Food and Nutrition Security in Guatemala

Food security for a nation of major natural-disaster vulnerability and fragile Mega-diversity © istockphoto

Guatemala

[1] Noel W. Solomons
[2] Edwin Josué Castellanos
[3] Florencio Rolando Cifuentes Velásquez
[4] Silvana Maselli Conde
[5] Mónica Ninnette Orozco Figueroa
[6] Pamela Marie Pennington
[7] Jack Clayton Schuster
[8] Gamaliel Giovanni Zambrano Ruano

Future food and nutrition security for **Guatemala hangs in a balance between modernization of agricultural practices,** adequate management of rich water and land resources and policy strengthening, **and demographic expansion, poverty, defiling the environment and natural disaster vulnerability.**

Summary

The Republic of Guatemala is the northernmost country of the Central American Isthmus. It is topographically and geographically diverse, with both an Atlantic and Pacific coastline, coastal plains and central mountainous highlands, with lakes, rivers and forests. Features of its geography and geology make the country inordinately disaster-prone, including major earthquakes, disruptive volcanic eruptions, periodic droughts alternating with hyper-precipitation with flooding and landslides. Guatemala is one of 17 nations declared to be "mega-diverse", by virtue of its rich genetic diversity in native flora and fauna species.

Since the middle of the last century, Guatemala has experienced a quintupling of its population, now estimated at 16 million. It is a blend of European (Iberian) culture, introduced by the Spanish colonizers and Maya culture from its indigenous inhabitants. The partition of non-indigenous and indigenous residents is roughly equal, with the latter predominating in the rural areas and the former in its urban settings.

Some 34% of the 108,900 km² surface-area is covered by forest, including the second largest rainforest in the Americas, but this has almost been halved over the last four decades. Thirty-eight percent of the land is devoted to agricultural pursuits (livestock, export cropping, staple crops and horticulture). Guatemala's economy is exportation-dependent, with the main commodities being traditional crops such as coffee, sugar, banana, cocoa and cardamom.

The popular Guatemalan diet is still based around the traditional elements of maize, legumes, vegetables and coffee, with minimal animal-food sources. The North American Free Trade Agreement (NAFTA) has, however, increased the availability of inexpensive, imported processed foods. More than half the Guatemalan population suffers from food and nutrition insecurity as measured by the 8-point Latin American and Caribbean Household Food Security Scale (ELCSA). These are in the context of the highest prevalence of stunted growth (short stature) in the Western Hemisphere.

Guatemala is renowned for its productivity in research and universities and specialized research units, but the training of professionals, investment in resources and mutual coordination are all in need of strengthening to modernize and meet the problems of climate change, rampant deforestation and food insecurity.

I. National Characteristics

a. Country physical size, arable land inventory, landscape and environmental heterogeneity

The Republic of Guatemala, with an area of 108,900 km², lies within the Central American Isthmus just South of Mexico. It can be divided into 3 main topographic regions: the rainforest lowlands (in the North, bordering on Mexico and Belize): the highlands (in the South-Central portion), and the Pacific lowlands (in the South). The Sierra Madre mountain range, an extension of the Rocky Mountains, contributes to highly diverse terrain with many microclimates and life zones. Indeed, the country boasts a total of 14 life zones in spite of its relatively small area (de la Cruz, 1982). The mountains are bordered in the South by a chain of 30 volcanoes, including the 4,220-m Tajumulco, the highest peak in Central Americas. The fertile volcanic soil is a boon to Guatemalan agriculture, especially from the downslopes and to the Pacific lowlands, supporting cultivation of sugar cane, rubber and palm oil among other export crops.

The South-Central highlands contain most of the population of the country, including the capital of Guatemala City, which holds about 30% of the country's population in its metropolitan area. The northern lowlands lie on limestone with unfertile soils, which were mainly covered with forest until the 1970's when the government implemented an internal migration campaign to occupy those lands. Subsistence agriculture quickly gave way to cattle ranching, which is currently the main land use, although recently there has been an increase in palm oil plantations. The northern part of these lowlands is still covered with dense forest and is under conservation as the largest protected area in the country: the Mayan Biosphere Reserve.

According to the last land-use map for the year 2012 (GIMBOT, 2014), 34% of the country is still covered with forest, down from over 60% 40 years ago; 38% of the land is dedicated to agriculture, including 15% for cattle ranching, and 11% each for permanent and seasonal agriculture. Finally, 23.5% of the land shows a combination of secondary forest and shrub, growing on degraded soils or dry areas, with the remaining 4.5% including inland water, wetlands and urban areas.

b. Demographic characteristics and future trends

The country is divided politically in 22 departments, which in turn are divided into 340 municipalities. Guatemala is by far the most densely populated country in Central America with over 16 million people (INE, 2016). The population growth is rapid at 2.5% in the last decade, resulting from a high fertility rate (3.1 according to the last estimate). These demographic data are estimates derived from the last census in 2003; the government has promised a long-awaited census for 2017.

The census bureau estimates that the country crossed the landmark of 50% urban population about 7 years ago, with 2 million living in the capital, Guatemala City (density: 1,600 persons/km^2) and a total of 5 million in the metropolitan area. The development of middle-size cities has recently been identified as an important development strategy for the country. At the other extreme, the northern department of Petén is sparsely populated with a density of only 21 persons/km^2. This region was practically uninhabited 50 years ago, when the central government started an internal migration campaign to populate this area.

Despite the urbanization trend, fertility rates remain above 5 in the rural population. Twenty-four languages are spoken in Guatemala, with Spanish the official tongue; additionally, there are 21 Mayan groups, as well as *Xinca* and *Garifuna*. Indigenous groups show the lowest socioeconomic indicators in the country.

[1] Noel W. Solomons, Scientific Director. Center for Studies of Sensory Impairment, Aging and Metabolism (CESSIAM).Guatemala Country Representative to IANAS, cessiam@cessiam.org.gt **[2] Edwin Josué Castellanos,** Co-Director. Center on Environment and Biodiversity (CEAB), Universidad del Valle de Guatemala, ecastell@uvg.edu.gt **[3] Florencio Rolando Cifuentes Velásquez,** Director. Center for Agricultural and Food Studies (CEAA), Universidad del Valle de Guatemala, rcifuen@uvg.edu.gt **[4] Silvana Maselli Conde,** Head. Plant Genetic Resources Unit, Center of Agricultural and Food Studies (CEAA), Universidad del Valle de Guatemala, smaselligua@gmail.com **[5] Mónica Ninnette Orozco Figueroa,** Director. Center for Atitlán Studies (CEA), Universidad del Valle de Guatemala, mnorozco@uvg.edu.gt **[6] Pamela Marie Pennington,** Director. Center for Biotechnology Studies (CEB), Universidad del Valle de Guatemala, pamelap@uvg.edu.gt **[7] Jack Clayton Schuster,** Co-Director. Center for Environmental Studies and Biodiversity (CEAB), Universidad del Valle de Guatemala, jschuste@uvg.edu.gt **[8] Gamaliel Giovanni Zambrano Ruano,** Director of the Center for Industrial Processes (CPI). Universidad del Valle de Guatemala, zambrano@uvg.edu.gt

Recently, extensive emigration to the US has been the norm, particularly from the impoverished highlands. It is estimated that at least 10% of the Guatemalan population now live in the US, with remittances accounting for 11% of the country's Gross Domestic Product (GDP) (IOM, 2013).

Population projections by the Population Observatory at ECLAC (2015) forecasts a population of 24 million by 2050, with a large urban component. With the relatively modest GDP growth rate of 3% observed in the last years, and the high inequality in income (ECLAC, 2010), it is expected that around 50% will remain in poverty through the coming years, leaving the country with the lowest Human Development Index in the region (UNDP, 2010).

c. Fraction of the population suffering from food and nutrition insecurity and the FNS trajectory

More than half of the Guatemalan population suffers from food and nutrition insecurity as measured by the 8-point Latin American and Caribbean Household Food Security Scale (ELCSA); it is more prevalent in rural areas and among the poor. Acute food security is present in the central and western highlands of Guatemala, as assessed by the satellite-based Famine Early Warning (FEWS NET). After a "stressed" condition in 2016, the prospects of the next highest state of "crisis" in terms of risk of crop failure and famine have been raised for 2017.

d. Agricultural modes

Agriculture contributes approximately 14% of the GDP. It is the major source of employment and contributes about 40% of the total foreign exchange through exports (CAMAGRO-Agrequima, 2015). The major agricultural modes include peasant subsistence, semi-commercial and export agriculture. However, based on access to land, size of land, access to credits, insurance, technology, market and education, agriculture is classified in Guatemala as infra-subsistence, subsistence, surplus and commercial agriculture (MAGA, 2016). About 93% of the producers hold a farm of a maximum of 1.6 hectares (ha) (IARNA_URL and IICA, 2014). According to CAMAGRO-Agrequima (2015), the major crops and sectors linked to agriculture include banana, sugar cane, coffee, oil palm, rubber, cardamom, staple crops, cash crops (snow peas, green beans and broccoli), potato, mango, papaya, livestock (meat and dairy products) and the porcine sector.

e. Is the country self-sufficient in agriculture?

The major crops and agricultural products are presented in **Table 1**. It is clear that the country is self-sufficient in some food products, but there is a shortage in others. The county is not capable of satisfying the demand for most staple crops and animal products. The internal demand is complemented through the importation of commodities. Even though the main diet of most Guatemalans relies on maize (mainly white) and black beans, the production is not enough to supply the demand. Most of the rice, wheat and yellow maize are imported. Some of the factors that influence the volume of maize and black bean production include very low productivity, weak agronomic management, plant varieties, pests and irregular rainy seasons in the last years. The main driving force for the rest of staple crops is the extension of the land surface dedicated to those crops. Most of Guatemalan agriculture is dryland agriculture that depends on rainfall.

f. Major export/import crops and markets

The major exports include our traditional crops like coffee, sugar, banana, cocoa and cardamom. The target market includes the US and some Central-American, European and Middle-Eastern countries (**Table 1**). The coffee and sugar market is more diverse since it also includes some Asian countries. Non-traditional export crops started during the 1980s and their specific contribution to the GDP increases annually. Some of those crops include vegetables (snow peas, broccoli, green beans, mini-vegetables) and fruits (lime, mangoes, pineapple, cantaloupe, plantain, strawberries and blackberries). Except for snow peas, whose main market in Europe, the bulk of this produce goes to the US and Central-American markets.

g. Potential sources of Food and Nutrition Security (FNS) instability

Food Nutrition Security (FNS) Guatemala is at risk. Although several potential sources of instabili-

Table 1. Major Agricultural Products of Guatemala

Crop	Production (MT)	Yield (t/ha)	Imports (I)		Exports (E)		Commercial Balance (I/E)
			MT	Country	MT	Country	
Traditional export crops							
Bananas	3,248,215	46.4	9,418	Honduras (85%) and USA (12%)	1,968,939	USA (90%) and Honduras, El Salvador and Italy (6%)	0.0
Cocoa	12,412	2.9	720	Nicaragua (81%) and Honduras (17%)	37,233	El Salvador (62%) and USA (17%)	0.0
Coffee	251,660	1.0	26	Vietnam (91%)	219,624	USA (43%), Japan (15%), Canada (9%) y Germany, Belgium and Italy (19%)	0.0
Sugar cane	27,546,560	95.0	27	USA (73%) and Venezuela (18%)	1,799,341	Several countries (48%), USA (12%), South Korea (11%), Chile (9%), China (9%) and Ghana (6%)	0.0
Cardamom	36,344	0.5	107		34,226	Saudi Arabia (28%), United Arab Emirates (20%), Syria (6%), Jordan (6%) and other countries	0.0
Fruits							
Avocado	101,437	10.2	2,653	Mexico (99%)	3,346	El Salvador (66%) and Honduras (32%)	0.8
Lime	121,683	16.9	127	Mexico (91%) and USA (7%)	7,220	USA (78%), Netherlands (7%) and Saudi Arabia (5%)	0.0
Mangoe	115,883	12.2	129	Mexico (53%), Vietnam (32%) and USA (11%)	21,031	USA (88%) and Honduras (7%)	0.0
Apples	24,103	3.5	14,827	USA (53%) and Chile (46%)	1,594	El Salvador (83%), Nicaragua (11%) and Honduras (6%)	9.3
Peaches	32,714	11.8	918	USA (56%) and Chile (44%)	1,205	El Salvador (99%)	0.8
Cantaloupes	538	21.8	220	Honduras (75%) and USA (11%)	419	USA (97%)	0.5
Oranges	792,717	26.9	38,719	Honduras (97%)	20	El Salvador (92%)	1,936.0
Pineapple	245,674	27.4	76	USA (38%), Vietnam (21%), Honduras (21%) and Costa Rica (19%)	21,766	USA (64%) and El Salvador (33%)	0.0
Plantain	223,771	18.2	1,118	Mexico (45%), Vietnam (26%) and USA (25%)	146,143	USA (55%) and El Salvador (38%)	0.0
Vegetables							
Snow pea	43,173	5.6	16	USA (64%) and Belgium (35%)	35,449	Reino Unido (73%), Netherlands (11%) and Belgium (10%)	0.0
Broccoli	75,833	13.4	267	China (85%) and Ecuador (6%)	42,670	USA (64%) and El Salvador (27%)	0.0
Onion	130,641	28.6	26,313	Mexico (95%)	28,629	USA (64%) and El Salvador (27%)	0.9
Bell pepper	53,781	23.4	32	Honduras (76%), Peru (16%), El Salvador (6%)	9,755	El Salvador (71%) and USA (24%)	0.0
Potato	516,520	25.1	3,648	Canada (60%) and USA (39%)	64,945	El Salvador (99%)	0.1
Tomato	318,210	35.3	180	Honduras (99%)	66,914	El Salvador (80%) and USA (17%)	0.0
Carrots	76,585	28.8	12	Mexico (54%) and USA (34%)	31,170	El Salvador (70%), Honduras (19%) and USA (8%)	0.0

Table 1. Major Agricultural Products of Guatemala

Crop	Production (MT)	Yield (t/ha)	Imports (I)		Exports (E)		Commercial Balance (I/E)
			MT	Country	MT	Country	
Staple crops							
Rice	32,437	3.0	95,379	USA (95%)	930	El Salvador (42%), Costa Rica (28%), Nicaragua (14%) and Honduras (8%)	102.6
White corn	1,776,408	2.1	44,260	USA (92%)	6,921	El Salvador (99%)	6.4
Yellow corn			740,580	USA (82%), Brazil (9%) and Argentina (85%)	8	El Salvador (72%) and USA (27%)	92,572.5
Black beans	227,945	0.9	11,133	China (43%), USA (29%) and Argentina (11%)	1,414	Costa Rica (46%) and El Salvador (38%)	7.9
Red beans			1,641	El Salvador (32%), USA (28%) and Nicaragua (19%), Argentina (95%)	482	El Salvador (38%), USA (31%) and Honduras (18%) and Costa Rica (13%)	3.4
Wheat	1,560	2.1	515,637	USA (91%)	563	Belice (71%) and Honduras (22%)	915.9
Animal products							
Beef	3,423,800 (1)	941,800 (2)	7,505	USA (67%), Nicaragua (15%), Costa Rica (13%)	3,406	El Salvador (77%) and USA (22%)	2.2
Pork	2,763,400 (1)	394,400 (2)	8,306	USA (98%)	210	Honduras (54%) and El Salvador (45%)	39.6
Chicken meat	199,715,400 (1)	123,296 (2)	69,874	USA (96%)	3,302	El Salvador (66%) and Hong Kong (China) (32%)	21.2
Eggs	4,854,657,600 (1)		794	USA (91%) and El Salvador (7%)	69	El Salvador (100%)	11.5
Liquid milk	490,126,280 (3)		37,430	Costa Rica (61%), Honduras (21%) and Mexico (13%)	65	Honduras (79%) and Costa Rica (19%)	575.8
Powdered milk			13,029	Nicaragua (34%), Costa Rica (22%), New Zealand (22%) and USA (7%)	181	Honduras (28%), El Salvador (25%) and Belice (21%)	72

(1) Number of units, (2) Slaughtered animals and (3) Non-processed milk.

ty have been identified, on a short-term basis the most important ones include the direct and indirect impact on the climate-change phenomenon.

Climate change includes irregular rainy seasons, with excess and shortage of water and floods alternating with droughts, frosts, hailstorms, high variation of temperature and relative humidity that allows the proliferation of arthropod pests and crop diseases, loss of agrobiodiversity as well as the loss of productive infrastructure. As an example, the effect of the prolonged drought in the last 3 years in Guatemala resulted in negligible maize and bean production in several areas of the dry corridor in eastern Guatemala. Since corn and beans are planted as part of Guatemalan dryland agriculture and no irrigation is available in the region, crop production was drastically reduced. The social and economic conditions of the rural population and postharvest losses are currently problematic. The most vulnerable population segment, constituting 60% of rural families, includes those having no land and infra-subsistence and subsistence farmers.

Other sources of FNS instability on the mid- and long-term basis include the change on the use of land from forest to crop production (deforestation), soil erosion due to cropping on steep slopes with no soil conservation practices, gradual loss of soil fertility and soil quality, desertification, genetic erosion (causing the loss of native corn and bean varieties), low use of improved varieties in staple

Box 1. Summary Chronology in Agriculture Research in Guatemala

- **1944:** The National Agricultural Institute (IAN) as a cooperative organization between the Guatemalan Government and the US Department of Agriculture was established. The research agenda included corn, beans, rice, wheat, coffee and rubber production.
- **1954:** The Inter American Cooperative Service for Agriculture (SCIDA) was created and replaced IAN. The new research center was financed and administrated by the US, making important advances in the modernization of the Guatemalan agriculture. With the creation of the new research center the Agricultural Extension Service was also born.
- **1970:** The Agricultural and Science Technology Institute (ICTA) was created, and the official launching took place in 1973. ICTA is the National Agricultural Research Center financed by the government of Guatemala and other donors and its name remains to the present. Since its creation, ICTA has been working on staple crops, vegetables, fruits and minor animal species. Their major activities are focused on peasant agriculture. At present, ICTA has five major research centers in the country.
- **1980–1990:** Agricultural research started in several organizations of the private sector, private universities, international organizations and NGO. The contribution of the National University (Universidad de San Carlos de Guatemala) started in 1950 when the College of Agronomy was created. Agricultural research in private universities also began since the creation of their Colleges of Agriculture (Agronomy Department at Universidad del Valle de Guatemala in 1977 and the College of Agricultural and Environmental Sciences in 1976).

crops, weak policies and weak participation of the agricultural public sector in assisting small-scale growers through effective extension and agronomic research programs, limited irrigation programs even though surface and subsurface water is available, high dependency on the use of chemical fertilizers and pesticides that are imported, low educational level of the producers, lack of effective programs to link growers to high-value chains for crop diversification, low number of associations and co-ops linked to the international market, and high dependence on foreign remittances.

h. Major agricultural challenges

Agriculture is one of the most important sectors in Guatemala for FNS and economic reasons. Some of the challenges that this sector faces in the development of the country include a growing population, the high level of hunger, poverty and malnutrition, as well as the factors for FNS mentioned in the previous section, in addition to the worldwide demand for high-quality products and an increase in competitiveness in a globalized market, the need for alternate energy sources that may compete for the use of land for food, the strength of rural development and the innovation of peasant agriculture. With those issues in mind, science, technology and innovation become an important engine for a constant increase in productivity and product quality. The major goal is to procure sustainable and climate-smart agriculture in harmony with the environment, natural resources, biodiversity and the quality of life of human beings. In response to those challenges, an important program in agriculture focused on the innovation of peasant agriculture is being promoted by the Ministry of Agriculture.

II. Institutional setting

a. National agricultural research systems

Although agricultural education began in Guatemala in 1877, it took over half a century for the establishment of the first research center. The National Agricultural Chemistry Institute was established to teach mineralogy, geology and soil fertility. Over the eight intervening decades, the institutional aspect of agricultural research has evolved, as summarized in **Box 1**.

An important aspect to be pointed out is that in 1990 the agricultural extension service was canceled by the government, and it was not until 2008 that a new extension system, named National System of Rural Extension (SNER) was relaunched in 2008.

i. Are research capabilities in need of further development?

Some of the major needs include the recognition by government, industry and policy-makers of the importance of education and human capital for research and innovation in the development of the country as a whole and agriculture and nutrition in particular. Strengthening post-graduate studies and accessing mainstream scientific journals and state-of-the-art technology is also critical. The latter should be coupled to an appropriate extension system for training and technology transfer.

ii. Areas of local strength

At present several institutions participate in the development and transfer of agricultural and forestry technologies. These include the National Agriculture Research Center (ICTA), which focuses its work on peasant agriculture and deals with staple crops, vegetables and fruits. Research centers of the colleges of agriculture of the different universities whose main lines of research include not only agriculture (peasant and export agriculture) but also environmental, biotechnology and biochemistry areas. We have different organizations of the private industry that focus their research on specific crop areas such as coffee (ANACAFE), sugar cane (CENGICAÑA and the 18 sugar mills), the rubber industry (Gremhule), and international organizations and the National Coffee Association (ANACAFE). Other sectors of the private industry such as oil palm, cantaloupe, banana and the Association of Non-Traditional Export Crops (AGEXPORT) have their own research and development departments. The contribution of some international organizations like the International Center for Tropical Agriculture (CIAT), Inter-American Institute for Cooperation in Agriculture (IICA) and the Center for Tropical Agriculture and Higher Education, along with international universities and NGO implement research and extension activities either by themselves or in cooperation with local organizations and institutions is also important. They usually work in a broad range of areas dealing with peasant agriculture and natural resources. Although agriculture in its extended concept includes crops, forest, animal science and food processing, most research subjects have been focused on crop production for local and international markets. As indicated by the National Council for Science and Technology (CONCYT), approximately 20% of the funds for research have been allocated to projects dealing with agriculture. Research on forestry, animal science and food processing needs to be strengthened.

iii. Networks of scientific collaboration inside and outside country

At the local (domestic) level, interinstitutional cooperation exists, but is weak and in need of strengthening. Each individual research center has its own collaborative network outside the country. This includes some Consultative Group for International Agricultural Research (CGIAR) centers, foreign universities, and international foundations and specific donors, including private industries and industry consortia.

iv. Access to and maintenance of the databases tracking agricultural systems

There is limited curating of and access to public databases in different government ministries, the CONCYT and the National Statistics Institute (INE). Fees can be required for data-bases. Even more limited are data-bases generated in universities, and even more so, those of private-sector institutions.

b. Universities and research institutes

i. Scientific development and infrastructure

Guatemala's National Science and Technology System (SINCYT) combines institutions and entities from the public, private and academic sectors. CONCYT, the core of the system, and its operative arm, the National Secretariat of Science and Technology (SENACYT), organize and link scientific activities with the SINCYT. Together they promote science, technology and innovation in the country, including administrating the National Fund for Science and Technology (UNESCO, 2010). CONACYT is also supported by sectoral and intersectoral technical commissions, integrated by public, private and academic institutions with common scientific and technological interests aimed at contributing to Guatemala's social and economic development. (UNESCO, 2010; SENACYT, 2015)

The nation's 15 universities play a major role in conducting scientific and technological research activities. The Universidad San Carlos de Guatemala (the only public university in Guatemala) runs 37 research centers and institutes located on several external campuses throughout the country. Only six private universities have research centers/institutes, headed by Universidad del Valle de Guatemala with 10 research centers, followed by Universidad Rafael Landívar with six. Another 10 public and private centers operate outside the higher education system and conduct research on specific topics of human health (CeSSIAM, Funadanier, INCAP, INVEGEM, National Laboratories for Health), agriculture (CENGICAÑA, IGCC, Cedicafé, ICTA), economy (ASIES, CIEN) and the social sciences (CEUR, FLACSO).

The country's public investment in scientific research and technological development through the SINCYT is extremely low compared to other countries in the region. For example, from 2007 to 2012, the government's investment in research and development ranged from US$ 18.1 to 23.5 million annually, representing 0.04% and 0.06% of the national GDP, respectively. Funding investments include natural sciences, engineering, medical sciences, agriculture, social sciences and the humanities (SENACYT, 2015).

Nonetheless, external funding from international public and private institutions, as well as NGO from the US, the European Union, Japan and Germany, among others, enable local research institutions to obtain funding for small-, medium- and large-scale projects.

III. Resource ecosystem characteristics

a. Water resources and challenges over the next fifty years

Guatemala's water resources exceed by far its demand for water: 97.1 billion m³ of available surface and groundwater, of which only 9.6 billion m³ are employed in consumptive and non-consumptive uses (Gabinete Específico del Agua, 2011); however, growing population demands, climate change, water pollution, water disputes (Basterrechea, 2013) and poor management by national and municipal government entities (IARNA, 2015) threaten this resource.

The total annual demand for water reached 20 billion m³ in 2005, consumed mostly by the industrial and agricultural sectors, followed by the hydroelectric energy production segment. Domestic uses only represent 3% of the total demand for water in the country (IARNA, 2015). Guatemala still faces major challenges in providing universal and high-quality coverage of drinking water and sanitation for all the population, especially in the neglected rural areas of the country. Such services represent cost-effective solutions to reduce poverty, chronic malnutrition, morbidity and maternal-child mortality, not to mention the impacts on the health and welfare of the general population as well as on the well-being of the environment (Gabinete Específico del Agua, 2011).

Social unrest surrounding water resources has increased recently due to a growing water demand from the agriculture and mining, as well as concomitant water-pollution concerns. Along with severe adverse climate events that have affected the country during the last two decades, there are threats to Guatemala's fragile hydrologic system. Attempts to design and implement multi-sector national legislation for the administration and regulation of the water resources have repeatedly failed, mainly because there is a lack of consensus among the sectors.

b. Soil resources and challenges over the next fifty years

The genesis of most soils of the country is from limestone, volcanic material, marine deposits at low altitudes, shale, serpentine and other igneous, sedimentary and metamorphic rocks, as well as from volcanic material transported by water that is eventually deposited downstream. The specific parental material and soil development depends on the geology, geomorphology and climate of each of the eleven physiographic and geomorphology regions into which the country has been divided.

The first soils' classification map was developed by Simmons et al. (1959) and was based on the genetic aspects of the soil. International systems used in Guatemala include the FAO-UNESCO system that allowed the identification of 10 of the 26 units identified by the system in the world, some soil taxonomic studies and a few technical-classification reports based on soil fertility. Based on soil taxonomy, soils have been classified in the sugar cane cropping system, soils of the South region of the coffee industry, and soils of the departments of Chimaltenango, Sacatepéquez and Sololá developed by the Ministry of Agriculture (González-Martínez, 2013). Other soil taxonomy studies have been implemented on specific areas of the country. Although soil taxonomy studies have not been developed for the entire country, based on some soil correlation between the study implemented by Simmons et al. (1959)

and the soils' taxonomy system, major soil orders identified for the country include those indicated in previous sections.

The topography of the land used in agricultures ranges from plains to steep slopes in the highlands (DIGEGR-MAGA, 2005). As indicated the natural vocation of most soils is for forestry. However, because of the land pressure and the high poverty level of most of the growers, agriculture is practiced even in class VIII of the USDA soil classification system. The distribution of the soils based on the land-use capacity system is presented in **Figure 1**. According to a Ministry of Agriculture classification by land-use, in 2000, the distribution of the land surface of Guatemala was classified as follows arable lands suitable for cultivation (34.2%); arable lands for grazing (16.8%); forest cover (41.1%); protected reserves (7.1%) and bodies of inland water (0.3%) with a small fraction of constructed urban centers. The major challenges over the next 50 years include reduction of soil erosion through implementation of soil conservation practices, use of land according to its capacity, completing the taxonomic classification of the soils for the entire country, conservation of water through appropriate soil management, and restoring marginal soils and increasing the soil-fertility level and quality of soils through climate-smart agricultural practices that promote organic carbon accumulation in the soil.

Over the next 50 years, Guatemala faces major challenges, centered on building resilience to adverse climate events and climate change, ensuring appropriate and equitable distribution of water to all the population segments, based on a human rights approach, and protecting the underground recharge zones and water sources from overexploitation and contamination.

c. Energy challenges

According to the World Factbook (CIA, 2016), Guatemala has an energy consumption estimate of 0.21 quadrillion Btu per year and the following potentials: wind potential of 3,445 km² class 3-7 wind at 50 m; solar potential of 328,690,840 MWh/year; 83,070,000 bbl of oil reserves and 2,960,000,000 m³ of natural gas reserves.

One in 10 Guatemalans is currently without a household electricity supply. Current national production is 10 billion kWh of electricity. The installed generating capacity was 3.73 million kW (2015) but some 61.9% coming from fossil fuels and 29.1% from hydroelectric plants with only 8.9% from renewable sources. National production of crude oil is 10,040 bbl/day with imports of refined petroleum products of 100,400 bbl/day. There are also carbon dioxide emissions from the consumption of energy of 13 million metric tons (mt).

Box 2. Main energy-associated challenges

- Reduction in fossil-fuel use
- Laws favoring the use of biofuels and renewable energies
- Reduction in the irresponsible use of biomass from wood and firewood
- Increase efficiency in energy use in industry, offices and residences
- Utilization of natural resources such as rivers, wind, thermal and solar energy
- In addition to the necessity of being more efficient and responsible in energy use, there is also a need to reduce emissions

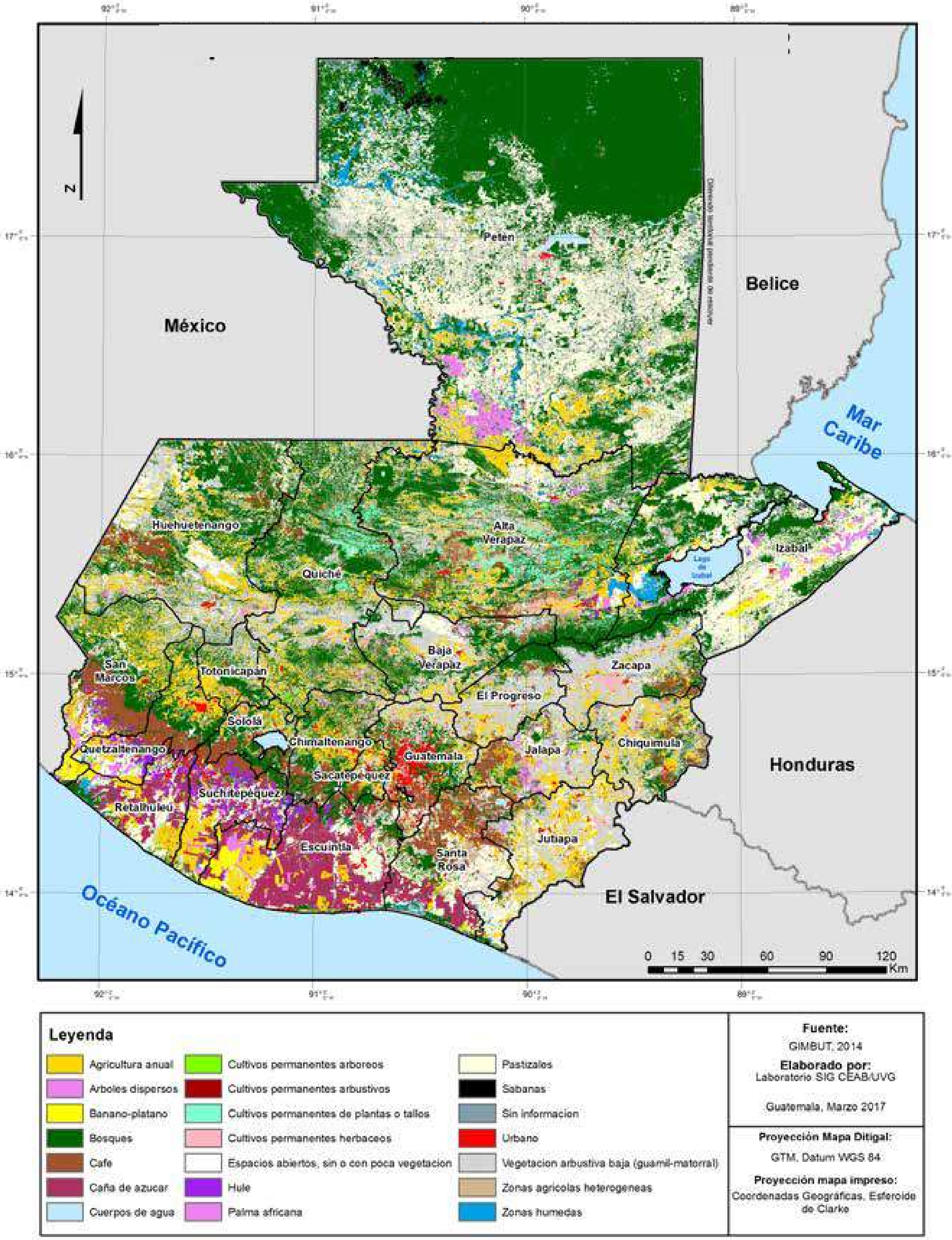
d. Biodiversity conflicts and challenges

The main threats to Guatemalan biodiversity have been described as recurrent in the last decades (CONAP, 2014), including the most recent official data for forest-cover lost: 146,112 ha (years 2006-2010), which corresponds to the 3.4% of the annual deforestation rate in the country. Deforestation is directly related to agroindustry monocultures, e.g., oil palm, sugar cane and grasslands. Other main threats to biodiversity are the 1,422 reported invasive exotic species, forest fires and climate change, with more frequent and intense hydrometeorological phenomena (CONAP, 2014), such as storms and drought, that result in agrobiodiversity loss, affecting the country's food security.

Environmental degradation is directly related to the lack of effective political instruments and to overlaps and gaps in regulatory frameworks (MARN, 2013). The value of agro- and biodiversity, their economic potential and their contribution to food security has not been fully recognized by the political class.

The implementation of the National Policy on Biodiversity, with its Strategy and Action Plan 2012-2022, that according to CONAP (2013), seek

Figure 1. Guatemalan Forest Cover and Land-Use Map for 2012



to develop political, juridical, social, financial and institutional conditions to ensure the conservation and sustainable use of biodiversity, including the fair and equitable sharing of the benefits arising for the use of biodiversity components and ecosystem services, remains the main biodiversity challenge to transcend.

i. Problems associated with overexploitation

The appropriate strategy for Guatemala is to limit or avoid overexploitation of land area for agriculture that will result in the destruction of native habitat and the extinction of species, as is currently happening in the rainforest area in the Petén, as discussed elsewhere. In addition to destruction of habitat, and consequently native species, the extension of chemicals used increases the probability of extinction, both in the natural areas as well as within the fields. The quality of agricultural practices also affects biodiversity, even in natural areas, e.g., drift of insecticide from agricultural fields to protected areas. Combined with monoculture, vulnerability to crop-specific disasters occurred in Guatemala with the introduction of foreign pests, such as with coffee (cherry borer and coffee rust), and citrus fruits (Huanglongbing). Guatemala requires a surveillance and monitoring system in which invading pest species are recognized comprehensively and early for timely control.

ii. Depletion of genetic diversity

As mentioned earlier, Guatemala has been recognized as a megadiverse country; that belongs to the Mesoamerican Center of genetic diversity. Plant genetic resources of worldwide economic importance, and their wild relatives, are found in the Guatemala, including the genera of *Zea, Phaseolus, Cucurbita, Capsicum, Manihot, Persea, Lycopersicon* and *Solanum*. The country is also very rich in underutilized species of high nutritional value (Orellana, 2012; Azurdia, 2016) and is a diversification center for the *Pinus* genus. The importance and contributions of these genera to food security and to the country's economy, as well as the urgent need for their sustainable use and conservation (ex situ and in situ) have been highlighted by national universities and international institutions in the last decades (CONAP, 2008; FAO, 2008; Maselli, 2013). These institutions have made important contributions to the World's Plan of Action (FAO, 2011) activities for the conservation and sustainable use of the plant genetic resources, to raising awareness of the depletion of genetic diversity of the Guatemalan agrobiodiversity (crops and their wild relatives, nutritional underutilized species, and fruits), and of Guatemalan forest genetic resources (INAB, 2012). Threats to agrobiodiversity are common to those of biodiversity in Guatemala and include the threat of genetic erosion. Studies on developing methods to measure genetic erosion have been conducted by Universidad del Valle de Guatemala (Maselli, 2014).

e. Implications of forestry trends

Despite that one-third of the Guatemalan territory remains under forest cover (the highest in Central America), the deforestation process has been intense in recent decades. As recently as four decades ago, forest covered two-thirds of the Guatemalan territory. The key factor in a 50% reduction since then is the internal immigration process to populate the northern territory of the Petén Province promoted by the central government in the 1970s. This policy initiated a strong deforestation process, the effects of which are still seen today, with the advancement of an agricultural frontier. Net deforestation rate was estimated at 1.7% for the 1991-2001 period; that rate was reduced to 1% for the last period of analysis available (2006-2010) (INAB et al., 2012). This was not the result of a reduction in deforestation, but rather a significant increase in afforestation coming mainly from three processes: new plantations established through the National Forest Incentive Program (PINFOR); regeneration of burned areas not converted into croplands and regeneration of abandoned agricultural areas, particularly in the highlands. The abandonment of agricultural land may be related to the strong immigration to the US coming mainly from small farmer communities in the highlands (Aguilar-Stoen et al., 2014).

The amount of gross deforestation has remained at around 100,000 ha per year for the 1991-2010 period; at the same time, the gain in forest cover has been increasing steadily in the same period. As a result, the net forest loss reported for the last period evaluated (2006-2010) was 38,600 ha per year (INAB et al., 2012).

f. Potential impacts of climate change

The entire region of Central America has been characterized as a region with high exposure to geo-climatic hazards due to its location and topography. The region has been identified as the most responsive tropical region to climate change (Giorgi, 2006). A series of extreme-weather events, e.g., hurricanes and droughts, in the recent years have resulted in various studies ranking Guatemala and other countries in Central America among the most vulnerable to climate change. For example, the World Risk Report prepared by United Nations University (2015) ranked Guatemala in fourth place among countries with the highest risk of suffering a natural disaster. The Global Climate Risk Index 2017 published by Germanwatch (2016) ranked Guatemala as number nine among the 10 countries most affected by climate events from 1996 to 2015, with 75 events occurring during that period resulting in a loss of 0.47% of the GDP.

The chapter on Central and South America from the Fifth Assessment Report of the Intergovernmental Panel on Climate Change IPCC (Magrin et al., 2014) concluded that for Central America, the expected temperature increase through the end of the current century will be between 0.6 and 2.0°C for the most optimistic scenario and between 3.6 and 5.2°C for the most pessimistic projection. This increase in temperature will be accompanied by a decrease in rainfall of up to 25%. This long-term trend of less precipitation will be accompanied by increasing variability of rainfall resulting in periods of extreme rain and extreme drought. Other modeling efforts show similar trends, with warming in the range of 2 to 4°C and a precipitation reduction of 10 to 25% (ECLAC, 2010; Imbach et al., 2012; Sáenz-Romero et al., 2010). Beyond these long-term trends, local farmers report that the timing of rainfall has been increasingly variable, making it extremely difficult to recognize the start of the rainy season and optimal planting time (Eakin et al., 2013).

g. Building resilience to extreme events

The approach to disaster management in Central America has focused on developing early warning systems and emergency response for extreme events (Saldaña-Zorrilla, 2008), rather than on strengthening local organizations and cooperatives, which could increase adaptive capacity among farmers through increased access to soft credits and information on global markets, as well as new technologies (Eakin et al., 2011). The experience of coffee growers in the Mesoamerican region (Castellanos et al., 2013) indicates that diversification in production systems and income generation is of utmost importance to reduce the vulnerability of rural communities to a highly variable environment.

h. Future outlooks

Due to its geography and topography, melting ice, rising oceans and oceanic acidity would seem to be less important going forward than rising temperatures, changing patterns of precipitation and especially the frequency and intensity of natural extreme adverse events. The exact scenario is beyond prediction.

IV. Technology and innovation

a. Role of biotechnology

i. Plant agriculture

The regulated, area-wide use of transgenic corn with insect-resistant traits could lead to pest suppression and prevention of resistance, as has been observed after several decades of application in the US (Hutchinson et al., 2010). In addition, it has been shown that Bt-maize can have reduced levels of fumonisin mycotoxins (Ostry et al., 2010). Contamination of corn-based products with these fumonisin toxins can adversely affect human health (Torres et al., 2013). Thus, this biotechnology has the potential to reduce the regional application of insecticides as well as the level of mycotoxin contamination in Guatemala's main staple. However, Guatemala has not regulated/licensed the use of transgenic crops, making this technology currently inaccessible in the country.

ii. Animal agriculture

According to Guatemala's National Council for Protected Areas (CONAP), in 2010 there were 27 laboratories associated with the use of biotechnology and/or safety in biotechnology in the country. Four of them were government, eight were private and the rest were academic institutions working on a total of 106 projects/programs. These programs were focused basically on the transformation and transference of resistant genes to common plant viruses and on the control of human vectors and diseases. So far, there are no reports of studies being conducted in higher organisms, such as animals (CONAP, 2010). Nonetheless, private companies are processing semen and bovine embryos to enhance the genetic pool of the local bovine breeds, thus to improve yields in meat and dairy production (BASA, 2008).

iii. Pests and diseases

The large-scale use of traditional chemical pesticides affects beneficial insects and biodiversity, in turn affecting agricultural sustainability (Whitmee et al., 2015). The biopesticide industry, as an alternative to chemical pesticides, is expected to grow over the next decade (Bergin 2016). Biotechnology for the control of insect pests has been part of several successful area-wide integrated pest-management programs in Guatemala. One such example is the control of insect pests of sugar cane using entomopathogenic fungi (COMIP, 1998). Another highly successful biotechnological application is the sterile insect technique for the screwworm eradication program, with Guatemala being declared in 1994 free of this important cattle pest (Wyss 2006). The sterile insect technique is also a central part of the Mediterranean fruitfly program that led to the elimination of this horticultural pest on the northern border with Mexico (Lynch 2002). Area-wide applications of biotechnological products are, therefore, an important component of the arsenal against insect pests for sustainable agriculture in the region.

b. Prospects for novel agricultural products

If Guatemala is to reach the second Sustainable Development Goal, i.e., "to eliminate hunger, achieve food security and improved nutrition and promote sustainable agriculture" (United Nations, 2016), the country will need to develop policies to ensure available agricultural biotechnologies are adopted to protect the environment, biodiversity and human health. To ensure the well-being and improved nutrition of future generations, Guatemala will need to intensify area-wide agriculture through a combination of integrated pest management that includes biological control methods and genetically-modified crops (Whitmee et al., 2015). It should be noted that highly-efficient, area-wide strategies are only possible with investments in multi-institutional agreements and research programs on pest biology. The adoption of these technologies also depends on the implementation of country-wide, participative strategies that include professionals from the fields of public health and the nutritional, environmental and agricultural sciences (Whitmee et al., 2015).

c. Opportunities for and obstacles to new management technologies

Many opportunities exist for new technology looking for adequate resource use, and of course, innovation is required. The use of organic waste and by-products can be employed as fertilizers, after being digested for the production of biogas. Where possible, the use of rainwater and treated water for irrigation, processes and domestic use will increase water availability. To facilitate processes, the use of natural treatment systems such as biofilters, wetlands, cascade aeration, among others, is imperative.

In terms of obstacles, the removal of hazardous pollutants is expensive and requires sophisticated technology. The use of natural systems requires time and in the case of wetlands, large extensions of land for implementation. Appropriate microorganisms and plants belonging to the environment must be handled to prevent the propagation of alien species.

d. Development of aquaculture/ marine resources

Fisheries are not, as yet, a fully-developed economic activity in Guatemala, contributing only 0.03% to the country's GDP. Nonetheless, they contribute significantly to the food security and economic welfare of many Guatemalans, mainly those living in the coastal areas of the country. This activity takes place primarily within Pacific and Atlantic Ocean waters. There is, however, an important sector working in artisanal fisheries in continental (inland) waters throughout the territory, producing approximately 15,500 mt of hydrobiological products per year. On the Pacific Coast, the leading activities are artisanal and industrial fisheries (small-, medium- and large-scale), which center on the catch of shrimp and associated marine fauna. On the Atlantic Coast, the majority of efforts are aimed at the catch of fish and shrimp with artisanal and small boats. Overall, annual ocean-fisheries production is approximately of 32,000 mt of hydrobiological products such as tuna, several types of fish (shark, mahi mahi, groupers, snappers, sardines, etc.), crustaceans (crab, shrimp and lobster), and mollusks (clams, squid, oysters and snails). In 2003, total exports reached approximately 23,000 mt, representing incomes of between US$ 50 and 80 million to the country (FAO, 2005).

Recently, a noteworthy reduction on the catch of marine resources has been reported, not only within the jurisdictional waters of the country, but beyond them, in Central American and Mexican waters as well. The possible factors are associated to climate change, which has disturbed the natural patterns and distribution of the marine species, the lax control of the artisanal and industrial fishers' activities, and the degradation of the marine floors (FAO, 2005). Inland, waters have been polluted by monocrops such as the palm oil and sugar-cane industries (EJA, 2014; ActionAid, undated), as well as mining (GHRC, undated) and other industrial and anthropogenic activities that impact the abundance and biodiversity of the freshwater species. Industrial activities, specifically the food and beverage sectors, which are largely responsible for the degradation of freshwater sources, accounted for 71.4% of emissions of organic water pollutants (UNEP, 2000).

The aquaculture activities center on the production of shrimp and tilapia (FAO, 2005), but there is little information regarding the volumes of production, uses and statistics that would allow measurement of the contribution of this activity to the national economy and food security.

V. Increasing efficiency of food systems

i. Prospects for technology-based increases in agricultural production

A major hurdle to be overcome, in terms of sustainable human development, is social inequity. For the sector of export-based cash crops, the producing and exporting community has the wherewithal to apply evolving technologies; a system of regulation and licensing will be needed for all forms of biotechnology to be applied. The food-production sector has been stagnated in time within the traditional peasant infra-subsistence and subsistence context. Agricultural cooperatives have a potential role to play. Technology is intrinsically important for this activity as well, but the source of investment has not been visualized. Both sectors will run into the negative consequences of climate change and the other factors related to soil and water.

ii. Infrastructure needs

As with most countries, with farming as a rural pursuit and markets in cities, transportation infrastructure (roads and bridges) lead the list of needs in that sector. To the extent that export of products is to be maintained or expanded, seaport facilities in the harbors and wharves in the ports need improvement and expansion.

b. Issues for food utilization and minimizing waste

Postharvest losses can reduce food utilization by 30-50% from setting to setting. A precise estimate for Guatemala is not available. International agencies for development have implemented a series of strategies to improve the production of horticultural products in Guatemala; however, the lack of infrastructure (above) is a factor in their not getting to markets and consumers and efficiency-of-use is poor. Refrigeration systems in internal transport and storage will be needed to begin to impact waste.

iii. Conflicts between food production and production of energy and fiber

Use of specific crops that do not harm food security is a requirement for the production of biofuels. Plant species have to be selected to assure that their tissues, fruits, seeds and other components can be processed in a profitable way for the extraction of oils, alcohol, fibers, cellulose, or the residues thereof for obtaining biomass, biogas, among others. The selection of areas for the cultivation of these plants should be done in a way that does not affect food-producing crops or perhaps alternating with them.

Government and laws should encourage the cultivation of plants for various purposes, as well as encourage the use of biofuels, while ensuring the food security of Guatemalans. It is also the obligation of the government to regulate emissions, while assuring an adequate energy supply.

VI. Health considerations

The primary aspects and linkages of agriculture to health are via the consumption of food; five important levels are listed in the Insert **Box 3**. The basis of the contemporary Guatemalan diet is constituted by the traditional elements of the Mayan cuisine of antiquity, namely maize, beans and squash. In recent centuries, the primary beverages have been coffee, hot gruels derived from the grains and seeds, and natural fruit drinks. Flesh from livestock, farm animals, hunting and fishing have been variable complements. The lactase non-persistent phenotype of the Amerindian and Mediterranean ancestors of contemporary Guatemalans limits the demand for and tolerance of dairy products with regular lactose content.

b. Foodborne diseases

Food- and waterborne diseases have historically been widely endemic, life- and health-threatening in Guatemala. This was one of the sites for the formulation of the "weanling diarrhea" paradigm, of the explosion of diarrhea once complementary foods are added to the diet. The prolonged contact with the hands in elaborating tortillas would be a factor in fecal–hand–oral transmission. Historically, latrinization and treated piped water have been rare in rural areas, but both elements of infrastructure have expanded greatly over the last decade. Overall under-5 mortality rates have declined from 124 to 35 per 1,000, from 1980 to 2000, and diarrhea disease accounts for 14% of mortality in this group (WHO, 2017).

Waterborne or soil-transmitted parasites are commonly found in rural Guatemalan communities. In a Western Highlands survey among school children, roundworms (*Ascaris*) were found in 18%, amebas (Entamoeba) in 16% and giardiasis in 11% of the 5,000 stool samples analyzed (Cook et al., 2009). Mycotoxins are a serious contaminant of maize (Torres et al., 2013). Aflatoxins have recently come into prominence as a possible contributor to poor growth (Prendergast & Humphrey, 2014).

c. Overconsumption/malnutrition

i. Undernutrition

If we embrace malnutrition in all of its forms, the concern for undernutrition supersedes that for overnutrition in Guatemala within the public health agenda. The condition-of-interest is that of early-life growth retardation and low stature (stunting), often termed "chronic malnutrition." The Hunger Zero Pact (SEGEPLAN, 2013) was dedicated to focusing on its prevention in the first 1,000 days of life. Guatemala has the highest prevalence of stunting in children under 5 years of age in the Western Hemisphere, at 49% in the 2008-9 DHS survey, falling only to 46.5% in the follow-up in 2014-15 (MSPSA-ENSMI, 2015). Currently, the prevalence of the indigenous subsegment of the population has a 61.2% stunting rate. Stunting is not a full-fledged undernutrition disorder, as the lower limbs are specifically affected out of proportion to the upper body and head (Bogin and Varela-Silva, 2009).

The international response to reduction in stunting has followed the line of assuring an adequate diet and providing multiple micronutrients, but efficacy trials of both modalities have not shown impressive results. Environmental stress is

Box 3. Linkages Between Agriculture and Healthy via Issues of Food Consumption

- **Food safety:** Microorganisms, toxins and contaminants in the food supply.
- **Nutritive value:** The quantity, density and bioavailability of essential macronutrients and micronutrients.
- **Energy balance and diet profile of consumption:** An individual's energy intake and expenditure must be in balance, and the pattern of health-protective and health-noxious foods and constitutents.
- **Fuels for cooking:** Forestry and fiber implications of the fuels used for cooking.
- **Monetary income for food acquisition:** Agricultural labor or sale of production for purchase of food and health-related items.

likely to be a more important determinant in Guatemala, in a truly multi-factorial situation (Solomons et al, 1993). The foodborne illness scenarios discussed earlier are part of the causality. In a major new epidemiological analysis covering 137 developing countries conducted by the Harvard School of Public Health, Danaei et al. (2016) conclude: "FGR (Fetal Growth Retardation) and unimproved sanitation are the leading risk factors for stunting in developing countries. Reducing the burden of stunting requires a paradigm shift from interventions focusing solely on children and infants to those that reach mothers and families and improve their living environment and nutrition."

In addition, micronutrient malnutrition is a concern in Guatemala and the Central-American region. These include vitamin A, iodine, iron, zinc, vitamin B12, vitamin E, vitamin D and omega-3 fatty acids. A three-decade, stable national program of sugar fortification with retinyl palmitate and salt fortification with potassium iodate since the 1950s have both been effective interventions. Trace-element nutrients, iron and zinc, are not highly bioavailable from the corn and bean diet. Weekly supplementation with iron is provided by government clinics for selected subsegments of the Guatemalan population. Nutritional-sensitive agriculture needs to consider the unmet micronutrient gaps in the diet in forward planning.

ii. Overnutrition

Sixty-seven percent of Guatemalans aged 15 and above are overweight, among whom 29% are obese [World Bank, 2017]. The breakdown by gender and age is not available. This classifies Guatemala with one of the ten highest prevalence values for excess weight in adults. A reflection into adulthood of the early short-stature is an increased susceptibility to excess body weight. In any event, overweight and obesity represent a public health problem in this nation with a 50% rural residency.

The other contextual risk for overconsumption is that for vitamin A. With the fortification of table sugar with this vitamin, dietary-intake surveys have documented daily consumption chronically exceeding 1,500 µg of the preformed vitamin, a risk-level for bone demineralization, and occasionally exceeding the 3,000-µg level for fetal birth-defects risk.

d. Expected changes in consumption patterns

Guatemala has been in a phase of rapid nutritional transition over recent decades, with a Westernization of the dietary pattern driven by urbanization, improved transport to the rural areas and opening of North-South food trade. Bermúdez and coworkers (2008) demonstrated a reduction in the diversity of "traditional" foods and a rise in "modern" foods in recent food-intake surveys. The precise nature of future development is so multi-factorial and contingent on local and international factors as to be unpredictable. The maize and bean culture is deeply rooted in the Guatemalan populace, but movement from home-prepared to ready-to-use tortilla flours and packaged, cooked beans exemplifies a change toward convenience solutions. Mechanization of household, industrial and agricultural pursuits should further reduce average daily-energy expenditure, hopefully to be accompanied by a concomitant or greater decrease in caloric intakes.

e. Understanding and incentivizing behavioral change

Guatemala has been a leading setting for cultural anthropology, including aspects of food and diet. The understanding of the cultural basis of attitudes and practices, including food taboos and avoidances is profound (Cosminsky, 1977). Much of the behavioral concern has been around maternal eating habits in pregnancy and lactation, which are deeply ingrained. Moreover, rather than intervene and guide a change in practices, respect for the "wisdom of the Mayans" has been the watchword in both anthropology and public heath.

As mentioned, fortification programs, which do not require diet change for effectiveness, are instituted in Guatemala. Where behavioral change might emerge to become a strong public health consideration is in maintaining energy balance with growing overweight and obesity, and in the control of saturated fat, sodium and sugar intake. Traditionally fat intakes are low, as maize preparations do not require frying. One rural study in an indigenous community showed low sodium intakes (Melse-Boonstra et al., 1998); this, however, might not reflect the corresponding urban reality. As a sugar cane-producing country, sugar is abundant and relatively inexpensive. Curbing the "sweet-tooth" of Guatemalans in a sea of sugar, however, will represent a major challenge.

VII. Policy Considerations

a. Distortions created by subsidies and other outmoded agricultural policies

Outmoded is a term in the eye of the beholder and, in agricultural policy, and with respect to the slow advancement of the basic structure, harmony among measures might require retention of older modes. Concessional fertilizer distribution was a visible governmental policy of the administration of 2000-2004, but it has generally been judged as more of a public-relations ploy for popularity among the rural populace than a concerted strategic policy. No other susidization programs are widely recognized.

b. Promoting nutrition-sensitive agriculture to provide healthy and sustainable diets with associated issues for resource use and food prices

Nothing as comprehensive or integrated as outlined in the heading exists for Guatemala. An extensive quotation from the 2014 FAO Fact Sheet on trends in agricultural policy for this nation describes the enunciation of relevant government policies, "The National Policy on Integrated Rural Development (2009), which has the overall objective of: "achieving a progressive and permanent progress in the quality of life of the priority subjects [...] through the equitable and sustainable use of productive resources for integrated human development in rural areas; ii. The National Agricultural Policy 2011-2015 has the goal of creating the conditions for productive actors to generate an equitable and sustainable economic development, fostering employment and reducing poverty and inequality. It prioritizes the promotion of rural economies, indigenous and peasant communities, in order for them to become surplus producers and to invigorate local economies". (FAO, 2014).

c. Policies that foster technological innovation

On the broadest scale, for agriculture and other pursuits, the research-granting mechanism of the CONCYT has participation from the Ministry of Economics and a point-assignment for the potential to develop a patentable product is employed. The government collaborates with the offering of international study fellowships for students to study advanced technology in Korea and Taiwan in many fields of engineering and technology, some of which may be applicable to the agrosector upon their return.

d. Policies to build human resources (e.g., education, gender, equity)

As noted, Guatemala is one of the 10 most inequitable countries with its GINI coefficient of 48.7. Gender equity in basic schooling has been a theme in Guatemala since the mid-1980s, and major success has been made in closing the gap; however, the overall state of public education for both sexes is currently in serious decline.

e. Policies that seek to redesign the agricultural ecology (land use, bioeconomy, etc.)

Policies of the nature of redesign in land use, for historical reasons that date to the Revolution of 1944 and the counter-revolution of 1954, would be beyond the purview of a Ministry or Administration, and require legislation. The legislature is currently in a cumbersome impasse, and the theme of redesign is far from consideration.

f. Policies to promote consumption of healthy food

The format of inquiry for action on healthy foods, promoted across the world by the International Network for Food and Obesity/non-communicable diseases Research, Monitoring and Action Support (INFORMAS) (Swinburn et al., 2013), based at INCAP. This inquiry has the backing of the Guatemalan SENACYT. Movement toward the public discussion conducted in February, 2017, but the process is a long way from producing legislation or ministerial regulations.

g. Comparative advantages of Guatemala in agriculture

The availability of low-cost agricultural workers, an anachronism in labor policy, is an advantage for labor-intensive production. Water resources, if well managed according to the principles outlined previously, are superior to most tropical countries. The traditional climate, to the degree that it resists climate change, has year-round growing seasons in most of the arable regions.

h. International trade issues

Guatemala is a co-member of the Central American Free Trade Agreement (CAFTA). Currently, the instability and ineptness of formulating trade policies, mainly in the US, and other countries that might join a protectionist and exclusionist approach, would be an unpredictable barrier.

i. Market challenges

For internal commerce, the infrastructure of roads and waterways for transport are the challenges. Internationally, airport and port facilities for export of crops to overseas markets is deficient.

VIII. Conclusions

a. Some potential national scenarios for agricultural production over the next fifty years

Three distinct sectors would be the players in this scenario interplay: peasant subsistence agriculture; expanded mechanized production for national consumption, and expansion and diversification of cash-crop (exportation) productions. The scenarios involve the parallel and co-equal persistence of each, or the emergence of two to the exclusion of the third or the dominance of only one to the reduction of the other two. The peasant sector seems the most likely to head toward extinction.

b. Highest priority actions to achieve agricultural sustainability

This review would suggest that resolution of water tenency issues, conserving arable land and instituting environmentally-sensitive agricultural and land-use practices would be the priority actions, whatever be the actual scenarios going forward.

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