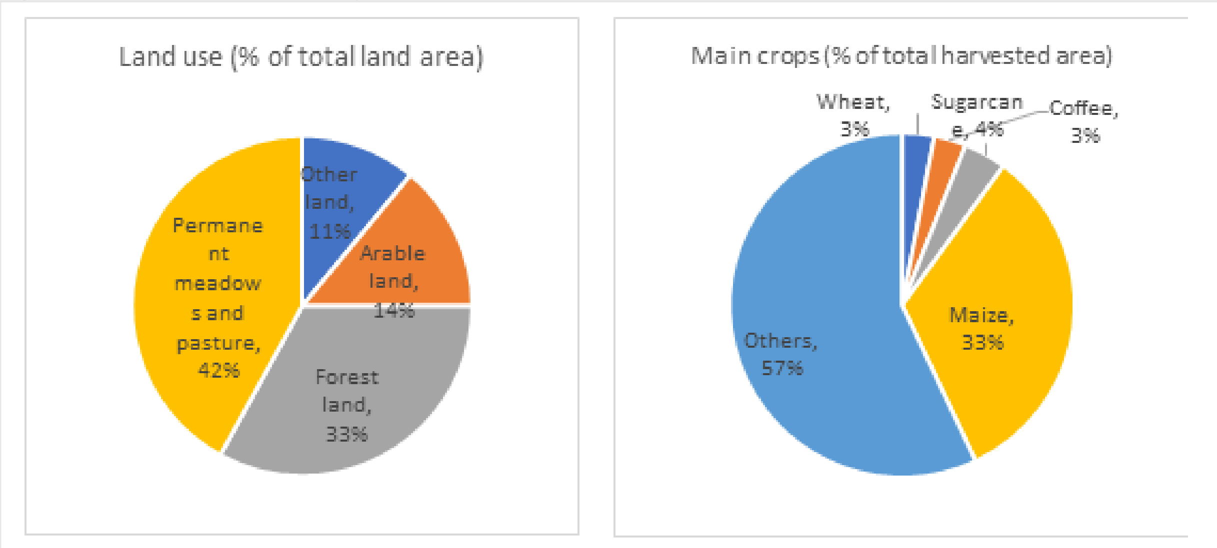
1 Introduction: Snapshot of agricultural production in Mexico

With its GDP estimated at USS$ 2.4 trillion in 2017, Mexico is currently the second largest economy in Latin America, after Brazil, and the eleventh largest economy in the world. Over the past three decades, the country has struggled to significantly raise its trend growth rates. Notwithstanding various market reforms, including the North American Free Trade Agreement (NAFTA), which entered into force in 1994, Mexico's real GDP growth has lagged behind that of other similar developing nations, both in Asia and in Latin America. Consequently, GDP per capita and other improvements in living standards have stagnated. As far as economic productivity is concerned, Mexico is a blend of two economies moving in opposite directions: (1) a highly productive modern economy and (2) a low-productivity traditional economy. While annual productivity has grown 5.8% in modern firms it has declined 6.5% in traditional firms (CIA, 2017; World Bank, 2018a).

The services sector (currently estimated at 64% of GDP) and manufacturing sector (currently estimated at 31.6% of GDP) have increasingly spearheaded the country's economic growth, while the agriculture sector's contribution has declined from around 13.7% of GDP in 1965 to 3.8% in 2017 (CIA, 2017; World Bank, 2018b). Despite being one of the cradles of human agriculture with the Mesoamericans (8000 – 2000 BC) developing domesticated plants such as maize, squash and beans, **Mexico is not a major player in the world agricultural economy. However, domestically, agriculture is an important sector, employing 13.4% of the 54.51 million people from the labour force.**

Mexico's agriculture is heterogenous with progressive large-scale commercial farming mainly cultivating irrigated wheat in the north and smallholder farming predominantly cultivating rain-fed maize in the centre and south of the country. Half of the country's territory is held by communal land ownership (*ejidos*), which constrains the sale of agricultural land (FAO, 2016). Most land owners (73%) are smallholders that own at most 5 hectares. Medium-sized land owners (22%) own up to 20 hectares and only 5% large-scale farmers own more than 20 hectares (World Bank et al., 2014). Figure 1 shows how Mexico's 198 million hectares of territorial land is used and which major crops are cultivated.

Figure 1: Land use and main crops in Mexico as of 2014

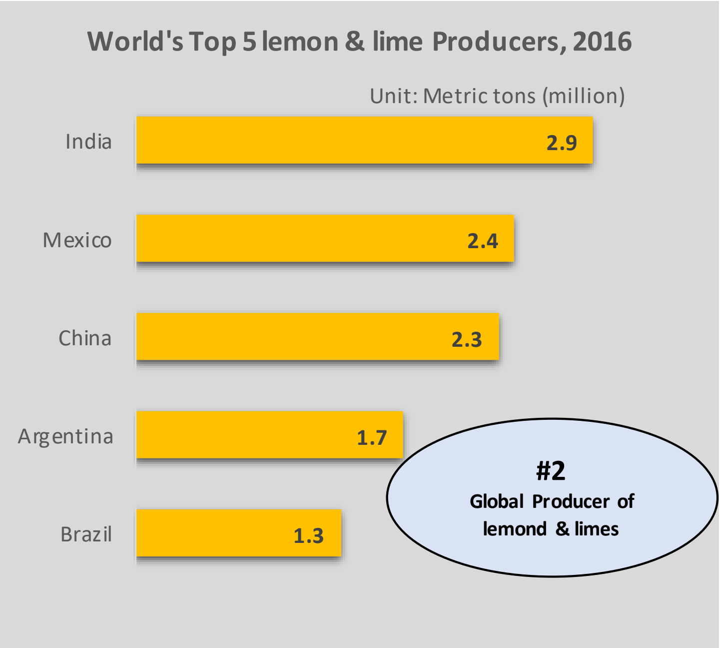


Source: World Bank et al. (2014)

Box 1: Agricultural and food products of strategic importance to Mexico

Mexico [has] identified 15 agricultural and food products (agrifoods) that are of strategic importance for its agricultural sector (in terms of their contribution to production values and/or growth potential). These agrifoods include eight crops (barley, coffee, maize, dry beans, rice, sorghum, sugarcane and wheat), five livestock products (beef, eggs, milk, pork and poultry) and two fisheries products (shrimp and tuna). Those selected agrifoods made an important contribution to Mexico's total production value of crops, livestock and fisheries in the period 1990 to 2009 (on average 65%) (UNCTAD, 2013, p. 60)

Mexico is the world second largest producer of lemons and limes



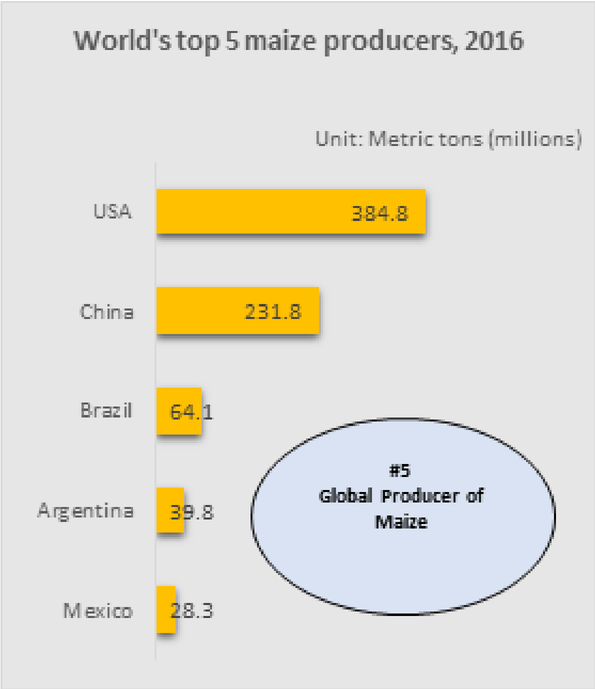
- **Mexico is the world second largest producer of lemons and limes** which occupy around 0.2 million hectares of land across the country
- **In 2016, Mexico produced 2.4 million metric tons of lemons and limes accounting for about 13.8% of global output**
- Mexico is also the second largest exporter of lemons. For instance, **in 2016, Mexico's value of exported lemons and limes stood at $425.3 million (12.3% of global exports)**

Source: FAOSTAT (2018)

Although Mexico is the world's second largest producer of lemons and lime, its yield is lower than that of Argentina, Brazil and China. As of 2016, lemon yield in Mexico stood at 14.9 metric tons per hectare compared to Argentina's 32, Brazil's 26.7 and China's 21.8 metric tons per hectare (FAOSTAT, 2018).

Mexico is the world fifth largest producer of maize

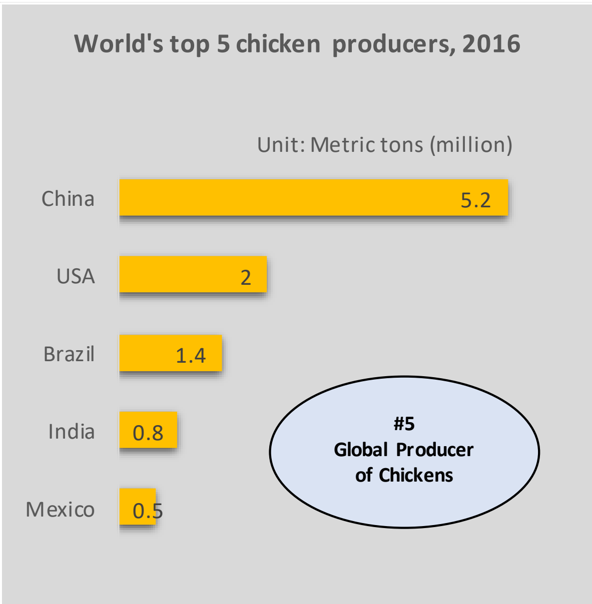
- Maize is Mexico's chief cereal crop. The country is the world fifth largest producer of maize
- In 2016, Mexico's maize farms covered a total of 7.6 million hectares, with 39.8 million metric tons produced
- Maize production is split into two seasons: spring/summer crop (75% of total production) and fall/winter crop (25%)
- Spring/summer maize is predominantly rain-fed, mainly produced in the states of Jalisco, Chiapas and Mexico
- Top fall/winter maize producing states are Sinaloa (70%), Tamaulipas (7%) and Veracruz (6%) (USDA, 2017).



Source: FAOSTAT (2018)

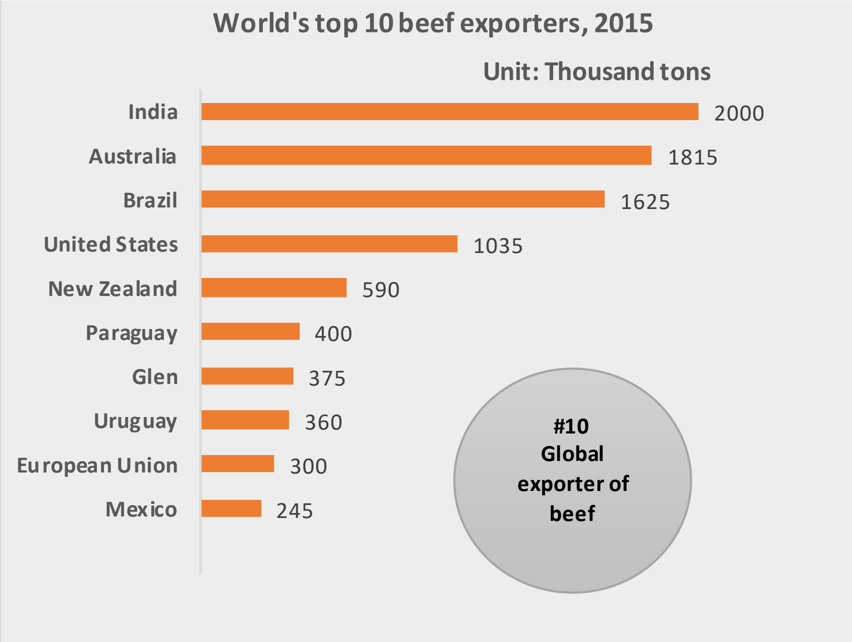
Mexico is the world fifth largest producer of chickens

- **Mexico is the world fifth largest producer of chicken**
- In 2016, Mexico produced 0.5 million chickens
- Mexico is also the world fifth largest producer of eggs
- In 2016, Mexico produced 54.4 billion eggs (equivalent of 2.7 million metric tons)



Source: FAOSTAT (2018)

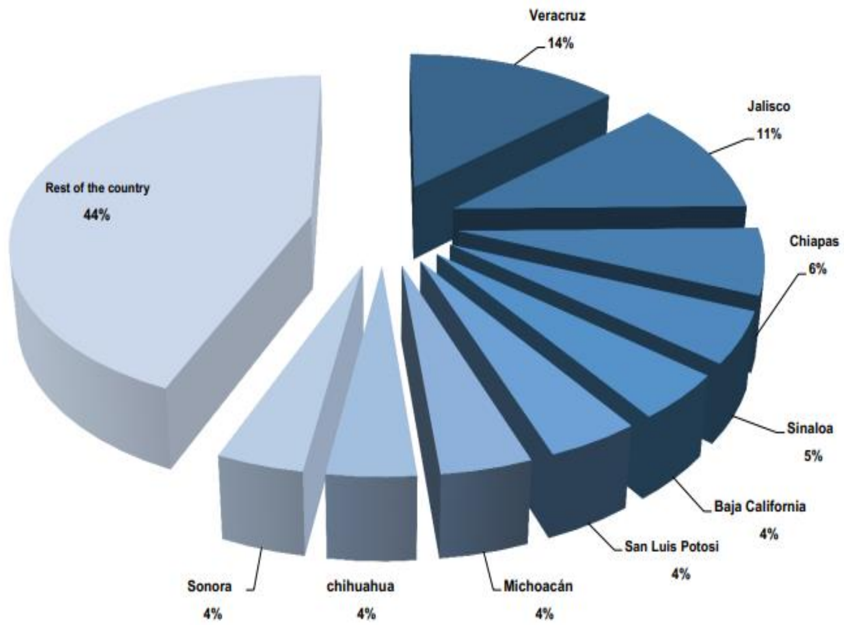
Mexico is also the world tenth largest producer of beef



- Mexico is the 10th largest producer of beef, with 32 million heads of cattle in 2015
- In 2015, Mexico was among the top 10 beef exporting countries

Source: Febrero (2016)

Cattle production by State, 2014



- More than 60% of the national territory (130 million hectares) are devoted to grazing (99.6%) and fodder production (0.4%)
- With 60% of the territory, beef production generates about 0.6% of GDP

Source: Febrero (2016)

Mexico also produces several other crops such as groundnuts, coffee, sorghum and sugarcane that put the country on the world map.

#2 Producer of Agave

#9 Producer of coffee

#4 Producer of Sorghum

#6 Producer of Sugarcane

Mexico's farming, particularly smallholder agriculture, is mainly concentrated in the south where various crops such as maize (corn) sugarcane and fruits and vegetables are produced. In the north, it is mainly large-scale farming including wheat and cattle production that are prevalent as shown in Figure 2.

Figure 2: Main producing states of major crops in Mexico, 2009

Source: UNCTAD (2013)

Mexi;co's agriculture sector is divided into five key agro-ecological zones each supporting a wide range of crops depending on the climatic conditions, topography and soil conditions as shown in Figure 3.

Figure 3: Agro-ecological Zones in Mexico

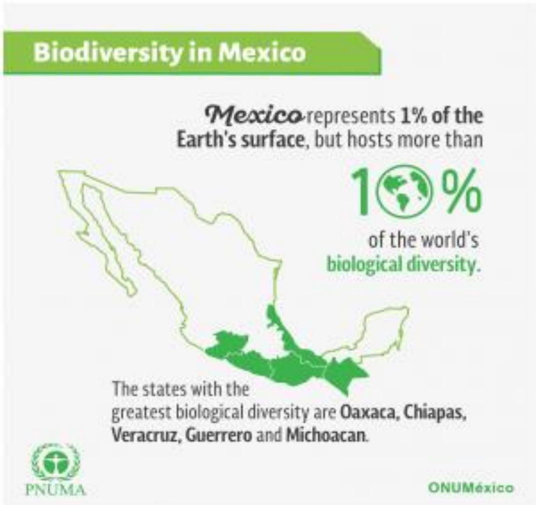
Source: Campbell and Berry (2003a)

These major agro-ecological zones can be described as follows. (1) The central north and north west, generally mountainous and arid to semi-arid, is a predominantly pastoral and wheat region. (2) The centre extending to the north west and south west of the country, temperate, is a mostly maize, wheat, sugarcane, winter fruits and vegetables and pastoral region. (3) The tropical hot and humid southern and south-eastern region is where coffee and some fruits and vegetables are cultivated. (4) The tropical hot and sub-humid south-eastern region and some coastal areas in the central-western region is where coffee, sugarcane and some fruits and vegetables are cultivated. (3) The sea-land transition, the coastal area mainly along the south-eastern and south-western region, is where some fruits and vegetables are also produced.

Mexico's agriculture sector is supported by its rich endowment of natural resources including biodiversity.

1.1 Snapshot of biodiversity in Mexico

Mexico is one of the most megadiverse countries of the world, hosting more than 10% of the world's biological diversity. Its location, complex topography, climate and evolutionary history are a source of a great richness of environment, fauna and flora, and this has placed the country among the top five places in the world. Of the 34-world biological 'hot spots' (areas of greater biological endemism in the biosphere), three are in Mexico. These are: **The Pine-Oak Forests of the Sierra Madre (including the Sierra Madre del Sur and the Neovolcanic axis); Mesoamerica (including Southeast Mexico, the Atlantic and Pacific coasts and the Balsas river basin); and the southern portion of the California Floristic Province**. The country also boasts of three of the 37 "Wilderness Areas" of the planet. These are: The Chihuahuan Desert, which covers part of the states of Chihuahua, Coahuila and Nuevo Leon; the Sonora Desert, which occupies Sonora State and the Baja Californian Desert, located in both states of the peninsula (CONABIO, 2009).



Source: www.teebweb.org/teeb-mexico/biodiversity/

According to a report by TEEB Mexico[1], **30 – 35% of Mexico's national territory is covered by forests**, jungle or other types of vegetation, placing the country at 12th position in terms of global forest area. Furthermore, majority of Mexico's flora and fauna are endemic; and between **50% and 60% of the known species of plants of the world are represented in Mexico**. The states with the greatest biological diversity are found in the south, with **Oaxaca being the biodiverse-richest State**, followed by Chiapas, Veracruz, Guerrero and Michoacán.

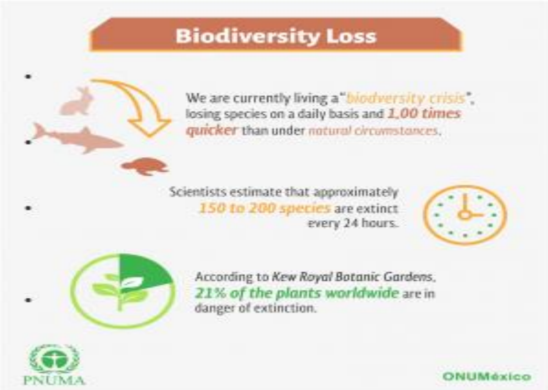
Regarding marine wealth, the Gulf of California, at 1200 km long by 150 km wide and with depths of up to 4000 metres, is one of the most diverse seas in the world. Also known as "the aquarium of the

[1] www.teebweb.org/teeb-mexico/biodiversity/

planet," the Gulf of California is home to 875 fish species, 580 marine birds and 35 marine mammals (CONABIO, 2009).

1.2 Challenges to biodiversity in Mexico

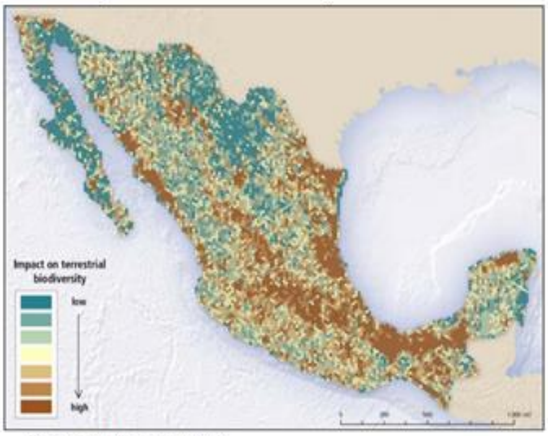
In terms of drivers and pressures, **Mexico experiences threats to biodiversity from agricultural conversion**, a major driver of deforestation in some regions. Land use change, driven by agricultural expansion, is creating fragmentation and loss of forests, grasslands, wetlands and other habitats. For instance, between 1990 and 2000, **Mexico lost roughly 1.1% of its forests annually, over half of which was attributable to agricultural expansion** (Schmook & Vance, 2009). Furthermore, **agricultural intensification, agrochemicals, and eutrophication from agriculture runoff are causing pressures on biodiversity** both on terrestrial and marine habitats. The pressures of livestock grazing on forests and grasslands are also severe.



Source: www.teebweb.org/teeb-mexico/biodiversity/

In addition to agricultural impacts, several other factors have been cited as leading causes of Mexico's biodiversity loss including **land use change for agriculture, urbanization, unsustainable tourism, pollution growth, climate change, invasive alien species and pertinent poverty leading to overexploitation of natural resources.**

Map of threats to biodiversity in Mexico



Source: Febrero (2016)

1.3 Challenges to sustainable agriculture in Mexico

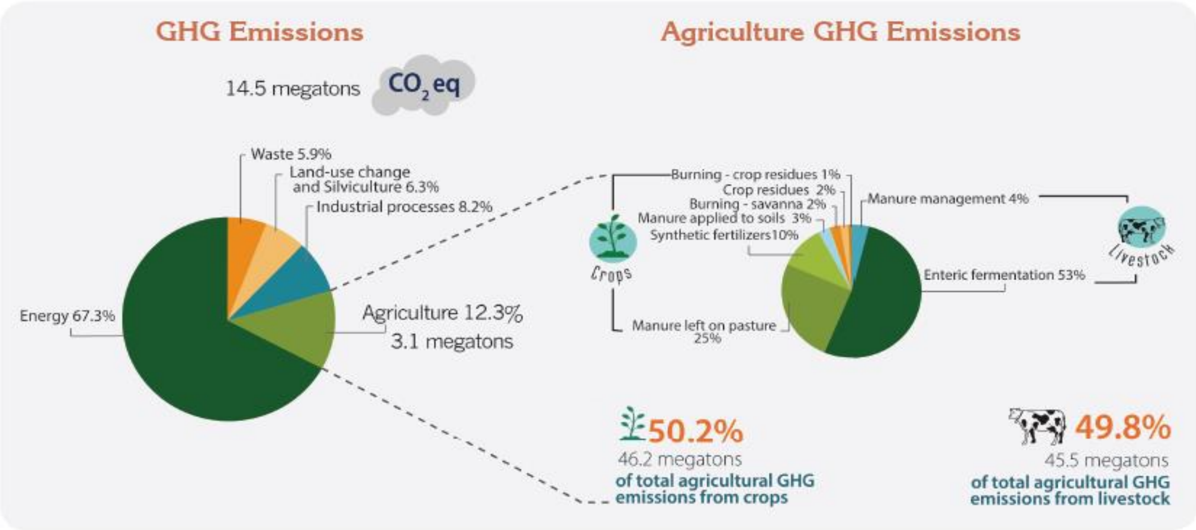
Globally, food systems are now the source of 60% of terrestrial biodiversity loss, 33% of soil degradation and 61% of the depletion of commercial fish stocks. The situation in Mexico is largely consistent with these global statistics.

Mexico's agriculture has a very long history, stretching back to the Mesoamericans (8000 – 2000 BC) that developed domesticated plants such as maize, squash and beans. Farming became even more organized after the arrival of Spaniards in 1519. However, the boost in agriculture started in 1944 when an American biologist, Norman Borlaug, sponsored by the Rockefeller Foundation, started plant breeding and crop science which sparked what is known as the "Green Revolution" (Roseburg, 2018). These reforms heightened the use of modern technology, high yielding crop varieties, chemical fertilizers, irrigation facilities, and improved farm implements and crop protection measures. Up to the 1960s, Mexico experienced dramatic improvements in agricultural production and productivity and the country grew most of the food it needed and became a net exporter of some agricultural products, particularly wheat (Ganzel, 2007). However, the drive to increase agri-food production has had a major toll on the environment including, *inter alia* **loss of soil fertility, soil erosion, diminishing**

water resources, and air, soil and water pollution. Today, **Mexico is on position 11 on the list of countries with the highest rate of greenhouse gas emissions in agriculture** (FAO, 2015).

According to World Bank et al. (2014), in Mexico, the most GHG emissions in 2010 emanated from the following sectors: energy (67.3%), agriculture (12.3%), and industrial processes (8.2%). Land use change contributed 6.3% of the total GHG emissions. Within agriculture, the highest contributions to emissions were from enteric fermentation[2] (53%), manure left on pasture (25%), and synthetic fertilizers[3] (10%) as shown in Figure 4.

Figure 4: Agriculture and greenhouse gas emissions in Mexico (2010)



Source: World Bank et al. (2014)

Agriculture is driving its own demise

Agriculture is a key driver of environmental degradation. It is directly responsible for approximately 10 – 12% of global greenhouse gas (GHG) emissions and indirectly for roughly another 10%. It is the main driver of land use change and associated biodiversity loss, uses 92% of global fresh water and approximately 20% of primary energy.

Besides causing environmental damage, agriculture is, above all other industries, reliant upon a well-functioning environment. It is vulnerable to temperature extremes, water availability, atmospheric soil and water pollution, pest and disease outbreaks, biodiversity loss, tropospheric ozone, high winds, among others.

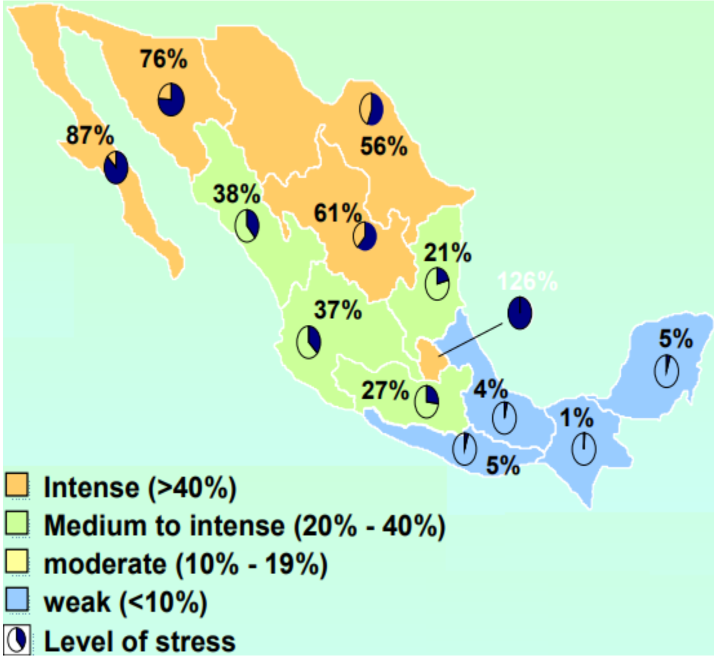
The global agricultural system is thus both a driver and a victim of environmental change.
Source: Gathorne–Hardy (2013, p. 37)

[2] FAO. 2014. FAOSTAT (Available from http://faostat.fao.org/).
[3] The World Bank. 2012. World Development Indicators (Available from http://data.worldbank.org/data-catalog/worlddevelopment-indicators)

Impact of water scarcity on agriculture

Water shortage is a serious threat to sustainable agriculture in Mexico. By 2009, **agriculture accounted for nearly 75% of the water usage** in the country (World Bank, 2009) and there have be no significant changes over the years. However, **its use is very inefficient, with almost 55% of the total usage being wasted, mainly due to leaking and excess irrigation**. The most vulnerable regions to water deprivation are the northern and central parts, which are classified as arid and semi-arid as shown in Figure 5.

Figure 5: Water problem in Mexico



- **The northern and central parts have the lowest availability of water, where the water problem intensity is over 40%.**
- Out of the total cultivated area of the country, only 6.2 million ha are equipped for irrigation, representing 23% of the total cultivated area.
- Out of the total area equipped for irrigation, 93.5% is done by surface irrigation (5.8 million ha), 4.8% by sprinkler irrigation (0.3 million ha) and the rest of 1.7% by localized irrigation (0.1 million ha).
- Out of the total area equipped for irrigation, 67% is done with surface water and 33% with groundwater (World Bank, 2009).

Source: www.oecd.org/env/cc/36426852.pdf

Impact of climate change on agriculture

Over the last four decades, Mexico has proven to be most susceptible to extreme weather events in Latin America, including heavy rainfall and landslides. Between 1970 and 1990, **18% of all disasters in the region affected Mexico**. The country has also experienced droughts, floods, frost, and hail **affecting 15% of farmers** between 1980 and 2000 (World Bank et al., 2014).

Source: World Bank et al. (2014)

According to the World Bank (2014) projections, **precipitation is expected to decrease in most of the country with varying degrees**. For instance, rainfall fluctuations between -14 mm and +33 mm are expected in the north-western Mexico (Baja California, Baja California Sur, sections of Sonora, and Chihuahua); while some parts such as Sinaloa, Jalisco, Michoacán, Veracruz, Tabasco are expected to experience severe decreases in rainfall of up to -

114 mm. Temperatures are also expected to increase ranging from: +1 ˚C in neotropical regions to +2 ˚C in arid regions (Sonora, Chihuahua, Coahuila). Such **changes in weather patterns are expected to affect farmers in various ways chiefly through reduction in average crop yields** (World Bank et al., 2014)

However, Mexico has embraced sustainable agriculture and biodiversity conservation, through a variety of national level strategies and policies, which have evolved over time. These include the National GHG Inventory (2001, 2006, 2009 and 2012); National Development Plan (PND, 2007-2012); Agricultural Sector Program (2007-2012); National Water Program (2007-2012); National Climate Change Strategy (ENACC, 2007 and 2013); United Nations Program for Reducing Emissions from Deforestation and Forest Degradation (ENAREDD, 2008); Climate Change General Law (LGCC, 2012); Nationally Appropriate Mitigation Action (NAMA, 2013); Climate Change Special Program (PECC, 2014-2018); and Sectoral Program for Agriculture, Livestock and Fisheries (PSAGP, 2013-2018) (World Bank, 2009; World Bank et al., 2014).

Within the agriculture sector current initiatives include **the National Development Plan 2013-2018 which emphasize "building a productive agriculture and fisheries sector to ensure food security of the country; the Agricultural, Fisheries and Food Development Program (2013-2018); the National Strategy for Sustainable Production and Consumption and the Conservation and Sustainable Use of Soil and Water (COUSSA).**

To further conserve and protect its biodiversity Mexico has also been actively involved in monitoring and implementing the objectives of the Convention on Biological Diversity. For example, Mexico has come up with various national strategies, legislation and administrative instruments to address the obligations under the conventions. For instance, under the CBD (1992), **the country implemented its first National Biodiversity Strategy in 2000**. This has been updated with the current **National Biodiversity Strategy and Action Plan (NBSAP) and in Spanish, "Estrategia Nacional sobre Biodiversidad y Plan de Acción (2016-2030**). A detailed discussion of current policies and initiatives is provided in Section 2.0.

Mexico has also expressed interest in combating global climate change. At the 2015 United Nations Climate Change Conference, **Mexico submitted an Intended Nationally Determined Contribution (INDC) and made a commitment to unconditionally reduce greenhouse gas emissions (GHGs) and black carbon (BC) by 25% below business-as-usual (BAU) in 2030.** As part of achieving these commitments, the Mexican Government set an ambitious goal of meeting 0% deforestation rate target by 2030 (México Gobierno de la República, 2014).

1.4 TEEB Implementation in Mexico: Promoting biodiversity and sustainability in the agriculture and food sector project

1. To complement the Mexican Government initiatives for agriculture sustainability and biodiversity conservation, **the United Nations Environment (UN Environment), with the support of the European Union (European Commission), launched a four-year project for "Promoting biodiversity and sustainability in the agriculture and food sector in Mexico**.

2. This project is in line with the Cancun Declaration[4] adopted at the 2016 December CBD COP13 in which governments commit to mainstream biodiversity across all sectors. The project would contribute to integrating biodiversity values into national accounting and reporting systems and will encourage sectors that depend or have an impact on biodiversity to adopt integrated approaches for its conservation and sustainable use. In addition, and in line with the Declaration, the project will contribute to supporting sustainable production and consumption throughout value chains, the safe and sustainable application of technologies, and the phasing out of harmful incentives and strengthening of positive incentives.

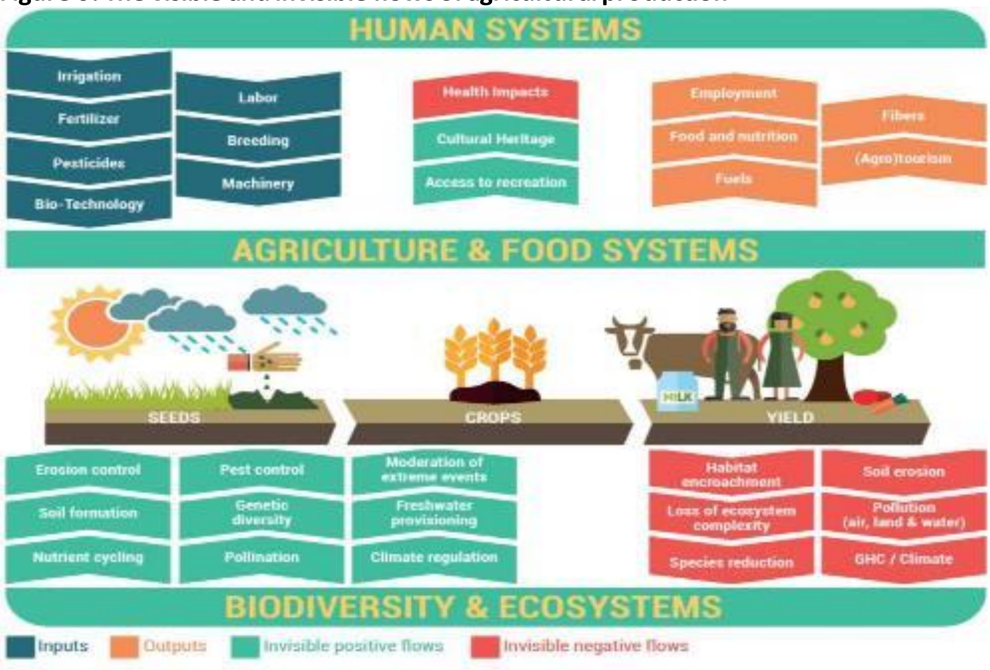
3. **The overall objective of this project is to protect biodiversity and contribute to a more sustainable agriculture and food sector with well-functioning ecosystems**. This will be achieved by:
    - developing and applying instruments to capture the value of ecosystems services across the entire life cycle in the agri-food and the non-food agricultural raw material sectors;
    - identifying intervention options protecting biodiversity and promoting well-functioning ecosystems and by direct engagement with farmers, agri-businesses, government, and civil society (including consumers).

4. The TEEBAgriFood Framework[5] will be used to assess the sectors for the EU Partner countries in scope. The focus in this action is capturing the value of ecosystems services, protecting biodiversity and promoting well-functioning ecosystems of the framework. The action aims to be comprehensive, from farm to fork (i.e. across the entire value chain). The Framework allows decision-makers (regulators, agri-business and farmers) to see explicitly any trade-offs that arise through the application of different measures, as compared with Business-As-Usual (BAU).

5. The rationale for the development of the TEEBAgriFood Evaluation Framework, is to provide a comprehensive and universal framework that captures all the positive and negative impacts and externalities across the entire agri-food value chain. It is a frame of reference that can enable us to answer the question “what we should value, and why?” It can be used to evaluate a policy question, a business question or an accounting question[6]. The TEEBAgriFood schematic (Figure 6) below provides a visual illustration of some of the impacts and externalities that might be omitted were we not to apply a holistic and comprehensive evaluation framework.

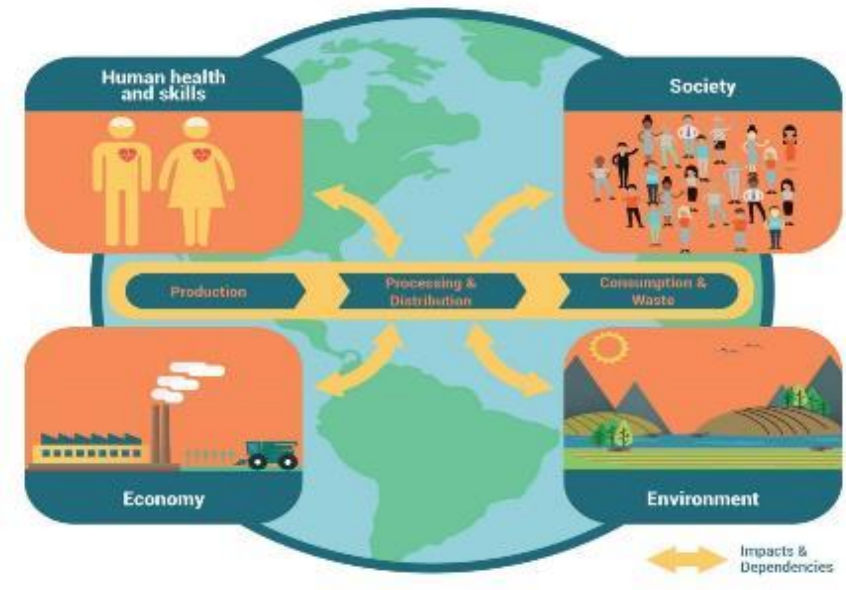
[4] http://www.cbd.int/cop/cop-13/hls/Cancun%20Declaration-EN.pdf
[5] The current published version of the Evaluation Framework can be found here: http://www.teebweb.org/agriculture-and-food/#framework. The Framework that is to be published in the upcoming TEEBAgriFood ‘Foundations’ report is an evolution of this previous version but retains the same core components. The ‘Foundations’ report is due to be published in Q1 2018 and thus the Framework will be finalized before the current EC Partnership Instrument project is contracted.
[6] For more details, see Chapter 3 in the TEEBAgriFood Interim Report: http://www.teebweb.org/publication/teebagfood-interim-report/

Figure 6: The visible and invisible flows of agricultural production



The schematic in Figure 6 above refers to the impacts and dependencies that occur within the farm-gate, but the Evaluation Framework looks at inter-linkages across the value chain, and trade-offs across capital stocks in the eco-agri-food systems complex. This is illustrated in the schematic below (Figure 7).

Figure 7: The eco-agri-food systems complex



6. The project builds on the momentum of the international TEEB initiative[7], TEEB country studies[8], TEEB for Agriculture and Food[9] and on national interest.

[7] http://www.teebweb.org/
[8] http://www.teebweb.org/areas-of-work/country-studies-home/
[9] http://www.teebweb.org/agriculture-and-food/

7. It also builds on the on-going UN Environment/TEEB initiatives in Mexico.
   - In 2017, GIZ, in collaboration with UN Environment Mexico, has started a German Climate Fund (IKI)–funded project on “mainstreaming biodiversity into the Mexican agriculture sector”, with the objective of integrating the value of biodiversity and ecosystem services into the decision-making and planning instruments of key change agents in the public and private sector in the Mexican agricultural sector. UN Environment Mexico is the implementing partner for the TEEB component of this project (approximate value 500.000 EUR), and the TEEB Office will provide technical support.
   - UN Environment Mexico also actively supports an inter-institutional working group on ecosystem service valuation, chaired by the Ministry for the Environment and Natural Resources (SEMARNAT), to exchange information on a regular basis in order to coordinate research efforts and to strengthen capacity.
   - The National Biodiversity Agency of Mexico (CONABIO) has submitted a draft final report for a global study on maize on behalf of TEEBAgriFood with case studies in Mexico, Ecuador and the United States.
8. TEEB will work closely with:
   - The Natural Capital Protocol, and links will be made to ensure representation from those firms which have already committed to Protocol on the project meetings.
   - The Partnership Instrument project "Natural Capital Accounting and Valuation of Ecosystem Services" (AAP 2015) involving UNDESA, UNEP-TEEB and the Secretariat of the Convention on Biological Diversity (sCBD) which aims to apply macro accounting in five countries including Mexico.
   - BIOFIN[10] is a global partnership developed to improve biodiversity management through sound financing and economic thinking. BIOFIN works directly with Finance and Environmental ministries in 30 countries helping them to understand how to use finance solutions to maintain ecosystems and the services they provide, and Mexico is part of this partnership.
   - UN-REDD Safeguards[11] were developed to promote benefits and protect against potential risks during the implementation of REDD+ actions. Five Aichi Targets including Targets 5 and 7 are relevant for REDD+ Safeguard.

Beyond these specific country links, there are complementarities between this project and initiatives providing guidance and opportunities in this space including FAO-OECD Guidelines on Responsible Supply Chains; the BioTrade initiative managed by UNCTAD[12]; the Intergovernmental Science- Policy Platform on Biodiversity and Ecosystem Services (IPBES)[13]; ESMERALDA[14] (Enhancing Ecosystem Services Mapping For Policy And Decision Making); FAO assessment/Platform on mainstreaming biodiversity in agricultural sectors[15] and DG Research and Innovation initiatives such as FOOD 2030[16].

[10] Can be found: http://www.biodiversityfinance.net. Assessed Nov 2017
[11] Can be found: http://www.unredd.net/knowledge/redd-plus-technical-issues/safeguards.html. Assessed Nov 2017
[12] www.biotrade.org
[13] http://www.ipbes.net/
[14] http://www.esmeralda-project.eu/
[15] http://www.fao.org/biodiversity/en/
[16] http://ec.europa.eu/research/conferences/2016/food2030/index.cfm

2 Overview of national policies in agriculture and biodiversity

Mexico is committed to ensuring sustainable land management in the agriculture sector and other land uses as emphasized under the National Development Plan 2013-2018.

2.1 The National Development Plan 2013-2018

One of the aims of the National Development Plan 2013-2018 is to "**build a productive agriculture and fisheries sector to ensure food security of the countr**y" and emphasizes the **"promotion of the sustainable use of natural resources of the country**," as its key strategy. This strategy is linked to the Conservation and Sustainable Use of Soil and Water (COUSSA) which was implemented in 2008 to promote sustainable practices in agriculture, livestock, fisheries and aquaculture activities.

The **Conservation and Sustainable Use of Soil and Water (COUSSA) and the Strategic Development Project Drylands (PRODEZA),** complement and implement components of the National Development Plan 2013-2018 strategy through action plans including:

1. Involving rural producers in implementing their projects.
2. Prioritizing the change in productive activities that are not commensurate with the productive potential.
3. Supporting actions for soil conservation and improved water infiltration.
4. Comprehensively take care of the territory with the watershed approach, which works by capturing and storing rainwater, combined with the completion of works and soil conservation practices and water.
5. Improving the greening rangeland (SAGARPA, 2013).

2.2 The 2013-2018 Agricultural, Fisheries and Food Development Program

In December 2013, the government of Mexico, through SAGARPA, unveiled a new six-year agricultural development plan called the **2013-2018 Agricultural, Fisheries and Food Development Program**, which is part of the **National Development Plan** that was announced on May 20, 2013. Considering the vision of the program, which is to build a "**new face of the countryside**", it appears Mexico is trying to fix some of the problems that have marred the subsidy programs, particularly that of not benefiting the rural poor smallholders. According to the GAIN Report (2014), Mexico intends to ensure a productive, competitive, profitable, fair and sustainable food sector, and food secure country by:

- Increasing participation of domestic production from a combined 58%, in 2011, to 75% in 2018 for the following grain and oilseed crops - rice, dry beans, corn, wheat, soybeans, and sorghum.
- Achieving growth in the agricultural and fisheries sectors allowing output (or GDP) to break with the historical trend, from 1.4% per year to 3% per year over the next six years.
- Achieving balance in the agro-food trade sector between value of imports and exports.

Under the Program, ten "Change Pillars" are proposed to create change in the agro-food sector:

1. Increasing the productivity of smallholdings through partnership models (“Clusters”) and integration of the supply chain.
2. Optimal use, sustainable and modernization of water.
3. Promote domestic production of strategic inputs, fertilizers and improved seeds.
4. Encourage innovation, the applied technology development and technical assistance with a new “Extension Service”.
5. Management and prevention of climate and market risks.
6. Promote the production of healthy and safe food.
7. Encourage timely and competitive financing.
8. Boost regional development, agro-parks and strategic projects.
9. Planning the supply-demand balance: “Control Panel”.
10. New organizational model of the Secretariat IFAT (Innovative, Flexible, Agile and Transparent).

2.3 The National Strategy for Sustainable Production and Consumption

Mexico is committed to more sustainable production and consumption of goods and services through efficient practices in the use of water, materials, energy and elements of biological wealth. (Huerta et al., 2016). Specifically, the **National Strategy for Sustainable Production and Consumption** encourages and guides an inclusive and facilitating green growth that preserves our natural heritage, while generating wealth, competitiveness and jobs (SEMARNAT, 2015). It consolidates the work of the Federal Government, led by the Secretariat of Environment and Natural Resources, in addition to the contribution of different actors in the environmental, public, private, academic and social sectors and with support from the German Development Cooperation Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

National Strategy for Sustainable Production and Consumption

Vision of the Strategy

BY 2020 various actors of Mexican society are committed to the change process towards an equitable and responsible economy, founded on production systems, distribution and sustainable consumption; actively participate in processes that favour the transformation of production and consumption patterns thus forming new lifestyles based on economic, social and environmental responsibility. Practices related to water use, materials, energy and elements of the biological wealth of the country are conducted with a focus on life cycle and are efficient and competitive. It also emphasizes the decoupling of economic growth from deterioration and social and environmental degradation and linked with the respect and care of the biosphere, economic valuation of natural resources and environmental services and reducing inequality and poverty. also contribute to mitigation and adaptation to climate change, moving towards local, regional, national sustainability and the planet.

Objective
Promoting production and consumption practices that contribute to sustainable development of Mexico.

Specific objectives

1. Contribute to changes in patterns of production and consumption by applying the gender equity approach favouring decent employment and equal access to opportunities for meeting basic needs and aspirations conducting thereby forming a better quality of life.
2. Promote processes of production, distribution and sustainable consumption to reduce economic, social and environmental impacts thereof, products and services.
3. Develop sustainable markets at the local, regional, national and international-oriented sustainable products that generate green jobs and contribute to fighting poverty, incorporating the gender equity approach level.
4. To promote sustainable consumption in supply chains both public and private strategies and different actions depending on the gender situation identified.
5. Generate a broad, plural, diverse and inclusive development of synergies institutional framework, systems development planning, implementation, monitoring and evaluation of programs and action plans, funding and accountability, incorporating the perspective of equity of genre.

Source: SEMARNAT (2015)

2.4 The evolution of agricultural policy

Mexico's agricultural policy has a long history with several twists and turns. Major agricultural policy reforms started in 1917 when the Mexican Constitution was amended to recognize the land rights of the original occupants under their regimen of customary tenure. A new land tenure system, known as *ejido*, was implemented in which land was to be returned to the original people and to other landless peasants (Wohlgemuth, 2014).

The 1930s, under the leadership of Cárdenas, was a period of most sustained pro-peasant rural economic policy. At that time, the agrarian reforms were pursued which included the redistribution of a significant share of commercial farmlands and investment in the productive capacity of the new social sector. For instance, many of the coffee haciendas were parceled out and given to their former workers as part of the *ejido* system (Wohlgemuth, 2014). However, with the change of leadership in the 1940s, with Camacho as president, government agricultural spending was shifted towards large investments in irrigation infrastructure and subsidized credit and inputs, which primarily benefited commercial farms in northern Mexico (Fox & Haight, 2010a). The government was interested in growing exportable crops, particularly wheat. So, in 1944, under the auspices of an American biologist, Norman Borlaug, plant breeding and crop science was pursued which sparked what is known as the "Green Revolution" (Roseburg, 2018), a concept that later was adopted by various countries across the world, particularly in Asia. Consequently, between 1943 and 1958, Mexico went from being a net importer – about half its wheat, to a net exporter – nearly 500,000 tons of wheat a year (Burton, 2009; Ganzel, 2007).

However, the agricultural policies that favoured commercial farmers came under great criticism starting from the 1960s such that by the early 1970s, the Mexican government re-embarked on pro-poor policy reforms that included extension of access to subsidized credit, inputs, support prices and rural infrastructural investments. Unfortunately, increased spending associated with subsidies and the skyrocketing debt put Mexico under the scrutiny of the donor community which recommended a series of Structural Adjustment Programs (SAPs) as a panacea. In order to become eligible to negotiate the terms of its loans, Mexico was required to, *inter alia*, abolish the *ejido* system, privatize of its state-owned industries and implement deep cuts in social spending and emphasize on export production. Consequently, nearly all government subsidies in the agricultural sector were eliminated. Tariffs for key products including corn, beans, rice, potatoes, pork, and chicken disappeared (Wohlgemuth, 2014).

It is worth noting that implementation of SAPs in the agricultural sector proceeded more slowly and cautiously than in other sectors; such that by 1992 the Salinas administration had employed various policies to transform the agricultural sector into a more efficient producer for the international economy. For instance, in 1988, Mexico got an Agricultural Sector Loan (ME-2918) from the World Bank to guide agricultural reforms for two-and-a-half years. According to Heredia and Purcell (1995), the overall objectives of the program were to:

1. remove global food subsidies and target remaining food subsidies to the poor;
2. reduce government intervention in agricultural markets, in part by moving from guaranteed prices for grains (corn and beans excluded) toward market-determined pricing;
3. abolish export controls and quantitative restrictions on key products;
4. reduce the role of agricultural parastatals;
5. liberalize agricultural trade;
6. cut the subsidization of inputs;
7. increase the efficiency of public investment in agriculture in real terms; and
8. decentralize and cut staff of the agriculture ministry.

By 1993, it was apparent that the adjustment policies were not helping the agricultural sector as envisaged. The most affected were the smallholder corn and bean producers. As such, **starting from the mid-1990s, the government embarked on 'revitalized' agricultural support policy under which several programs were implemented to abate the adverse welfare effects of agricultural liberalization** as expounded below.

The Agricultural Support Policy

In 1994, Mexico launched a major direct support program known as **the Program of Direct Rural Support** or **PROCAMPO**, which was followed by another one called **the Alliance for the Countryside** or **Alianza Para el Campo**, in 1996. The main objective of both programs was to enhance investment and productivity in the agriculture sector without distorting production incentives, thus enabling the integration of agricultural producers into the market economy.

Under PROCAMPO, farmers received an annual lump-sum payment of about 867 pesos per hectare. In total, 12 billion pesos (US$3.5 billion) was spent in 1994 benefiting 3.3 million growers of corn, beans, sorghum, wheat, rice, soybeans, and cotton, which together accounted for 70% of Mexico's arable land. The beneficiary was expected to maintain the same plot of land under some designated productive use until the scheduled termination of the program in 2008. The program was extended until 2012 with no redefinition of its objectives (OECD, 2011).

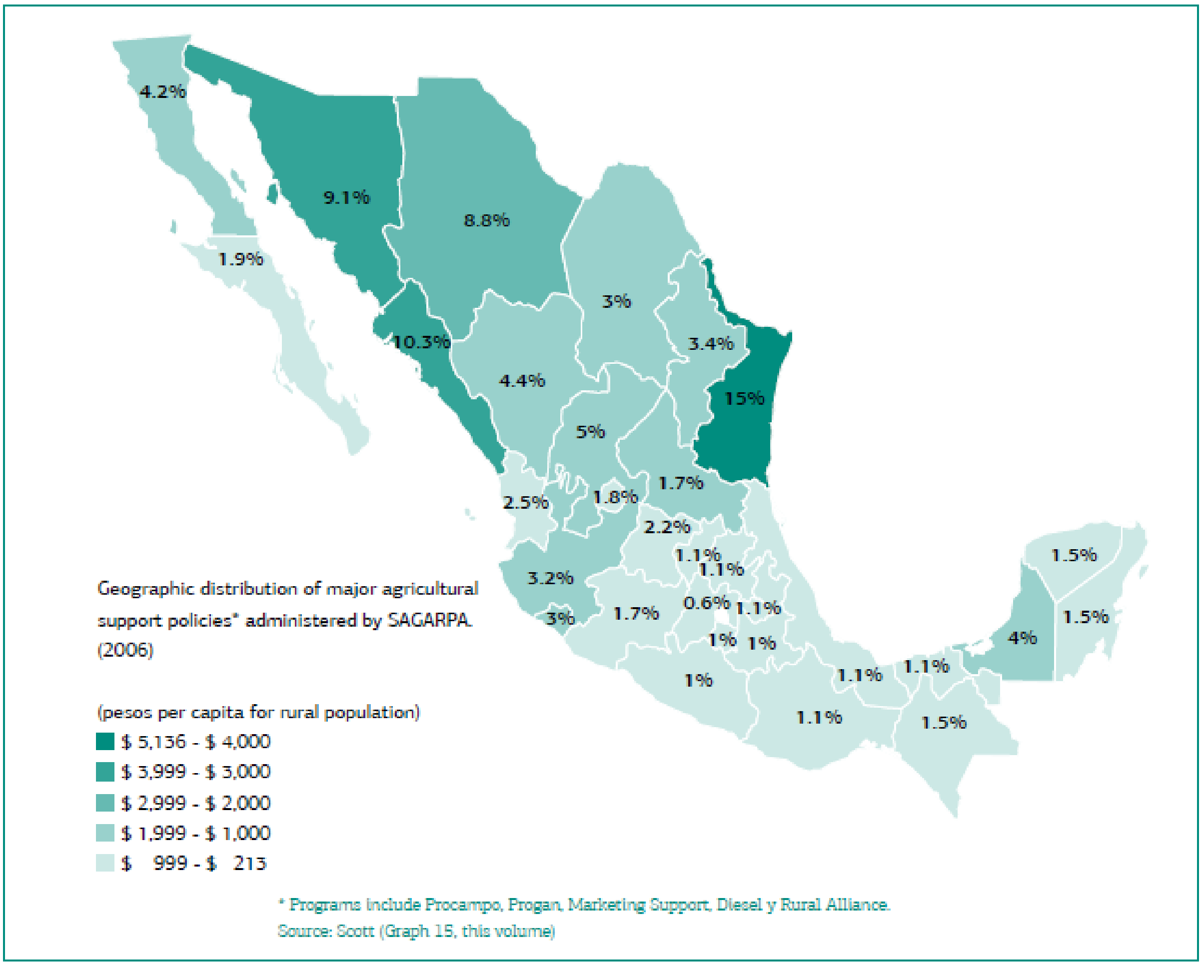
In 2014, PROCAMPO was widely reformed and renamed PROAGRO Productivo (Productive PROAGRO) to reduce distortions and improve its effectiveness. Under PROAGRO Productivo, farmers are eligible to receive subsidies based on actual production, instead of land size, as it was the case previously; and the maximum subsidy amount per beneficiary cannot exceed Mex$100 000 (approximately US$7 750) per crop cycle (FAO, 2016). On the other hand, under the Alianza Para el Campo, financial support was demand-driven, such that farmers had to petition for financial or technical assistance to undertake particular productive investments (Schmook & Vance, 2009).

From 2003, Mexico implemented a price support programme called **Incentivo Complementario al Ingreso Objetivo (Target Income Programme)** to guarantee a minimum income to small- and medium-scale grain and oilseed farmers. Under this program, which is overseen by the Agricultural Marketing Support and Services Agency (ASERCA)[17], farmers receive the difference between a predetermined income (called the "target income") and the market price. In case of a reduction in market prices of grains and oilseeds, adjustments are made accordingly to ensure farmers' profitability (FAO, 2016).

However, Mexico's agricultural support policy has been criticised by some quarters. According to Fox and Haight (2010a), the Mexican government's farm support policy is sharply biased against low-income producers. The authors contend that instead of reaching the intended smallholders, the support programs such as Procampo, turn out to benefit large scale growers. For instance, by 2006, agricultural spending by the Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), which is the overseer of various programs including PROCAMPO, revealed high concentration in northern Mexico where most large-scale growers operate as shown in Figure 8.

[17] ASERCA was created in 1991, replacing the previous entity CONASUPO in charge of government purchases at fixed prices, in order to better reflect Mexico's agricultural trade liberation process. The government no longer purchased grains and oilseeds, but a "marketing payment" was given to small and medium producers FAO. (2016). Country fact sheet on food and agriculture policy trends - Mexico. http://www.fao.org/3/a-i6006e.pdf.

Figure 8: Geographic concentration of agricultural spending by SAGARPA, by state, 2006 (M$ rural per capita)



Source: Fox and Haight (2010a)

Fox and Haight (2010b) also argues that despite a huge increase in agricultural spending since 2001, almost doubling in real terms by 2008, farm employment fell significantly which may suggest that the farm job crisis is not due to a lack of public spending, but rather that rural (farm) employment has not been a priority. Furthermore, the authors argue that the subsidy programs lack transparency and accountability.

2.5 Biodiversity Conservation in Mexico

Mexico recognize the role of natural capital stocks in its economic development through a number of national and international initiatives. **The Government of Mexico has defined an ambitious agenda in the preservation its biological diversity, as highlighted in the National Development Plan 2013-2018** (Plan Nacional de Desarrollo 2013-2018), which explicitly included the term "green growth" as one of its main objectives and stressed the importance of environmental sustainability in its objective[18].

Moreover, the sector program of the Ministry of Environment and Natural Resources (SEMARNAT), PROMARNAT 2013-2018, defines the work program of the environmental sector in line with the National Development Plan. The promotion of low carbon growth and the importance of generating green jobs are among the main priority areas[19].

For over 20 years, **Mexico has also created and constantly improved its System of Economic and Environmental Accounting**. Mexico regularly updates a national inventory of the damage to the environment and natural resources caused by human activities of production, distribution and consumption and publishes the book "The Natural Capital of Mexico" (El Capital Natural de México) (INEGI, 2013).

Besides, Mexico has implemented several policy instruments for the preservation of biological diversity and its natural resources. For example, **Mexico has 181 federal Protected Natural Areas; schemes for the Payment for Ecosystem Services (PES) covering almost 3 million hectares of the national territory; and operates over 12,000 Units of Wildlife Conservation and Management** covering around 39 million hectares (corresponding to over 19% of the national territory)[20].

In December 2016, Mexico hosted the 13th Conference of the Parties to the Convention on Biological Diversity (CBD COP13) in Cancun, with the motto "Incorporating biodiversity for well-being". Together with the other members of the Convention, Mexico promoted the ambitious agenda of integrating biodiversity into four sectors: agriculture, forestry, tourism and fisheries. The COP13 provided a unique opportunity to integrate ecosystem services into public policy and decision making, while contributing to policy coherence (Sustainable Development Objective, ODS 17.14) and the transition towards a green, more inclusive and sustainable economy[21].

The TEEB for Mexico Initiative is an important tool working towards strengthening the above-mentioned efforts of the Mexican government towards green and inclusive growth and contributes to the implementation of the recommendations of the world-wide, renowned Green Economy Initiative of UNEP. This initiative seeks to highlight the benefits of a transition to a green economy, increase public investment towards green sectors and demonstrate that a green economy would contribute to

[18] http://www.teebweb.org/teeb-mexico/biodiversity/

[19] ibid
[20] ibid
[21] ibid

a higher rate of economic growth while at the same time combating poverty, improving social equity and preserving the country's natural capital[22].

At the international level, Mexico is party to a number of international conventions that promote forest and biodiversity conservation including the '**Convention on Biological Diversity** (CBD), 1992'. Mexico has also been actively involved in monitoring and implementing the objectives of the Convention on Biological Diversity. **Mexico has come up with various national strategies, legislation and administrative instruments to address the obligations under the conventions**. For instance, under the CBD (1992), the country implemented its first National Biodiversity Strategy in 2000. This has been updated with the current National Biodiversity Strategy and Action Plan (NBSAP) (2016-2030) as discussed further below.

2.6 National Biodiversity Strategy and Action Plan (NBSAP); "Estrategia Nacional sobre Biodiversidad y Plan de Acción (2016-2030)

Mexico's Estrategia Nacional sobre Biodiversidad y Plan de Acción (2016-2030) is broadly aligned to the global Strategic Plan for Biodiversity 2011 – 2020 and its Aichi Targets as well as the United Nations 2030 Agenda for Sustainable Development. The NBSAP (2016-2030) has also been developed in line with the provisions contained in the document Natural Capital of Mexico: Strategic actions for valuation, preservation and restoration (2012). It also presents an important opportunity and framework to mainstream biodiversity criteria in such policies, plans and programs, within and across sectors, and at all levels of government, to ensure the continued provision of ecosystem services necessary for the well-being of the Mexican people.

Specifically, Mexico's National Biodiversity Action Plan (NBAP); National Goal 2.2 emphasizes the development of **strategies for integrating biodiversity in agriculture, forestry, fisheries and tourism sectors**. Mexico's NBAP outlines 20 national goals developed in line with Aichi Targets outlined in Table 1.

[22] ibid

Table 1: Mexico National Biodiversity Action Plan

Reference	Target	Related Strategic Goals/Aichi Targets
National Goal 1.1	By 2030, Mexican citizenship values the importance of biological diversity through processes of education, training, communication and dissemination and performs actions for conservation and sustainable use.	1
National Goal 2.1	**By 2019, the National Development Plan (PND) and programs subject to the Planning Act, include a strategic and transversal vision of the assessment, sustainable use and conservation of biodiversity.**	2
National Goal 2.2	**There are strategies for integrating biodiversity in agriculture, forestry, fisheries and tourism sectors.**	2
National Goal 3.1	By 2018, have an inventory of the main incentives and subsidies affecting biodiversity identified the type of impact.	3
National Goal 3.2	By 2018, it has a strategy to modify and align the main incentives and subsidies that favour conservation and sustainable use of biodiversity, including methodologies to assess their impact.	3
National Goal 3.3	By 2030, will have been reduced, eliminated or replaced those incentives and subsidies for public policies, including those aimed at social welfare, impacting biodiversity detrimentally, particularly in protected natural areas (PNA) and priority sites for biodiversity.	3
National Goal 3.4	By 2020, 100% of economic incentives, including subsidies, aimed at productive projects related to agricultural development actions integrate environmental sustainability.	3
National Goal 4.1	**By 2018, the National Strategy for Sustainable Production and Consumption is instrumented with an outreach program at all levels of government and other sectors and have initiated actions for implementation.**	4
National Goal 4.2	By 2030, it has basins and aquifers in equilibrium with an integrated and sustainable water management with integrated management of water resources.	4
National Goal 5.1	By 2020, the downward trend of the rate of loss of all natural habitat is maintained and will be reduced significantly degradation and fragmentation.	5
National Goal 5.2	By 2030, will have fallen to a value close to zero the rate of loss and degradation of protected natural habitats.	5
National Goal 5.3	By 2018, is instrumented National Policy Seas and Coasts under effective intersectoral coordination scheme.	5
National Goal 6.1	By 2030, populations of fish, invertebrates and aquatic plants are harvested and grown in a sustainable manner, applying the ecosystem approach, based on knowledge of the state of sustainability that is continuously updated.	6
National Goal 6.2	By 2020, has increased the adoption of non-destructive fishing gear, it has reduced illegal and bycatch and fishing activity has minimal impacts on marine, coastal, freshwater and biodiversity.	6
National Goal 6.3	By 2020, they have established representative fishing shelters major fisheries and their habitats, thereby ensuring its permanence.	6
National Goal 7.1	By 2030, have become conventional farming practices sustainable in a lot of producers and agricultural area.	7
National Goal 7.2	**By 2030, efficient and sustainable water use has spread significantly in the national agricultural area.**	**7**

National Goal 7.3	**By 2030, the use of fertilizers and pesticides are made with sustainability criteria in national agricultural area.**	**7**
National Goal 7.4	By 2020, contributes to the conservation of the genetic integrity of wild species of agricultural importance by determining the surface and the species that Mexico is the center of origin and center of genetic diversity.	7
National Goal 7.5	**By 2030, aquaculture is done in a sustainable manner, without promoting the loss of natural habitat, introduction of exotic species and pollution is reduced.**	**7**
National Goal 7.6	By 2020, forest ecosystems likely to use, are used in a sustainable manner and integrated landscape management maintaining its connectivity and its environmental services and promotes biodiversity.	7
National Goal 7.7	By 2020, the area of forest plantations with native species in degraded sites without encouraging the loss of natural habitat are increased.	7
National Goal 8.1	By 2020, the presence of contaminants in air, water and soil are kept safe for health and biodiversity levels.	8
National Goal 9.1	By 2020, it has updated and prioritized lists of invasive alien species in the country.	9
National Goal 9.2	By 2020, it has updated and prioritized lists of invasive alien species in the country.	9
National Goal 9.3	By 2020 show significant progress in prevention, management, control and eradication of invasive species priorities in accordance with the National Strategy on Invasive Species.	9
National Goal 10.1	By 2030, they have been reduced threats to ecosystems, species at risk and priority marine species, including reef areas and are under protection and activities that form part of them are sustainably.	10
National Goal 10.2	By 2030, it has a national policy of integrated management of wetlands.	10
National Goal 10.3	By 2030, it has a national strategy for care reefs.	10
National Goal 11.1	By 2020, at least 17 percent of land areas and inland water and 10 percent of marine and coastal areas are preserved and handled efficiently and equitably through protected areas and other conservation (biological corridors, amu community conservation areas, psa, voluntarily areas designated for preservation), promoting its connectivity and landscape integrity and continuity of the environmental services provided.	11
National Goal 11.2	By 2020, all NPAs have a management program.	11
National Goal 12.1	By 2020, the species listed endangered and priority have a program to support conservation and recovery.	12
National Goal 12.2	By 2020, it has national lists of priority species at risk and updated regularly.	12
National Goal 13.1	By 2020, have established programs for conservation of genetic integrity of cultivated plants and domesticated animals and of wild relatives, particularly those which Mexico is center of origin and diversification and have economic or cultural value.	13
National Goal 14.1	By 2020, essential ecosystem services are maintained for human welfare and national security through the development and strengthening of inclusive mechanisms that incentivize and compensate the conservation and restoration of ecosystems.	14
National Goal 15.1	By 2020, the resilience of ecosystems is maintained and increased, by conserving biodiversity and preventing and reducing threats and impacts that deteriorate and break.	15
National Goal 15.2	By 2030, will have been restored at least 15 percent of degraded ecosystems, thereby contributing to climate change mitigation, and	15

	adaptation to increasing resilience and the fight against desertification.	
National Goal 15.3	By 2020, they include characterization studies of national and regional climate change, vulnerability and impact to assess the effects of climate change on the hydrological cycle to achieve the necessary adjustment.	15
National Goal 16.1	By 2020, it has the necessary legislation to implement the Nagoya Protocol, they have strengthened the institutional capacities of the actors involved, and it has a monitoring system access cases, which incorporates exchange mechanisms national information.	16
National Goal 17.1	The Strategic Plan 2011-2020 and the Aichi are reference for the sectoral programs of the APF and 2016, it has published the National Biodiversity Strategy of Mexico (ENBioMex) and Action Plan 2016-2030.	17
National Goal 17.2	By 2020, there is a monitoring system for the National Biodiversity Strategy of Mexico (ENBioMex) and Action Plan 2016-2030.	17
National Goal 18.1	By 2020, have increased and strengthened programs and public policies with a gender perspective, aimed at valuing and respecting knowledge, traditional practices and innovations of indigenous and local communities that affect the conservation and sustainable use of biodiversity.	18
National Goal 18.2	By 2020, have strengthened the consultation processes that ensure the full and effective participation of indigenous peoples and local communities.	18
National Goal 19	By 2020 has increased scientific and technological knowledge about biodiversity, its values, functioning, status and trends, and the consequences of its loss and knowledge is widely shared, transferred and applied.	19
National Goal 20	No later than 2018, a strategy that identifies sources of internal and external financing, based on an analysis of gaps in resource mobilization in line with the commitments made by Mexico under international conventions is implemented and those established by Mexico in their National Goals and the ENBioMex.	20

Source: https://www.cbd.int/nbsap/targets/default.shtml

Despite these on-going efforts, challenges to conserve biodiversity and ensure sustainable agroecosystems still remain. Many natural areas and habitats are threatened, for example, **it is estimated that Mexico lost 35% of its forest cover in the past 20 years (INEGI, 2014). Furthermore, 2,606 species are in danger of extinction, threatened or subject to special protection (NORMA Oficial Mexicana 059, 2010)**

Within agricultural landscapes**, land degradation is an important factor in Mexico's national economy impacting 65% of the national land area**. By 2003, it was estimated that **losses of nutrients and productivity in agricultural and grazing areas cost over $2 billion a year**, losses due to salinization approach $1 billion and the cost of deforestation are up to $0.5 billion. It has also been shown that land degradation is an important contributing factor to rural-urban migration in Mexico (Campbell & Berry, 2003b).

3 Case studies on agricultural impacts in Mexico

There is a growing concern on the potential environmental effects emanating from agricultural landscapes and agri-food systems. However, there is paucity of studies assessing environmental impacts of agri-food systems across the value chain in Mexico. A **few studies conducted mostly at farm gate points towards significant impacts including land degradation. Consequently, important ecosystem services including carbon capture, habitat provision as well as provisioning ecosystem services such as food and water are being negatively affected**. Four case studies are explored here in depth.

Case study 1: Agriculture and cattle raising are among the key drivers of soil degradation in Mexico

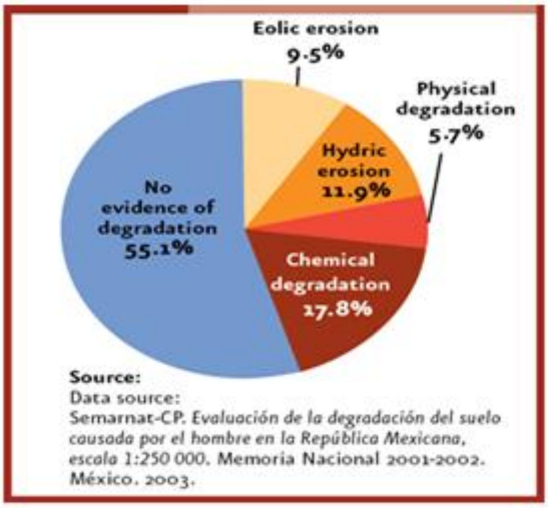
Soil degradation in Mexico is increasingly recognized as a serious problem of great concern. According to the Institut de recherche pour le développement (IRD, 2012), about 80% of the land is subject to erosion. The central state of Michoacán is the most affected, with more than 2 million hectares affected, representing 70% of the surface area. Soil degradation remains a key challenge for the sustainability of agriculture and biodiversity as it involves the loss of biological diversity and destruction of soil structure. It affects land productivity and therefore, a major threat to food security.

While soil degradation in Mexico can be attributed to an interlocking force of natural process including climate, rugged and changeable topography and fragile soils, agriculture and cattle raising are considered to be the key driving factors (Institut de recherche pour le développement, 2012).

An investigation by SEMANART and *the* Colegio de Postgraduados (2003), entitled Assessment of soil degradation caused by man (Evaluación de la degradación del suelo causado por el hombre en la República Mexicana, escala *1:250 000*, in spanish), gives the most comprehensive assessment of soil degradation in Mexico. The study considered four degradation processes namely, hydric and eolic erosion, and physical and chemical degradation.

According to SEMARNAT (2008), hydric erosion is defined as the massive removal of soil materials by water currents while in eolic erosion, the wind acts as the soil-removal agent. On the other hand, chemical degradation involves processes leading to the reduction or elimination of soil biological productivity, and is strongly linked with the expansion of agriculture. Whereas, physical degradation refers to a modification of soil structure evidenced by the loss or reduction of water-absorption and storage capacity.

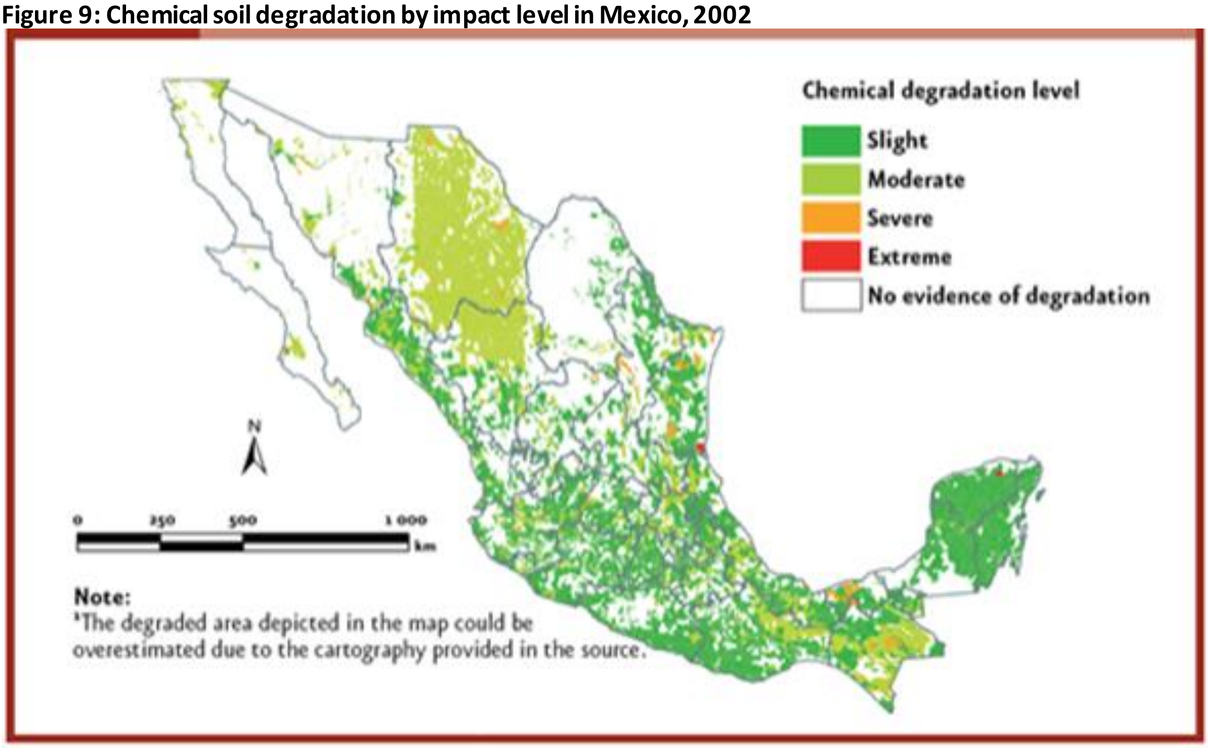
Relative area affected by soil degradation process in Mexico, 2002



It was found that, 44.9% of soils in Mexico showed some type of degradation. **Chemical degradation was found to be the dominant soil-degradation process in Mexico affecting 17.8% of the country land area,** followed by hydric erosion (11.9%), eolic erosion (9.5%) and physical degradation (5.7%).

The study results showed that chemical degradation occurred in all states (Figure 9), **the most affected being Yucatan (55.1%)** and the least being Baja California Sur, Coahuila, Baja California and Sonora, where the area evidencing chemical degradation represents 5.5% or less of the corresponding state territory as shown in Table 2. **Chemical soil degradation could be attributed to a wide range of industrial and agricultural activities, including hydrocarbon spills, excessive fertilizer and pesticide application, poor materials management, hazardous and urban solid wastes**.

Figure 9: Chemical soil degradation by impact level in Mexico, 2002



Source: SEMARNAT (2008)

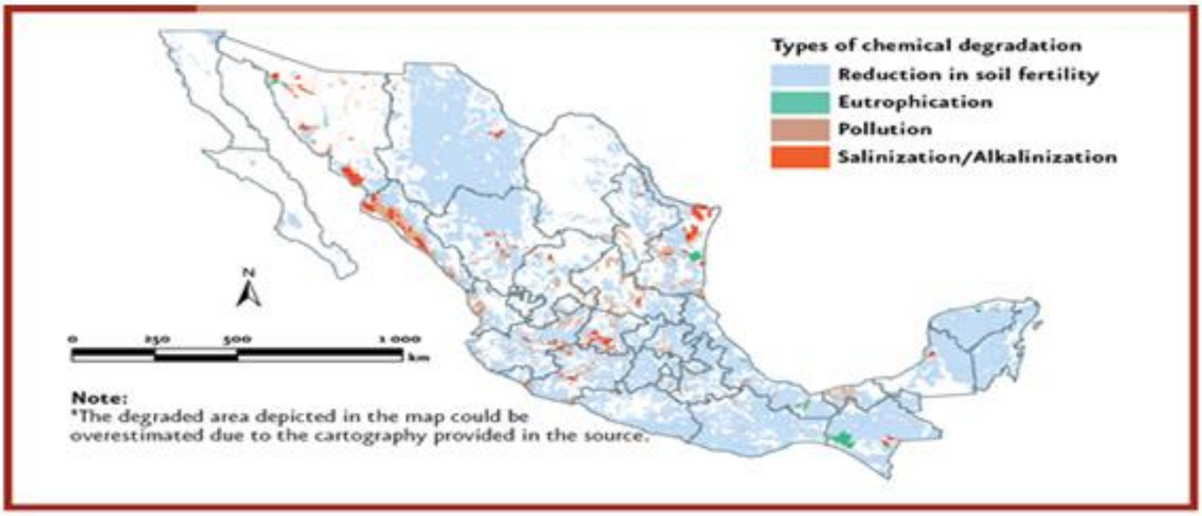
Table 2: Chemical degradation by type and state, 2002 (Area expressed in thousand hectares and percentage)

	Reduction in soil fertility		Pollution		Salinization-Alkalinization		Eutrophication		State area affected	
	Area	Proportion	Area	Proportion	Area	Proportion	Area	Proportion	Thousand hectares	(%)
Aguascalientes	57.81	10.7	15.03	2.8	0	0	2.87	0.5	75.71	14.0
Baja California	111.72	1.6	0	0	98.15	1.4	50.40	0.7	260.26	3.6
Baja California Sur	132.75	1.9	1.56	0.02	0	0	0	0	134.31	1.9
Campeche	1 401.18	25.5	0	0	4.31	0.1	0	0	1 405.50	25.6
Coahuila	344.83	2.3	18.46	0.1	1.42	0.01	0	0	364.70	2.4
Colima	142.17	26.2	3.08	0.6	0.81	0.1	0	0	146.06	27.0
Chiapas	2 330.24	32.5	4.36	0.1	25.22	0.4	40.07	0.6	2 399.90	33.5
Chihuahua	5 455.26	22.2	5.10	0.02	30.46	0.1	0	0	5 490.81	22.4
Distrito Federal	11.77	13.4	0	0	0	0	0	0	11.77	13.4
Durango	2 107.78	17.4	19.02	0.2	16.66	0.1	0	0	2 143.46	17.6
Guanajuato	658.20	22.2	100.98	3.4	97.39	3.3	0	0	856.56	28.9
Guerrero	891.52	14.2	6.71	0.1	0.10	0.002	0	0	898.33	14.3
Hidalgo	473.75	23.2	80.29	3.9	0.11	0.01	0	0	554.15	27.2
Jalisco	1 528.85	20.2	99.29	1.3	28.51	0.4	0	0	1 656.64	21.9
Estado de Mexico	544.66	25.9	0.49	0.02	0.11	0.01	0.46	0.02	545.71	26.0
Michoacan	1 218.91	21.5	28.48	0.5	67.00	1.2	0	0	1 314.40	23.2
Morelos	138.38	29.6	0.62	0.1	1.36	0.3	0	0	140.37	30.0
Nayarit	507.71	18.7	15.29	0.6	14.79	0.5	0	0	537.80	19.8
Nuevo Leon	464.01	7.4	133.08	2.1	9.33	0.1	7.92	0.1	614.34	9.8
Oaxaca	1 670.95	18.3	5.87	0.1	0	0	1.80	0.02	1 678.62	18.4
Puebla	735.84	22.0	5.47	0.2	0	0	0	0	741.31	22.1
Queretaro	198.06	17.5	0	0	1.11	0.1	0	0	199.17	17.6
Quintana Roo	1 020.10	25.7	0	0	0	0	0	0	1 020.10	25.7
San Luis Potosi	697.66	11.6	158.42	2.6	6.03	0.1	1.87	0.03	863.98	14.4
Sinaloa	1 410.84	26.5	49.97	0.9	193.98	3.6	0	0	1 654.80	31.1
Sonora	564.53	3.2	19.90	0.1	307.25	1.7	33.85	0.2	925.52	5.2
Tabasco	695.35	30.1	34.14	1.5	0	0	0	0	729.49	31.6
Tamaulipas	1 201.11	16.1	280.27	3.8	145.56	1.9	19.66	0.3	1 646.60	22.0
Tlaxcala	90.27	23.1	1.55	0.4	0	0	0	0	91.81	23.5
Veracruz	2 120.17	31.0	15.80	0.2	10.91	0.2	18.15	0.3	2 165.04	31.6
Yucatan	2 128.32	55.0	1.64	0.04	0	0	1.30	0.03	2 131.26	55.1
Zacatecas	549.68	7.4	78.54	1.1	3.98	0.1	11.86	0.2	644.06	8.7
National Area Affected	**31 604.37**	**16.6**	**1 183.4**	**0.0**	**1 064.57**	**0.6**	**190.20**	**0.1**	**34 042.55**	**17.8**

Source: SEMARNAT (2008)

The dominant chemical degradation type was the reduction in soil fertility, affecting 92.7% of the total country area, resulting from the decrease in the availability of soil minerals and organic matter (Figure 10 and Table 2).

Figure 10: Chemical soil degradation by specific degradation types in Mexico, 2002

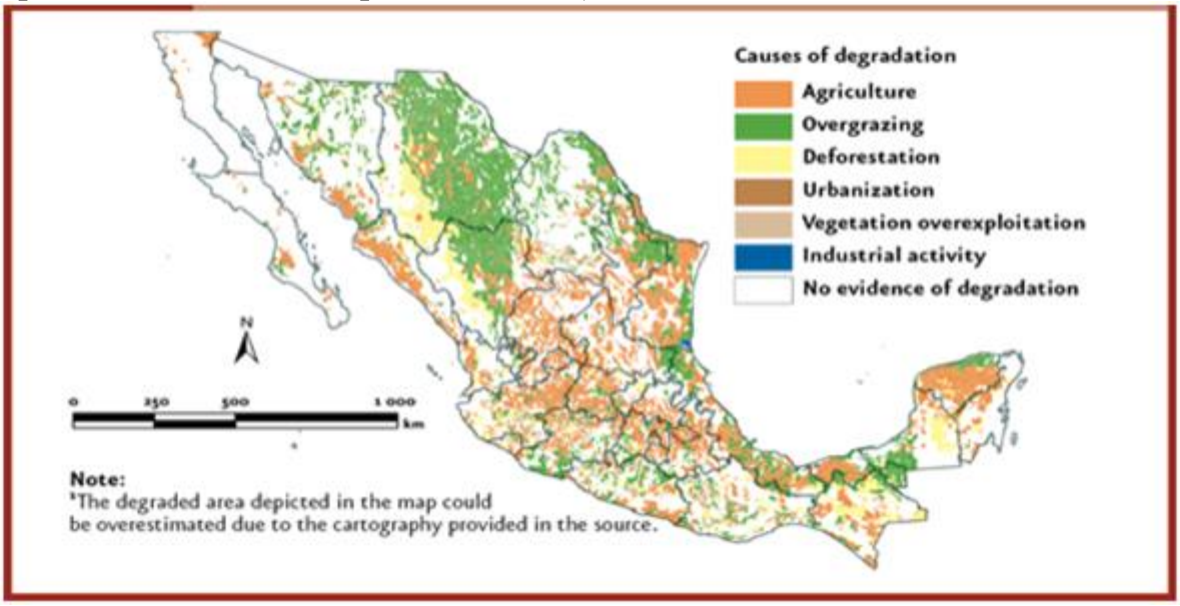


Source: SEMARNAT (2008)

This degradation type occurs in more than half of Yucatan and nearly one third of Tlaxcala, Chiapas, Morelos, Tabasco and Veracruz (Figure 10 and Table 2). The other specific chemical degradation types were pollution salinization and eutrophication which were far less widespread, altogether representing 7.3% of the chemically degraded area in Mexico.

Agriculture and cattle raising were found to be the major causes of soil degradation, altogether accounting for 35% of the country's degraded area (17.5 % each). This was followed by deforestation at 7.5% and the rest could be attributed to urbanization, vegetation overexploitation and industrial activities (Figure 11).

Figure 11: Main causes of soil degradation in Mexico, 2002



Source: SEMARNAT (2008)

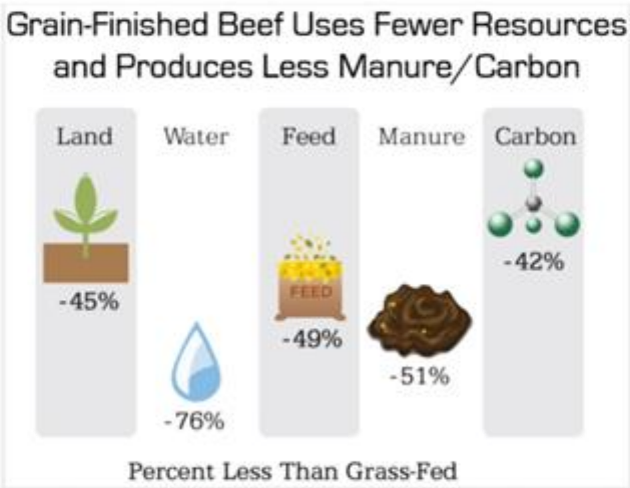
Case Study 2: Value chain analysis of environmental impacts of beef production in Veracruz

Beef production plays a significant role to the Mexican economy, both for domestic consumption and international trade. Presently, Mexico is ranked the tenth largest beef producer, with 1.9 million tons per year (USDA, 2018). It hosts more than 1.1 million cattle ranches and more than 30 million heads for beef production, of which 17% is produced in the state of Veracruz (Huerta et al., 2016; SAGARPA, 2009).

However, livestock production is associated with a higher environmental footprint, with wide-ranging impacts on air and atmosphere, land and soil, water, and biodiversity. At farm level, **cattle raising is among the major cause of soil degradation in Mexico leading to the loss of biological diversity and land productivity**. For Mexico to meet its green growth commitments as stipulated in, *inter alia*, the National Strategy for Sustainable Production and Consumption, reducing environmental impacts along the beef production value chain is critical.

Debate around the environmental performance of intensive versus extensive systems is still an area under investigation. Evidence points towards the intensive system having less environmental footprint in terms of land, water, feed, manure and carbon as illustrated in **Error! Reference source not found.**. However, the magnitude of the impacts could vary depending on the level of analysis across the beef production value chain.

Figure 12: Comparison of environmental impacts between intensive and extensive production systems

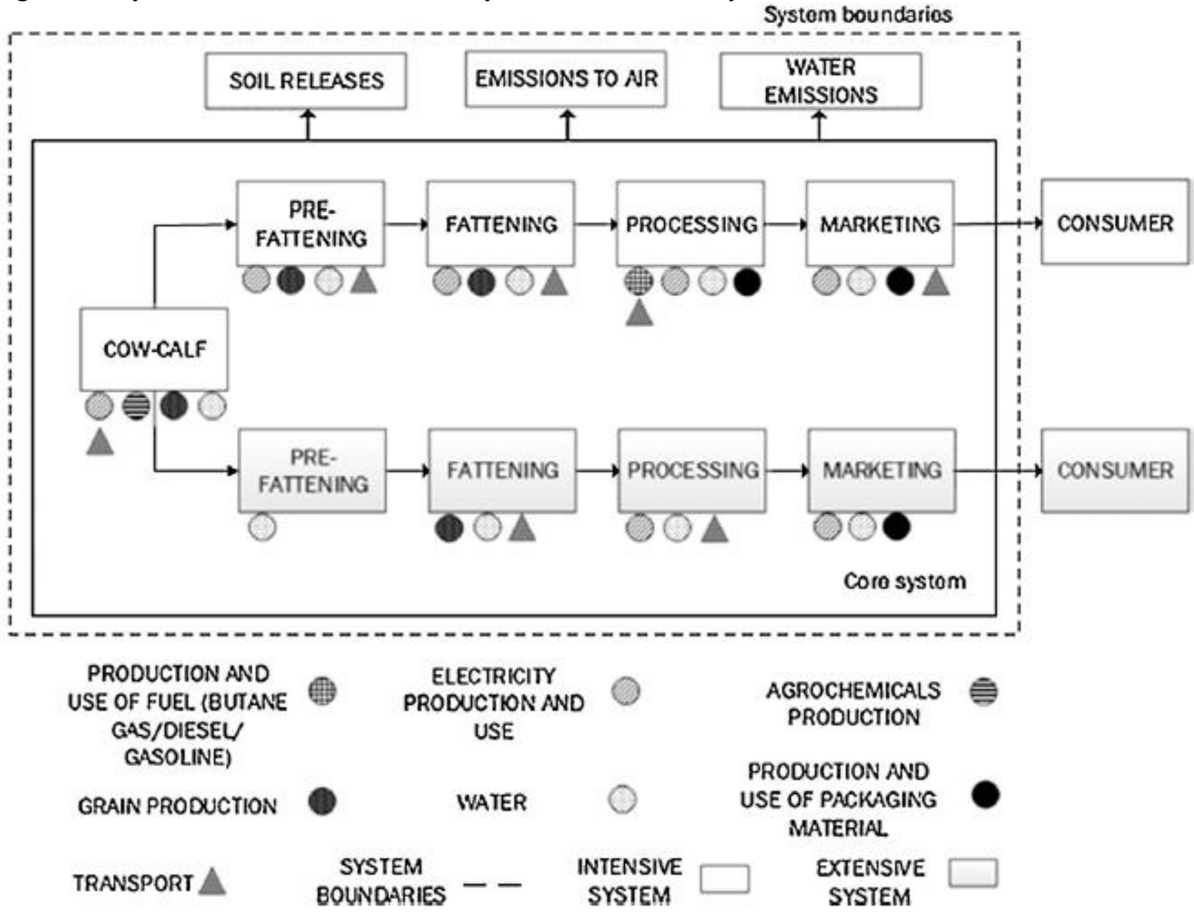


Source: Febrero (2016)

A study by Huerta et al. (2016) assessed **the environmental impacts in the production of 1 kg of beef throughout an entire production chain** under **extensive and intensive beef production systems** using the state of Veracruz as a case study.

The system boundary used included farm production to consumer consumption, including intermediate stages of product processing, marketing and transportation as shown in Figure 13. The functional unit used was 1 kg of boneless and fatless beef. The life cycle inventory was built using information from case studies; farmers, slaughterhouses and retail point managers who provided information from records and expert knowledge were interviewed. The study included cow-calf processes, pre-fattening, fattening, processing and retail.

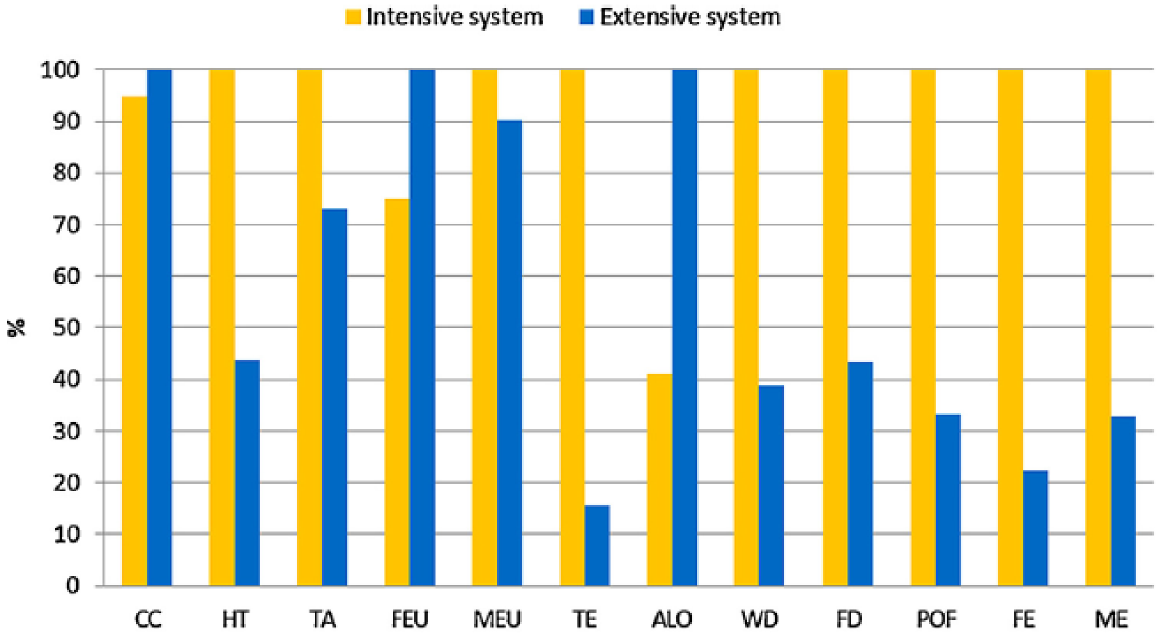
Figure 13: System boundaries of intensive system and extensive system



Source: Huerta et al. (2016)

The intensive and extensive of beef production systems were assesses against twelve environmental impact categories namely, Climate change, Human Toxicity, Terrestrial Acidification, Freshwater Eutrophication, Marine Eutrophication, Terrestrial Ecotoxicity, Agricultural Land Occupation, Water depletion, Fossil Depletion, Photochemical oxidant formation, Freshwater Ecotoxicity, and Marine Ecotoxicity. Figure 14 shows the extent of the impacts.

Figure 14: Impact categories

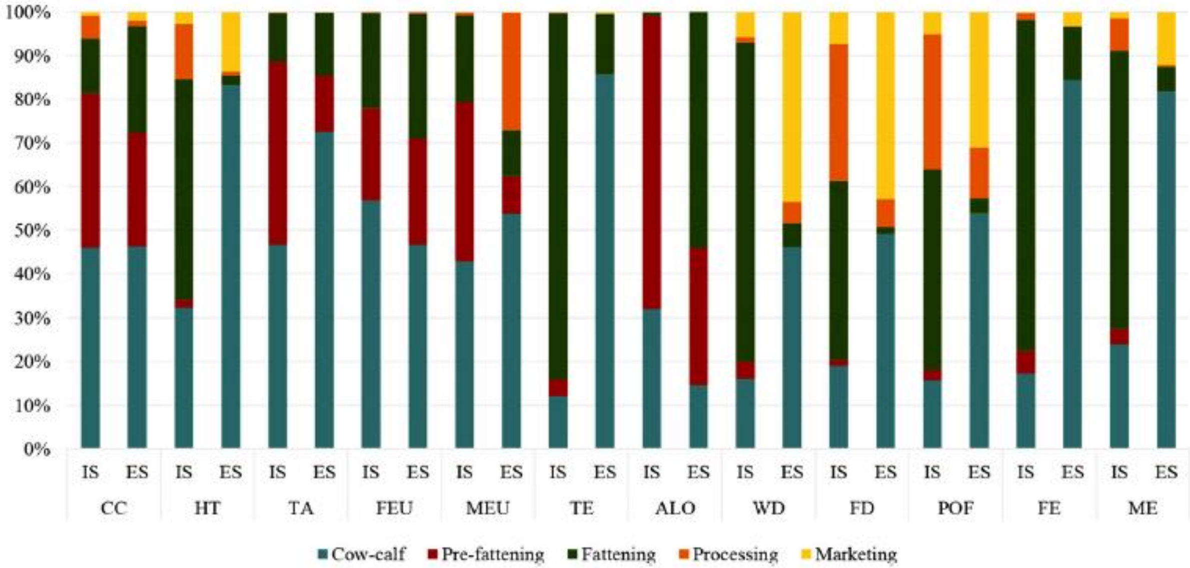


Impact category (percentages) comparison for intensive and extensive systems. Comparison per 1 kg of meat. **CC** = Climate change, **HT** = Human toxicity, **TA** = Terrestrial acidification, **FEU** = Freshwater eutrophication, **MEU** = Marine eutrophication, **TE** = Terrestrial ecotoxicity, **ALO** = Agricultural land occupation, **WD** = Water depletion, **FD** = Fossil depletion, **POF** = Photochemical oxidant formation, **FE** = Freshwater ecotoxicity, **ME** = Marine ecotoxicity. Source: Huerta et al. (2016).

The results in Figure 14, indicate that **the extensive system (ES) has better environmental performance in nine out of the twelve impact categories** including **human toxicity, terrestrial acidification, marine eutrophication, Terrestrial ecotoxicity, water depletion, fossil depletion, photochemical oxidant formation, freshwater ecotoxicity and marine ecotoxicity**. In contrast, the Intensive system (IS) led to lower climate change impacts, freshwater eutrophication and agricultural land occupation.

An analysis was also carried out to compare the extent of the impacts across the production stages as shown in Figure 15.

Figure 15: Comparison by production stages and impact categories



IS = Intensive production system, ES = Extensive production system.

CC = Climate change, **HT** = Human toxicity, **TA** = Terrestrial acidification, **FEU** = Freshwater eutrophication, **MEU** = Marine eutrophication, **TE** = Terrestrial ecotoxicity, **ALO** = Agricultural land occupation, **WD** = Water depletion, **FD** = Fossil depletion, **POF** = Photochemical oxidant formation, **FE** = Freshwater ecotoxicity, **ME** = Marine ecotoxicity. Source: Huerta et al. (2016)

The results demonstrated that **at the cow-calf stage**, the extensive system had a predominant impact on, human toxicity, terrestrial ecotoxicity, marine eutrophication, terrestrial ecotoxicity, water depletion, fossil depletion, photochemical oxidant formation, freshwater ecotoxicity and marine ecotoxicity.

The fattening stage of intensive system, has a predominant impact on human toxicity, water depletion, terrestrial ecotoxicity, fossil depletion, photo-oxidants formation, freshwater ecotoxicity and marine ecotoxicity.

The marketing stage did not have a predominant impact on any category. Overall, the results indicated that **the extensive system has better environmental performance than the intensive system for nine of the twelve studied categories**. This analysis highlights a need for beef production systems in Mexico to improve their efficiency for Mexico to meet its commitments to sustainable production and Consumption.

Case Study 3: Land use change affecting ecosystem services provision in tropical montane cloud forests of Mexico

Tropical montane cloud forests deliver many ecosystem services to the Mexican society including timber, the supply and purification of fresh water, and carbon sequestration. However, **the provision of ecosystem services is increasingly under threat due to land use change from forest conversion to other land uses including agriculture and urban development**. For example, in the highlands of the State of Veracruz, previously forested lands were converted into coffee plantations and cattle ranches. To assess the impact of land use change on ecosystem services, Martínez et al. (2009) carried out an analysis of land use change in nine small watersheds (<15 ha) covered by pristine cloud forest, coffee plantations and cultivated grasslands. They further analysed the impact of land use change on ecosystem services.

The highlands of La Antigua watershed, is located in the central region of the Gulf of Mexico (Figure 16). It covers 2623 km^2. The highland region covers 1294 km^2 and was determined based on topography and river flows. It is estimated that nearly 40% of this area is still relatively well preserved with relatively large extensions of cloud forests.

Figure 16: Location of the La Antigua watershed*

*The darker area highlights the study site (highlands of the watershed).
Source: Martínez et al. (2009)

There are 17 municipalities in the highlands of the watershed; 13 belong to the state of Veracruz and 4 to Puebla. Several municipalities (Banderilla, Huatusco, Las Vigas de Ramı´rez, Perote, and Tlachichuca) are marginally located within the watershed and therefore were not included in the current analysis. Many permanent and temporal streams and rivers cover the area. The largest and widest rivers running through the highlands are: Sordo, Pixquiac, Pintores, San Andre´ s, Calpixca´n, Texoco, Caracol, Tecomatla, and Gavila´n. All of them drain into La Antigua River after which the watershed is named.

An analysis of land use change from 1973 to 2003 showed a decrease in Cloud forests about 18% during the last 30 years (Table 3**Error! Reference source not found.**). There was also a slight decrease in tropical deciduous forest, croplands and coffee plantations. In contrast, natural ecosystems such as pine–oak forests, coniferous forests and alpine grasslands increased. There was an increase in s**ugar cane plantations by 3%, and in cultivated grasslands by nearly 16%**. There was also an increase in other land uses including urban expansion by about 4%.

Table 3: Changing land use (ha) and ecosystem service value (ES)

Ecosystem types	Area (1973)	%	Area (1990)	%	Area (2003)	%	Net area change % (1973-2003)	ES (1973)	ES (1990)	ES (2003)	Net ES change % (1973-2003)
								2004 US$/year (Millions)			
Cloud forest	52,090	39.3	42,690	32.2	27,95	21.1	-18.22	66.5	54.5	35.6	-30.8
Tropical deciduous forest	530	0.4	530	0.4	520	0.4	-0.01	1.7	1.7	1.6	-0.1
Pine–oak forest	9,260	7.0	8,700	6.6	11,240	8.5	1.49	7.3	6.9	8.9	1.6
Coniferous forest	5,480	4.1	4,150	3.1	8,980	6.8	2.70	2.9	2.2	4.8	1.9
Alpine grassland	930	0.7	880	0.7	1,220	0.9	0.22	0.2	0.2	0.3	0.1
Cropland	20,020	15.1	17,920	13.5	14,370	10.8	-4.27	3.5	3.2	2.5	-1.0
Coffee	30,500	23.0	24,860	18.8	24,500	18.5	-4.53	7.3	6.0	5.9	-1.4
Sugar cane	2,740	2.1	1,300	1.0	6,760	5.1	3.03	0.5	0.2	1.2	0.7
Cultivated grasslands	8,220	6.2	23,930	18.1	28,940	21.8	15.79	1.9	5.5	6.7	4.8
Other land uses	2,970	2.2	7,500	5.7	7,970	6.0	3.77				
Total	**132,460**		**132,460**		**132,460**			**91.9**	**80.5**	**67.7**	**-24.2**

Source: Martínez et al. (2009)

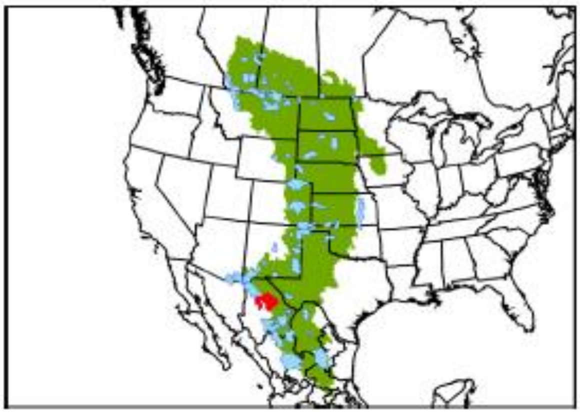
The analysis highlights the impact of landscape change on ecosystem services provided by natural ecosystems. An increased in pine–oak forests, coniferous forests, alpine grasslands, sugar cane plantations and cultivated grasslands increased over the last three decades led to an increase in ecosystem services. **A decrease in land area covered by cloud forest, tropical deciduous forest, croplands and coffee lead to a decrease in ecosystem services**. **Cloud forest alone resulted in very large losses of ecosystem services (US$ 30.8 million annually), which represented almost 93% of all ecosystem services losses in the area**, while cultivated grasslands represented 53% of all gains. Overall, **land use change in the highlands of La Antigua watershed has resulted in relatively large economic losses in ecosystem services, amounting to US$ 24 million annually**.

Case Study 4: Rapid expansion of croplands in Chihuahua, a major threat to North American grassland bird species

Grassland ecosystems are among the most threatened ecological systems, globally. **In North America, the extent and biological integrity of native grasslands is increasingly being threatened by agriculture, urbanization, energy development, desertification and invasive species**. According to Pool et al. (2014), **Governments and conservation organizations in North America have identified the highest priority grasslands from Canada to Mexico, with conservation of grassland biodiversity for the preservation of migratory birds as the key objective**. It is estimated that twenty-nine of the 33 (88%) grassland-obligate bird species breeding in western North America's Great Plains are migratory and **90% of these overwinter in the Chihuahuan Desert in Mexico**. The 2.7 million ha Valles Centrales is a region of northern Mexico comprised of desert shrublands, mountains and grassland valleys. It supports wintering populations of 28 migratory grassland bird species from the Great Plains, as well as threatened and endangered species in Mexico including Aplomado Falcon (Falco femoralis), Pronghorn (Antilocapra americana mexicana) and others.

A study by Pool et al. (2014) evaluated the impact of grassland conversion to agriculture in Valles Centrales from 2006 to 2010 on migratory birds using remote sensing techniques (Figure 17).

Figure 17: Location of Valles Centrales Grassland Priority Conservation Area (red)



Location of Valles Centrales Grassland Priority Conservation Area (red) in the context of the central grasslands bird conservation regions (green) and the complex of North American Grassland Priority Conservation Areas (blue) in the U.S., Canada and Mexico as designated by the Commission for Environmental Cooperation.

Source: Pool et al. (2014)

Study results revealed that **the area of cropland in the Valles Centrales GPCA expanded by 69,240 ha, or 13,848 ha/year**, from 203,015 ha in 2006 to 272,255 ha in 2011 (Table 4), **resulting in the loss of 19,505 ha of desert grassland, 49,929 ha of mixed desert grass/shrubland and 233 ha of other minor cover types.**

Table 4: Remotely sensed land cover change in the Valles Centrales of Chihuahua, Mexico, 2006–2011

Land cover type	Area (ha)		Change 2006–2011	
	2006	2011	ha	% change
Low-slope (<2%) Grassland	554,201	519,553	-34,648	-6.25
Cropland	203,015	272,255	69,240	34

Source: Pool et al. (2014)

It was further found that the amount of land cleared for cropland exceeded the amount permitted by 67,279 ha (more than 3500%). This is a clear demonstration of the lack of enforcement of land-use change policies, leading to rapid grassland loss in northern Mexico. According to the Comisión Nacional Forestal (2012), the Mexican federal agency SEMARNAT is mandated to collect MXN $7,513.62/ha in compensatory funds for land-use change authorized in arid and semi-arid environments. It is estimated that **the lack of enforcement of land use change policies in the Valles Centrales alone cost the Mexican government $505,508,840 MXN in lost revenue, or roughly, $43,524,311 USD between 2006 and 2011**. The purpose of the fee is to pay for restoration activities and projects to mitigate impacts to natural resources resulting from the land use change (Pool et al., 2014)

The study results also revealed that across 28 species of grassland-associated birds over-wintering in the Valles Centrales, **the capacity for approximately 355,142 birds had been reduced by the land use change, with conversion to agriculture being a predominant driver**. An estimated 6758 Baird's Sparrows, 132,723 Chestnut- collared Longspurs, 1396 Sprague's Pipits, 16,181 Lark Buntings, and 117,131 Vesper Sparrows have been displaced from formerly viable habitat as shown in Table 5.

Table 5: Selected bird species densities per square kilometer and the estimated number of birds displaced, due to habitat loss in Valles Centrales from 2006 to 2011.

Species	Mean density (2007–2011)	95% Credible interval	Max density (2007–2011)	Estimated number of birds displaced
Baird's Sparrow	9.76	7.36–12.46	19.47	6,746
Chestnut-collared Longspur	248.33	228.41–269.32	383.06	132,723
Lark Bunting	24.89	18.25–32.69	46.7	16,181
Sprague's Pipit	2.43	1.81–3.15	4.03	1,396
Vesper Sparrow	124.14	116.03–132.69	338.06	117,131
Brewer's Sparrow	57.42	50.78–64.58	111.12	38,501
Savannah Sparrow	50.01	44.2–56.06	167.91	58,177
Horned Lark	49.94	45.81–54.23	72.69	25,186
Grasshopper Sparrow	25.06	21.29–29.46	36.66	12,702
All grassland birds (28 spp.)	**626**		**1025**	**355,142**

Source: Pool et al. (2014)

This analysis is just a snapshot of the persistent trade-offs between agriculture and ecological integrity in Mexico. It also highlights a need to strengthen conservation efforts through sustainable agricultural practices, coupled with proper enforcement of land use change policies.

Overall, the case studies outlined above are not exhaustive, but highlight the current and potential future impacts of the agriculture on natural ecosystems and biodiversity. The case studies, further highlight the need to strengthen conservation efforts in the agriculture sector.

4 Conclusion

With its GDP estimated at USS$ 2.4 trillion in 2017, Mexico is currently the second largest economy in Latin America, after Brazil, and the eleventh largest economy in the world. Over the past three decades, the country has struggled to significantly raise its trend growth rates. The agriculture sector's contribution has declined from around 13.7% of GDP in the 1965 to 3.8% in 2017. **However, the agriculture is an important sector, employing 13.4% of the 54.51 million people from the labour force.** Mexico is **world's second largest producer of lemons and lime, fifth largest producer of maize and chickens, and tenth largest producer of beef. In addition, a number of** agricultural and food products (agrifoods) that are of strategic importance to the agricultural sector including barley, coffee, maize, dry beans, rice, sorghum, sugarcane and wheat, beef, eggs, milk, pork and poultry, and two fisheries products (shrimp and tuna). However, **the drive to increase agri-food production has had a major toll on the environment and a key threat to biodiversity loss.**

Presently, **agriculture in Mexico is facing many challenges including loss of soil fertility, soil erosion, diminishing water resources, and air, soil and water pollution**. Although Mexico is undertaking many steps to halt and reverse the pressures on the environment and biodiversity arising from the agri-food sector, there is a long road ahead to close the gap between aspiration and application. The case studies investigated reveal the potential for complex trade-off between social- economic and environmental objectives in Mexico's agri-food systems. Research into this area is still evolving, with an evaluation of possible trade-offs mainly focused at farm level. More comprehensive analysis of potential social-economic and environmental trade-offs is generally constrained by the complexity of the agri-food value chains and data availability.

An understanding of these trade-off is crucial for the effective implementation of Mexico's sustainable agriculture initiatives. **The UN Environment TEEB project on "Promoting biodiversity and sustainability in the agriculture and food sector in Mexico"** complements the Government's green growth initiatives by **highlighting several trade-offs made in land-use decisions and mainstreaming the values of biodiversity and ecosystem services values in decision-making**.

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