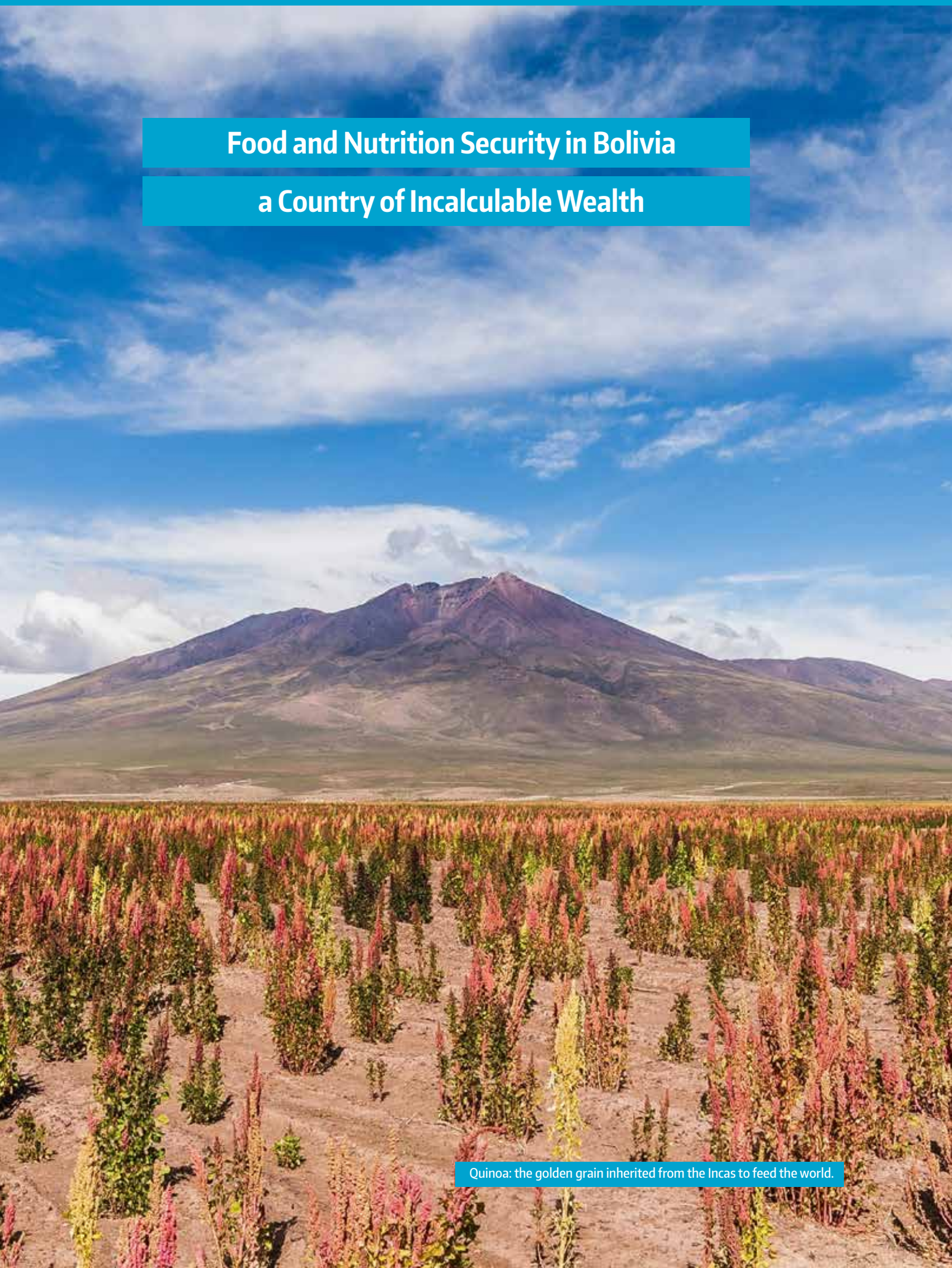
Food and Nutrition Security in Bolivia

a Country of Incalculable Wealth



Quinoa: the golden grain inherited from the Incas to feed the world.

Bolivia

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Bolivia is blessed with enormous biological and biogeographic diversity, but **must invest in science, technology and innovation to mitigate climate change and to meet future food challenges**

Summary

Bolivia is a country with a wide range of incalculable wealth, reflected in the abundance and diversity of its natural resources, culture and traditions. The sharp contrasts in its territory and people show that this is a part of the world with an enormous amount of diversity. Bolivia is inhabited by populations which, despite this legacy, have undergone extremely difficult circumstances. As a result, they have developed skills and experiences to thrive and adapt to the adversity of extreme situations. This is especially evident in the rural setting, where for centuries small farmers have learned to subsist, produce and support their families despite the difficult conditions. However, this immense scenario which harbors extremely diverse and nutritious productive systems, and is capable of feeding not only its population but the whole of the Americas in a sustainable, environmentally-friendly way, is not being managed in a planned, technologically appropriate manner. The growth of ecological awareness is a crucial element for achieving the survival of species and productive ecosystems in Bolivia, where, because of the biological complexity, hundreds of species interact in small spaces. Priority actions for achieving agricultural sustainability cannot separate productive aspects from considerations that promote respect for the other ecosystem resources involved in its fields and species. Some potential scenarios for better agricultural production for the following decades are based on scientific research to create capacities to achieve the optimal use of new energy forms. The development of new land management models and rational resource use would make it possible to focus on climate change adaptation and mitigation strategies, boost production and ensure that less of what is already produced is lost.

Introduction

In an ideal situation, a population reaches its optimal state of food and nutrition security when it is supported by food sovereignty. This is understood as the right of peoples to control and decide their own agri-food and productive system, thus accessing healthy, nutritious, culturally adequate food, produced in a sustainable, ecological way. Conversely, data on the current state of food security in Bolivia show that the country is at risk, due to the levels of national food insecurity, exacerbated by inadequate nutrition that currently affects a quarter of the population.

Bolivia's inhabitants are a long way from controlling the agri-food system that characterizes national production, since not only does the political slogan "indigenous native or peasant family farming" lack agroecological orientation, but also the numerous laws enacted fail protect its food stability, or the environment where they live and

produce food. Artisanal fishing and harvesting systems in several parts of the country continue to be based on inequitable processes that reduce their autonomy. The performance of food imports shows that in recent years, Bolivia has become increasingly dependent on a growing volume and variety of imported products.

Accordingly, the prices of various foodstuffs consumed by Bolivian households are increasingly reliant on the behavior of international markets. Thus, the human right to the permanent provision of healthy, nutritious, sufficient and culturally appropriate food is not guaranteed. The extreme parcelization of the ownership of the productive areas and the degradation of the land in the western part of the country, where most of the rural farmers are concentrated, together with the increasing migration to cities, are other variables that exacerbate the crisis of peasant production, which could gradually reduce its importance as a food producer. At the regional level, the country's tropical lowland regions have land suitable for agriculture that could play a more important role in the country's agricultural production, particularly regarding beef and dairy cattle and poultry production.

This document comprising various experts' views is not intended to provide a definitive opinion on the validity and scope of the concepts, but rather to constitute a space for analysis and discussion with the participation of governments and civil society. It could soon become the most significant issue for defining the prolongation and survival of the human species and other living beings. Bolivia certainly has potential and all it requires are attitudes, knowledge and practices which respect ancestral knowledge of the environment and are supported by the rigor of science and scientific research.

1. National characteristics

1.1. Area of the country, natural resources and environmental and landscape heterogeneity

Bolivia is currently a landlocked country bordering on the North with Brazil, the South with Argentina, the West with Peru, the SW with Paraguay and the SW with Chile. Bolivia has an area of 1,098,581 km^2, occupying 0.2% of the world's surface. Due to its altitudinal gradient, which ranges between 90 and 6,542 meters above sea level (masl), Bolivia is the country with eighth greatest biological wealth. It comprises five biomes, 23 ecological regions and 205 ecosystems. Although its forests account for just 3.5% of the world total, the country is home to 45-55% of the earth's biodiversity (http://bolivianing.com/bolivia). Bolivia is also one of the 10 most diverse countries with respect to vertebrates, with approximately 3,000 species. This mega-diverse geographic space contains one of the world's largest wildlife reserves, home to 422 mammal species (Bolivia has the largest

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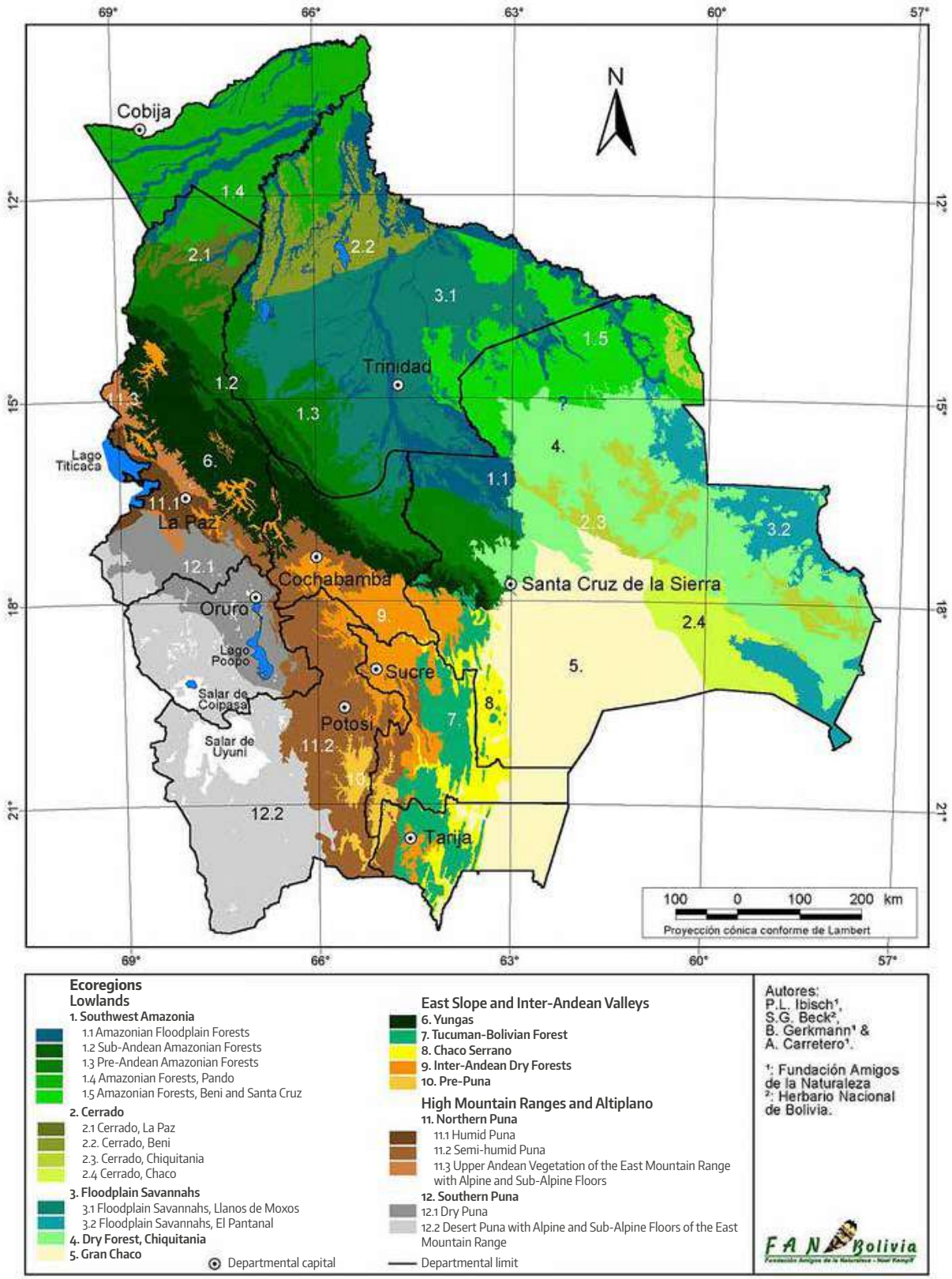
Figure 1. Ecological map of the regions of Bolivia (Ibisch et al. 2003)



population of jaguars and tapirs worldwide), 344 reptile species, 642 fish species, 378 amphibian species and more than 1,450 bird species (http://labiodiversidadenbolivia.com).

More than 17% of the Bolivian territory comprises protected areas and natural parks. The enormous contrast among regions is partly due to the Andes, which in Bolivia is divided into two mountain ranges: West and East. In addition to this natural wealth, the country possesses genetic resources, because of its domestication of species useful for food, medicine, industry and other applications. Bolivia is an immensely diverse country, because it has over 20,000 plant species, 134 of which are timber species and over 3,500 of which are botanical species for medicinal use (http://www.bolivianland.net/).

1.2. Ecoregions and environment, areas

In Bolivia, the various ecoregions, home to enormous biological diversity, are the result of major biogeographic influences in the Andes, the Amazon, the Valleys and the Gran Chaco, regarding both anthropological aspects (Moraes & Beck, 1992; Navarro, 2002), and the forms of agricultural production, which in many ways are also affected by climate change (Tejada, 2011). Based on man's age-old interaction with the environment, intense adaptation mechanisms were produced, creating heterogeneous, traditional and semi-natural anthropic landscapes in the extensive plains of the Beni, the mountainous areas of the Yungas of La Paz and the inter-Andean valleys on the East side of the Cordillera (Navarro, 2002). Several patterns of overuse and uncontrolled colonization affected the long-term productive potential in large areas (such as the high Andean zones of the eastern Cordillera and the lowlands of northern Chaco), which showed signs of degradation and potential transformation as a direct effect of the permanent pressure on resources (Killeen et al., 2005; 2008).

The five enormous biomes of this country are subdivided into 23 mostly agroproductive ecoregions (see **Table 1** and **Figure 1**). These areas include the Altiplano and Las Punas, comprising a large array of mountain ranges, plains and mountains located above 3,500 m with an area of 254,392 km² equivalent to 23.2% of the country's total area. The valleys cover an area of 160,162 km², 14.6% of the area of Bolivia, including the Yungas and mountainous headwaters. The alluvial plains (in the Amazon and Chaco region) have an area of 684,007 km², comprising 62.2% of national territory.

1.3. Productive Territory and Agricultural Capacity

The 2013 Agricultural Census registered 34,970,168 hectares (ha), equivalent to 32.4% of the total area (109,858,100 ha), which contribute to the country's food security and sovereignty. Arable land comprises 7,837,864 ha, 2,763,239 ha of which are planted in summer. This is followed by 2,349,062 ha of cultivated pastures; 1,635,898 ha of resting land and 1,089,665 ha of fallow land; 27,132,304 ha are non-agricultural land. Of this total, forests or mountains account for 13,775,113 ha, natural pastures 11,053,246 ha, other lands 2,153,726 ha and forest plantations 150,219 ha.

As for the main crop groups planted during the 2013 summer season, 43.4% of the area was cultivated with oilseeds and industrial crops (999,369 ha with soybean and the rest with sunflower, sugar cane and peanuts). A total of 31.9% of the area was used for cereal cultivation (390,668 ha with maize, and the remainder with grain sorghum, paddy rice, quinoa and wheat). Tubers and roots were planted on 7.5% of the area (170,447 ha with potato), vegetables on 3.9%, fruit trees on 5.8%, fodder on 6.1% and stimulants on 1.4% (http://www.paginasiete.bo/economia). Bolivia has 872,676 Agricultural Productive Units (UPA), 28.1% of which are located in the Department of La Paz, 20.8% in Cochabamba and 14.2% in Potosí (http://www.ine.gob.bo/pdf/boletin/).

1.4 Main constraints on National Agricultural Productivity

1.4.1 Low availability of irrigation

Only 7.1% of the area-under-cultivation in Bolivia has irrigation systems. Most agriculture remains rainfed, in other words, various crops

Table 1. Bolivia: Eco-regions, altitude, area and land use

Ecological Region	Altitude / Area	Land use
1. Amazonian Flood Forests in Beni, Cochabamba, La Paz, Pando and Santa Cruz: Amazonian forest plain, basins of the Precambrian Shield. In strips and watersheds of very variable size along the rivers.	100-500 m 63,588 km²	Use of wood, growing colonization, use of rubber and wild fruits. Large rivers are the main access roads in the Amazon.
2. Sub-Andean Amazon Forests of Santa Cruz: Sub-Andean zones north of the Andes elbow in Bolivia.	500-1,000 m 23,529 km²	Increased colonization, extraction of wood. Important hydrocarbon zone.
3. Pre-Andean Amazon Forests in Beni and Pando: 100 km from the last Andean foothills.	150-500 m 58,308 km²	Areas of colonization; Small-scale agriculture of large-scale, mechanized (especially Chapare, Cochabamba, and Sara and Ichilo, Santa Cruz) small-scale farmers from the west of the country, many secondary forests. Forest utilization, important oil zone.
4. Amazonian forests of Pando, Beni and La Paz: Amazon plain: in the west slightly waved, towards the east plane with outcrops of the precambrian shield.	100-300 m 71,217 km²	Use of wood, increasing colonization and thus agriculture. Large regions traditionally exploited by non-timber forest resources: rubber and chestnut. Extensive forest area, danger of deforestation (see neighboring side of Acre)
5. Amazonian forests of Beni and Santa Cruz: Plains, Precambrian penillanura.	150-400 m 59,905 km²	Use of timber, colonization and growing agriculture, until mechanized soybean and sunflower farming. Eucalyptus plantations.
6. Cerrado from La Paz: Plains of varying heights and shallows, of acid soils, affected by rainfall and floods, above all, by overflowing rivers of clear water.	180-500 to 1,000-2,000 m 9,837 km²	Very little livestock. Constant extensive agriculture of soybean and sunflower.
7. Cerrado from Beni and Pando: Flat and undulating savannas with differences of level to more than 20 m in the north, termiters floods by rainfall; Strongly weathered, nutrient poor soils, lateritic layers with pisolites	100-200 m 27,171 km²	Little livestock.
8. Chiquitano Cerrado of Santa Cruz: Plains, landscapes of hills and slabs (inselbergs).	120-1,000 m 23,491 km²	Cattle. High frequency of anthropogenic fires favor the expansion of Cerrado Fields at the cost of forests.
9. Chacoan Cerrado of Santa Cruz: Plain with few hills and small hills.	170-1,100 m 24,468 km²	Extense livestock farming. High frequency of anthropogenic fires.
10. Flood savannahs of the Llanos de Moxos in Beni, Cochabamba and santa Cruz: Grasses dominated by grasses and Cyperaceae; Aquatic and marsh plants (yomomo, curichi); Different types of forest islands, open forests (tajibales), palm forests and thorny low (tusecales). Gallery forests along the rivers.	100-200 m 94,660 km²	Livestock, tourism. Historical impact on the ecosystems by the pre-Columbian cultures of Moxos (Mojos) establishing embankments, ridges, channels and dikes.
11. Wetlands of the Pantanal in Santa Cruz: Especially plains with extensive areas of flood and large lagoons by the Paraguay River. Alluvial soils.	100-800 m 33,328 km²	Livestock, tourism.
12. Chiquitano Dry Forest in Santa Cruz: Plains, hills, slabs (inselbergs - Precambrian Shield).	100-1,400 m 101,769 km²	Industrialized agriculture, large-scale livestock farming, logging, mining, transportation of petroleum products (gas pipelines).
13. Gran Chaco in Santa Cruz: Tarija and Chuquisaca: Plain with few hills and small hills.	200-600 m 105,006 km²	Livestock, extraction of wood, firewood, charcoal, oil exploitation.
14. Yungas in Santa Cruz, La Paz and Cochabamba: A region of almost perennial Andean forests on the northeastern slope of the Andes. Partially very steep northeastern wetlands of the Bolivian (and Peruvian) Andes. Dissected valleys.	1.000-4,200 m 55,556 km²	Agriculture (locoto, coffee, coca, citrus, in the timberline especially potato, use of firewood, grazing, increasing colonization.

Table 1. Bolivia: Eco-regions, altitude, area and land use

Ecological Region	Altitude / Area	Land use
15. Tucuman-Bolivian Forest: in Santa Cruz: Tarija and Chuquisaca. Due to thermal and water seasonality (and lower minimum temperatures), they are clearly distinguished from the moist montane forests north of the Elbow of the Andes, which in this work are considered as the Yungas (Bolivian-Peruvian).	800-3,900 m 29,386 km²	Use of wood, agricultural activity and increasing grazing.
16. Chaco Serrano in Santa Cruz: Tarija and Chuquisaca: Low mountain ranges of the last foothills of the Eastern Cordillera of the Andes, low valleys, foothills.	700-2,000 m 23,176 km²	Agriculture, livestock, oil exploitation.
17. Dry Inter-Andean Forests in Cochabamba, Tarija, La Paz, Potosi and Chuquisaca: Large variation of deciduous plant formations ranging from dry forests in the Yungas region to the extensive valleys in the central and southern parts of the country. Valleys more or less dissected, small plains.	500-3,300 m 44,805 km²	Agriculture, livestock, use of firewood / wood; Severe soil erosion problems. Small areas and mostly heavily disturbed in the most unspoilt forests virtually unprotected.
18. Prepuna in Tarija, Potosi and Chuquisaca: Semi-desert of valleys more or less wide to dissected, small plains.	2,300-3,400 m 8,516 km²	Livestock (especially sheep and goats), some agriculture, severe soil erosion problems.
19. Wet Puna in La Paz: Natural potential vegetation is evergreen forest (dominated by *Polylepis* species) and is now found in less populated areas. Phytogeographically it is a region that shows affinities with the high Andean vegetation of the north of the Andes. Plain with hills around and to the south of Titicaca Lake, standing on the slopes of the Cordillera Real.	3,800-4,100 m 8,869 km²	Area of cultivation, ridges, livestock of sheep and cattle. Exploitation of minerals; tourism.
20. Semihumid Puna in Cochabamba, Tarija, La Paz, Potosi, Oruro and Chuquisaca: Low mountains, high plateaus, valleys. Andean forests almost completely destroyed.	3,200-4,200 m 67,600 km²	Livestock area of sheep and cattle, casually crops. Exploitation of minerals; tourism.
21. High Andean Vegetation of the Eastern Cordillera with Nival and Subnival Floors in La Paz and Cochabamba: Glacial valleys with lagoons, slopes, peaks, rocky peaks.	4,000-5,100 m 8,137 km²	Livestock of sheep and camelids, few cattle. Tourism. Exploitation of minerals; Problems of soil erosion.
22. Dry Puna in La Paz, Oruro and Cochabamba: High aridity, which may inhibit the development of extensive forest vegetation on its lower floors (there are only groves or chaparral areas in small areas with *Polylepis tarapacana* and *P. tomentella*). Low mountains, high altiplanic plateaus, wide valleys of the Desaguadero River.	3,500-4,100 m 35,973 km²	Livestock area of sheep and camelids. Locally grown quinoa (Chenopodium quinoa) and cañahua (Ch. pallidicaule).
23. Desert Puna with Nival and Subnival Floors of the Western Cordillera in La Paz, Oruro, and Potosi: It borders the Atacama Desert. Poor vegetation cover due to low rainfall and low temperatures is characteristic; There are only biotic elements present in one floor (*Nototriche turritella* in the Western Cordillera). hills/volcanos, extensive plains highlands, valleys with little vegetation, dunes, salares.	3,800-7,000 m 100,204 km²	Livestock area of camelids, sheep and few cattle. Exploitation of minerals and halogens; tourism.

Source: Adapted from Ibisch et al., 2003

are entirely dependent on rainfall. This limitation is exacerbated by climate change, expressed in different ways, such as the extreme drought experienced during this agricultural management period (2016-2017). Thus, 286,536 Agricultural Production Units, APU, equivalent to 32.9% of the total UPA registered in the country, cultivated 268,844 ha using various irrigation methods (INE, 2016). According to the Rural and Agrarian Problems Unit (UPRA), created by the Center for Studies on Labor and Agrarian Development (CEDLA), this "partly explains the low productivity of the country's agriculture, as well as the scarcity of several agricultural products at certain times of the year, a situation that requires their massive importation on a temporary basis (http://www.elpaisonline.com).

1.4.2 Low public investment in water and agriculture

The amount of public investment allocated to the agricultural sector and water resources is steadily declining. According to data presented by the Jubilee Foundation, based on the 2016 General State Budget (GSB), the budget allocated to the agricultural sector in 2015 was $447 million USD, which fell to $354 million USD in 2016, a reduction of 21%. By 2017, the GSB presented by the Ministry of Economy and Public Finance once again reduced the budget for the agricultural sector, from $354 million USD for 2016 to $197 million USD, equivalent to a 44% decrease. The water sector was assigned a budget of $70 million USD in 2015, which was cut by 21% in 2016, as a result of which this sector was allocated $55 million USD this year. According to the MEFP presentation, the 2017 budget for water resources will be $24 million USD, which means another cut for this sector, now totaling over 56%. The irony is that all this is taking place within a context of severe drought, in which only 7% of the area under cultivation in Bolivia has irrigation systems (HYPERLINK http://www.elpaisonline.com).

1.4.3 Unequal characteristics of irrigation in Bolivia

Most of the farms that use irrigation are located in the regions of the valleys and the Altiplano (94%), concentrating 68.1% of the total area under irrigation (in other words, of the 7.1% mentioned earlier). Due to the importance of APU with irrigation in the valleys and Highland regions and the low level of irrigation in the plains, the average number of hectares cultivated with irrigation is extremely low (0.93 ha/productive unit). Last, UPRA points out that "eleven crops concentrate 71.3% of the total area under irrigation in the country" which are, in order of importance: maize, potato, alfalfa, soy, rice, green bean, onion, peach, wheat, barley grain, and sugar cane, among others (http://www.elpaisonline.com/).

1.5. Demographic Characteristics and Future Trends, Cultural Food Anthropology and Health Considerations

1.5.1. Demographic characteristics

Bolivia's estimated population in June 2015 was 10,825,000 inhabitants (www.ine.gob.bo/pdf/boletin/NP-2015-64-pdf). However, between the 2001 and 2012 Censuses, the population growth rate slowed to just 1.71% per year, compared with 2.05% (1950-1976), 2.11% (1976-1992) and 2.74% (1992-2001), regarded as some of the highest in South America. This sharp decrease is due to a demographic dynamic characterized by:

a. A declining fertility rate, in which average parity fell from 6.7 in 1960 to 3 per woman ages 15 to 49 in 2015 (La Razón, 2013). By 2025, a rate of just 2.5 children per woman is projected, a decline attributed to greater awareness of responsible procreation;
b. The high mortality rate, particularly in the early years of life (0 to 5 years) and from the age of 65 onward, attributed to precarious health conditions and services, exacerbated by the incidence of undernourishment, malnutrition and unsanitary conditions;
c. Growing external migration. The period between the 2001 and 2012 censuses saw the departure of "562,461 Bolivians" (www.ine.gob.bo/pdf/boletin/NP-2015-64-pdf) largely attributed to the lack of opportunities and work in the country;
d. Low population density, since there are only 9.13 inhabitants per km² (2012 Census),

making it the country with the lowest density in South America;

e. Unequal population distribution that concentrates 71% (2015) in just three Departments (La Paz, Santa Cruz and Cochabamba), and

f. Poverty situation. According to FAO, based on data from the National Institute of Statistics (INE), in 2011, "44.95% of the Bolivian population was living in poverty; while 20.87% were living in extreme poverty" (www.fao.org/bolivia).

1.5.2 Future demographic trends

The Bolivian population will show the following trends in the future: declining population growth; decrease in the child and adolescent population (ages 0 to 19); predominance of the adult population (ages 20 to 59) and increase in the elderly population (60 years and over). According to INE (www.ine.gob.bo/pdf), life expectancy in 2015 was 71.3 (68.1 for males and 74.6 for females), and by 2025, it is expected to rise to 76.1. Urban concentration will increase following severe depopulation of the countryside: in 1950, Bolivia was predominantly rural (65%). By 2015, it had become mainly urban (69.1%) and by 2030, it is projected to be 75.2% urban and only 18.8%, rural, which is unthinkable and must be reversed (www.cepal.org/es). Future projection, according to INE, indicates that between 2000 and 2020, the population will increase as follows, by ecoregion: just 36.88% in the Altiplano 71.52% in the Valleys and 108.46% in the Plains.

1.5.3 Cultural anthropology, food habits and productive patterns

What is now Bolivia once comprised essentially agricultural and hydraulic cultures and civilization. However, since the Colonial period, there has been a predominance of extractive, export-oriented primary culture and economy, which prioritized the exploitation of minerals and, more recently, hydrocarbons (natural gas). Although this material and immaterial culture marginalized agriculture, it survived, and agriculture (animal, vegetable and forestry) and agribusiness now flourish in the eastern and southern Regions. In the western and Central Region (Altiplano, Valleys and Yungas), food production is traditional, empirical, single-family and small-scale; with low productivity, and profitability, and unable to fully satisfy their dietary needs. As a result, peasant contingents have not only stopped producing food, but have also migrated to the cities and abroad.

Although Bolivian food habits were traditionally based on natural, nutritious products, they have recently lost ground to foreign fast foods (junk food) and ultra-processed products. The World Health Organization (WHO) in Bolivia stated: "Ultra-processed products are replacing the traditional Bolivian diet. These are foods with little or no nutritional value, almost without natural elements with "a key role being played by advertising, including that targeting children"(*La Razón*, 2015).

1.5.4 Major Food-related Health Disorders

Particularly in cities, "Nutritional disorder remains one of the main factors that trigger preventable diseases" such as gastrointestinal and cardiovascular diseases, diabetes and obesity. In this regard, WHO warns that, "The prevalence of certain illnesses has increased as a result of poor eating habits, which even affect children: Santa Cruz presents the highest rates of diabetes with 300,000 people (15%) and about 400,000 children suffering from diabetes in Bolivia, according to data from the Ministry of Health in 2012 (http://www.eldeber.com.bo).

Undernourishment, malnutrition and eating disorders are largely the result of lack of education, guidance, information and knowledge, as well as the prevailing influence of certain uses, customs and traditions of the local and regional food culture. In the West, the consumption of potatoes and noodles prevails, whereas in the plains, cassava and rice are the main starchy foodstuffs consumed (http://www.eldeber.com.bo).

In the countryside, in order to supplement their meager diet, peasants travel to cities to buy food. And in the subtropical Yungas region, they have stopped producing their food and fruits and

turned to coca production for market reasons, and, ironically, import food and fruit. A proportion of the peasant, mining, labor and periurban population chews coca as a supplement and palliative food.

As a result, food and nutrition security and food sovereignty should be treated as a "state matter", since it is unconscionable that Bolivia, with its small population and immense territory capable of producing all types of food, should be considered vulnerable and dependent experience chronic food insecurity.

1.5.5 Higher exports and imports of foodstuffs

According to INE (2017), from 2010 to 2015, Bolivia's main food exports were: soybean, soybean by-products, quinoa and Brazil nuts. In the case of soybean and its by-products, in 2014, a total of $992,774,000 USD was reached. By 2015, this had fallen to $201,554,000 USD, a reduction of 20.3%. Quinoa exports have grown spectacularly, from $46,648,000 USD in 2010 to $63,446,000 USD in 2011, $79,916,000 USD in 2012; $153,259,000 USD in 2013 and $196,637,000 USD in 2014, as a result of the declaration of the International Year of Quinoa, promoted by the UN. However, in 2015, exports declined due to multiple adverse factors involving politics and international price competition, totaling $107,706,000 USD or 54.8% less than the previous year. As a result, Peru, prioritizing the mass production of conventional non-organic and therefore cheaper quinoa, surpassed Bolivia's export volumes by up to 10.75%.

At the same time, Brazil nuts experienced significant growth from $103,713,000 USD in 2010 to $192,027,000 USD in 2015, equivalent to an 85% increase (INE, 2017).

Nevertheless, the country's main exports are not food products. According to information from INE (2017), 80% of Bolivia's exports are currently concentrated in gas and minerals, while the remaining 20% are non-traditional exports. Between 2010 and 2015, food imports in Bolivia accounted for $3,218 million USD and, according to the Bolivian Institute of Foreign Trade (IBCE, 2017), peaked in 2014. In September 2016, a total of 458 products were imported. The main items were wheat flour for $65 million USD, representing 36% of the total imported volume; wheat grain, totaling $11 million USD, accounting for 9%; unroasted malt, totaling $22 million USD, representing 6%; potatoes or yams totaling 1 million, which represents 6%, and fresh apples for the sum of $12 million USD, which represents 5% (IBCE, 2017). The main food suppliers to Bolivia from January in the third quarter of 2016 were Argentina with $156 million USD, followed by Chile with $67 million USD, followed by Brazil with $50 million USD, Peru with $44 million USD and the U.S. with $39 million USD (IBCE, 2017).

2. The Energy Challenge in Food and Nutrition Security

Food and nutrition insecurity is an issue that encompasses a multitude of aspects and disciplines such as demography, population and poverty indices, agroeconomics and the economy of food production. Accordingly, it should not simply be treated in a *multidisciplinary* way, whereby various disciplines traditionally intervene without being fully integrated, collaborating independently in a common project, or in an *interdisciplinary* way, in which different disciplines participate, achieving a certain degree of integration involving the procedures, techniques and practices of each one of them. The problem must be addressed using a *transdisciplinary* approach, which seeks to achieve greater integration, both theoretical and practical and conceptually link its orientations, postulates, practices, analyses and methodologies, in order to create a new, more realistic cognitive map of the issue. It is necessary to have trans-specialized knowledge (http://prof.usb.ve/miguelm), which is a promising way to plan and organize the food and nutrition security of a country such as Bolivia.

The concept of transdisciplinarity points out, for example that the "*food and nutrition security*" variable of a society can be conceived of as a '*characteristic essence*' analogous to energy, in the sense that it can only change its form, degrade to a lower quality or terminal condition,

or grow or improve under certain conditions. This causality can therefore be handled through the concepts of laws extended from classic thermodynamics to the thermodynamics of organizational systems, and the logical principles of classical science extrapolated to this science (Trepp, 2017). One of these important flows is energy, which is presented in two different currents in the issue of food and nutrition security. The first has to do with the food intake and nutrition required to maintain biological life. This defines the food power required per person (kcal/day) that must be guaranteed, which in turn defines the second energy stream required, which refers to what is required for food production and must meet minimal conditions of quality, safety, nutrition, economy, competitiveness and efficiency.

From the technical point of view, in agriculture, energy needs and consumption for production depend on the technologies and materials used in the various phases and processes that take place. Likewise, in livestock technical activity, energy requirements and use are conditioned by breeding practices and technologies, and the management and care of the various livestock species used for food. Livestock in turn requires food and nutrition security for these animals, which involves the agricultural production of fodder and other plants for these purposes.

Thus, food security constitutes a specific aspect of the energy planning of a country's rural productive sector, which in turn is part of rural development planning in general. Agricultural energy planning studies the energy requirements for the production of agricultural goods -particularly of food- according to the application of various technologies determined by natural and social ecological factors, as well as cultural and economic agents that condition producers' work and activities.

The organization of food and nutrition security is therefore based on the energy planning of the rural productive sector, which begins with an energy analysis of the production of goods and foodstuffs, regardless of the planning methodology used. The energy analysis in this case consists, broadly, of the determination of energy consumption during food production in a baseline situation, in order to draw up the goals to be pursued and the scenarios to be reached within a specific time frame. Energy consumption by product is determined by "measuring" consumption by time, uses and quantities, according to the different technologies, methods and production tasks applied in the various biogeographic production zones that determine the corresponding energy-consumption patterns.

Energy analysis should be performed as a function of two groups of explanatory variables that make it possible to accurately interpret energy uses: socioeconomic and sociocultural. The first group includes energy infrastructures – boosted by the growing interest of the current government in turning Bolivia into the energy center of Latin America, through the construction of several anti-ecological dams in various parts of the country - and communications infrastructure, including the type of production units, land tenure and importance of the product. The second group considers social organization, instrumental and organic worldviews, physical-natural space management, ecosystem management, technological and energetic rationalities, and sociocultural and socioeconomic human groups (Gallo, 1989).

Energy analysis and planning of food production in the rural productive sector should incorporate a variable that considers the effects of climate change and global warming in order to mitigate their consequences on food security. In this regard, it should be remembered that the Andean civilizations prepared for the food insecurity that could be caused by climatic and meteorological factors by drying agricultural products (especially tubers), which could be safely preserved for about 15 years without losing their properties (http://agroingeniero.blogspot.com). Given the meteorological and climatic hazards that threaten rural production in the future, it would be feasible to adopt similar measures to these ancestral practices of storage and food preservation.

To ensure food security, food production must solve the chronic problems affecting it.

These include mitigating and controlling the limitations of the seasonal practice of rainfed agriculture, which obviously requires the introduction of irrigation. It is also vital to reduce seasonally occurring livestock losses due to extreme drought or floods spanning large tracts of grazing fields.

Greater political stability is required, particularly with respect to the design and support of policies and plans to ensure the consistency, durability and continuity of water supply and control on the one hand and the supply of commercial energy on the other or, failing that, the renewable use of locally available energy sources.

Last, future prospects for food security in the national context are linked to the recovery of food autonomy, since a large part of the agricultural food items and products in Bolivia comes from other countries and enters the country illegally. As long as these circumstances persist, it is pointless to invest intellectual and material efforts in the field of energy planning to ensure food and nutrition security.

3. National Status of Agricultural Research

3.1 Institutional Adjustments, Scientific Research in favor of Food and Nutrition Security, Universities

In the academic field, in 2013, the Vice Ministry of Science and Technology of the Ministry of Education presented the National Plan for Science, Technology and Innovation (PNCTI). In Bolivia, science, technology and innovation are produced by several types of providers: NGO, consultancies, government projects and programs, and public and private research institutions. Accordingly, the PNCTI was developed in a participatory process with significant participation by academia, including public and private universities and research centers, the central government and the productive sector.

The main normative framework for drawing up the PNCTI was based on the following documents: the New Political Constitution of the State, Article 103 of which guarantees the state's commitment to the development of science and scientific, technical and technological research for the benefit of the general interest, allocating the necessary resources and creating the State System of Science and Technology; the Patriotic Agenda to 2025. This Agenda establishes 13 pillars of development, Pillar 4 being Scientific and Technological Sovereignty with Its Own Identity and Pillar 8 being Food Sovereignty Through the Construction of Knowing How to Eat to Live Well; the Institutional Strategic Plan (ISP) of the Ministry of Rural Development and Lands, which establishes in its political mandate the formulation, execution and evaluation of policies related to the country's food security and sovereignty, as well as food safety; and the Avellino Siñani-Elizardo Pérez Law, which establishes, among the aims of education, the promotion of scientific and technological research associated with innovation and knowledge production as the guiding principle for alleviating poverty, social exclusion and environmental degradation, in keeping with the Law of the Productive and Community Revolution, which establishes, "Systems of research, technological innovation and timely information".

The impact achieved by PNCTI in the agricultural sector has been to emphasize the improvement of the scientific infrastructure and basic technology, with researchers and research centers or institutes in the public universities of the country's nine departments. Nevertheless, it is still illusory to think that this good intention has already been fully achieved in all possible institutional spheres. This potential is designed to be extended to several private universities and the National Institute of Agricultural and Forestry Innovation (INIAF), although it has not been fully operationally developed either. In this respect, the national axis (La Paz, Cochabamba and Santa Cruz) has more research centers and a more diversified potential, even though it fails to meet the demand of the sector's small producers. One high-level objective is to contribute food security

to food sovereignty by creating Technology and Innovation Centers to improve the productivity and competitiveness of the sector. To date, this is nothing more than a good intention that has failed to be achieved at the National level, much less in regions remote from major capital cities.

Although this Plan is designed to achieve the objectives set in government policies, in relation to security and food sovereignty, the Executive Committee of the Bolivian University (CEUB), in its capacity as Programming, Coordination and Execution Organization, has drawn up its own National University Science, Technology and Innovation Strategy. This strategy places greater importance on the issue than the government does, precisely as a result of the comparative advantages of being able to bring together the best trained professional technicians in the national context, whose level contrasts sharply with that of state institution employees.

This is the case of the University of San Simón (UMSS), for example, whose broad range of academic subjects establishes thematic priorities within key socioeconomic objectives for society, such as food security and sovereignty. These priorities determine the orientation of the allocation of national economic resources and those obtained from international cooperation, assigned to scientific research projects, on the basis of highly competitive schemes.

Although funding for science and technology activities remains an unresolved problem in the country, the objectives are geared toward greater linkage with the sector that requires knowledge. This is reflected in the efforts made to create information and publication networks available at the national and inter-institutional level (Constituent Assembly, 2008, Legislative Assembly, 2010, Executive Committee of Bolivian Universities, 2011, National University Strategy for Science, Technology and Innovation, 2011, DICyT, University of San Simón, 2011, Ministry of Rural Development and Lands, 2010, Ministry of Communication, 2016, Vice Ministry of Science and Technology, 2013). These networks, in addition to providing spaces for meetings, information exchange and greater coordination, provide up-to-date information that makes it easier to obtain clearer views on the global context of a particular situation, such as the status of food security nationwide.

4. Agricultural production, improvement and state of development

4.1 Agricultural Production, Plant Breeding and Their Contribution to Food Security

Food-security policies in Bolivia have historically prioritized a system aimed at autarky or self-sufficiency in the production of the main foodstuffs consumed in the country, taking advantage of the large number of existing thermal floors due to altitudinal differences and its proximity to the Tropic of Capricorn. This means that in the South and Center of the country, especially in the Andean zone, the seasons have different temperatures and hours of light, which, although not very noticeable, are sufficient to allow the cultivation of certain species originating in the Mediterranean and the Middle-Eastern zone, despite the fact that the whole country is located within the world's tropical belt. Bolivia's low population density makes it possible to produce a large proportion of the food consumed, although most of the national surface comprises soils with a limited agricultural vocation.

The North and the eastern region of the whole country is characterized by flat land, with some low hills, covering two thirds of the area; rainfall in the North and the sub-Andean zone is high, decreasing towards the South until it creates a semi-desert zone. This broad plain with a tropical climate contains the following agricultural regions:

1. **Fertile Plain of Santa Cruz.** Covers a flat region with deep, fertile soils produced by the alluvial deposit of the Rio Grande, and constitutes the country's main agricultural region, with the largest amount of capital invested in services for a modern agriculture based on the use of certified seeds. It has the highest concentration of the agri-food industry.

2. **Upper Amazon Region.** Located throughout the Department of Pando, in certain provinces in the North of the Departments of La Paz, Beni, and the NE of Cochabamba, it had natural forests which, since deforestation, have become acidified and are now rarely used for agriculture.
3. **Chiquitanía Region.** Located in the North and East of the Department of Santa Cruz, it has low mountains and acid soils. The main activity in the area is livestock raising. After deforestation, perennial grasses are planted, often associated with crops.
4. **Beni Savannah Region.** Located in the Department of Beni, this is a meadow that is partly flooded some months of the year, with wooded strips or spots, and acid soils. Cattle breeding is the most important economic activity in this part of the country.
5. **Chaco Region.** Extends to the SE of the country, in the Departments of Tarija, Santa Cruz and Chuquisaca. The agricultural zone includes a narrow strip attached to the Andean mountain range. The remainder has a regime of scant rainfall, concentrated in a few months, forming low, thorny canopy forests. In this zone, livestock production is based on browsing.
6. **Andean Region**. Encompasses the South and Center-West of the country with three ecoregions: A) The Altiplano, an undulating plain between 3,400 and 3,700 masl, between the Western and Eastern or Royal Mountain Ranges. Rainfall is greater in the North and scarce in the South. High-Andean species and introduced cold-tolerant species are grown. The low temperatures, water shortage and salinity of the soils in the southern zone limit agriculture in this region; B) Region of the Temperate Valleys. These open and closed valleys have been formed in the Eastern Cordillera, at an altitude of between 1,500 and 2,900 meters, with a temperate climate. This region produces most of the vegetables consumed in the country and temperate fruit trees; C) The Yungas Region is located on the eastern slope of the Andes in the Departments of La Paz and Cochabamba. Food species are grown on some of the gentler slopes, particularly in the Department of La Paz.

In October 2014, the IBCE manager stated, on the basis of data from INE, that Bolivia produces a food surplus, adding that Bolivia's main food import is wheat and flour. "We are a country which, in its food balance with the world, produces an obvious surplus thanks to the export of soybean, sunflower, sugar, chia, quinoa, beans, milk, among other products, so that after the additions and subtractions, we are a country that exports far more than it imports," he said.

According to INE data, food imports from January to August 2014 stood at $477 million USD, while exports generated $729 million USD, yielding a positive trade balance of $252 million USD. The foreign-trade expert noted that although the country imports some vegetables and fruits, this is mainly due to seasonality issues. He pointed out that no country produces all its food or is able to do so without imports.

4.2. Relation between the human population and agricultural production, analysis of the population in a state of malnutrition

According to INE, in 2012 the Bolivian population was 10,351,181 and by 2020, the population is expected to grow to 11,633,371. Based on the latest censuses, the population growth rate is decreasing considerably, although it remains the highest among countries in the region. On the other hand, statistics published by INE show significant productive increases in recent years. **Table 2** shows the percentages of the differences between the average production in agricultural years 1999/2000, 2000/2001 and 2001/2002 in relation to the average of the years 2010/2011, 2011/2012 and 2012/2013. According to the WFP, Bolivia has a chronic malnutrition rate of approximately 25%, which is above the region's average, whereas according to the FAO, it is 15%. According to government sources, chronic malnutrition affects less than 10% of the population.

The statistics also mask another worrying aspect, because the production increase is largely due to the expansion of the agricultural frontier

with significant deforestation, rather than to increases in productivity or yields-per-unit area. This situation is obviously not sustainable in the long term. A specific crop analysis during the same period, presented in **Table 2**, shows that in the case of cereals and pseudocereals, the increase in productivity per hectare as a result of the use of improved varieties and better technological management was extremely uneven: rice yield increased by 42%; wheat by 34.1%; sorghum by 7.5% and maize by 4.4%, whereas quinoa productivity decreased by 12.9%. Potato, cassava and banana, a significant source of carbohydrates in the country, recorded a decrease in yield of between 11.3 and 11.5%. Fruit trees - such as bananas and grapes - boosted their productivity by 37.3% and 22.4%, respectively, due to the use of improved varieties and better crop technology. Peach and pineapple crops also increased their productivity by 6 to 7%, whereas other crops saw a decline in yields due to diseases and pests and the use of obsolete production technologies. As for vegetables, onion showed a significant increase in productivity (62.4%); bean and garlic yields increased by between 6% and 7%, respectively whereas the other vegetables decreased their harvests per unit area.

Table 2. Percentage increases in most important foods produced in recent years

Cereals and pseudocereals	
Rice	68.0
Wheat	87.2
Maize	75.6
Quinoa	116.7
Sorghum	242.2
Fruit	
Plantain	45.4
Peach	18.8
Tangerines	12.5
Orange	61.2
Pineapple	0.8
Banana	-17.3
Grape	28.6
Tubers and Roots	
Potato	33.2
Yucca	-2.9
Industrial	
Sugar cane	66.1
Sunflower	44.6
Soybean	101.5
Vegetables	
Garlic	51.2
Peas	-9.2
Onion	132.2
Beans	183.3
Broad beans	17.1
Tomato	-50.4

Source: Drawn up by the author based on data from INE

The use of certified seed and seedlings varies according to the different areas of the country and by crop. Generally speaking, they are widely used in areas with entrepreneurial or medium-sized farmers, yet scarcely used in areas with subsistence farmers or not at all. Farmers who grow export crops use up-to-date technology, except in the case of quinoa, whose production is based on organic agriculture, which has so far proved unsustainable, due to the limited production of manure and the low amount of biomass produced for processing compost. Public research centers have a greater impact on areas with good or medium agricultural development, whereas achievements in highly populated areas such as the Andean zone and tropical areas with little agricultural development are extremely scarce. Private investments by certain foundations, such as the Patiño Foundation, Fundación PROIMPA and Fundación Valles, contribute with research work to the development of small Andean farmers' agriculture, especially in irrigated valley areas.

4.3 Other considerations that enhance the efficiency of food systems

4.3.1 Prospects and technologies based on increased agricultural production

In order to develop technologies that promote the increase of agricultural production, it is essential

to establish policies, programs and institutions that implement technological innovation strategies. In 2008, the government of Bolivia formed the National Institute of Agricultural and Forestry Innovation (INIAF) to oversee the country's agricultural innovation, in order to create technology to increase productivity in the agricultural sector. However, statistics show that during the 2008-2013 period, agricultural production remained practically constant (http://www.ine.gob.bo). The gradual reduction of external and internal financing for research and technology dissemination entities could partly explain the decline in the generation and diffusion of technological innovations (Blajos et al., 2015).

4.3.2 Infrastructure needs

Since mid-2015, Bolivia has experienced extremely variable weather conditions, particularly irregular rainfall regimes. This situation has a direct impact on agricultural production and highlights the lack of productive infrastructure, especially for irrigation. It is essential for the country to design a national irrigation program that not only involves building infrastructure, but is also accompanied by programs to disseminate technology and training in irrigation- system management. Another shortcoming regarding infrastructure is linked to the collection and storage of production. Current infrastructure storage conditions do not make it possible to preserve the seasonal production of diverse crops, which creates inefficiencies that translate into major price fluctuations and postharvest losses.

4.3.3 Postharvest limitations

The inadequacy and precariousness of the systems for the storage and conservation of the main agricultural products in the country are compounded by the increase in postharvest attacks by certain pests and diseases apparently favored by the effects of climate change. At the national level, there are no programs designed to create technological innovations aimed at controlling attacks by pests and diseases, which in turn makes agricultural activity more complicated and inefficient.

4.3.4 Access to food and distribution

The high rates of chronic malnutrition (25% to 27%) and obesity (4 of 10 adults, 3 of 10 students ages 13 to 17, 8 of 100 children under 5) registered in the country reflect the inequitable distribution of food (WFP, 2017). World events in which Bolivia actively participated, such as the International Potato Year (2008) and the International Year of Quinoa (2013) - which, among other things, encouraged the consumption of healthy food - have not had an effect on food quality, particularly by the most vulnerable groups. In addition to its historic dependence on wheat imports, in the past decade, the country has increased its consumption of food from abroad. Several imported products are essential components of the family basket.

4.4 The Livestock Situation in Bolivia and Its Contribution to Food Security

Livestock farms in Bolivia constitute an essential resource for the food security of peasant families who subsist in various ecological environmental conditions, from the Andean highlands, temperate valleys, semi-steppe or humid subtropical territories to the alluvial plains of the Amazonian tropics, adapting and surviving in extreme and variable climates.

Domestic livestock are distributed throughout the country and could be divided into two groups of animals on the basis of their origin: species that originated as a result of the animals introduced by the European conquistadors during the early decades of American colonization (bovines, sheep, goats, swine, equines and poultry) and Native American ones domesticated since the Inca empire period (camelids). Since the last three decades of the 20th century, introduced bovine populations have seen a drastic decline in their populations due to replacement or absorbent crosses with highly selected European and Indian races. However, there are still pure populations of this valuable animal's genetic resource of mixed European and African origin, from Criollo cattle (Gutiérrez & Pereira, 2015) that contribute to food security under extreme climatic conditions.

Table 3. Bolivia: Number of heads of cattle per specialty, by province, Agricultural Census 2013

Province	Cattle population	Specialty		
		Milk	Meat	Oxen
Bolivia	8,315,504	1,129,323	7,020,318	165,863
Chuquisaca	460,682	24,837	400,008	35,837
La Paz	501,753	162,990	332,333	6,430
Cochabamba	371,959	86,995	240,658	44,306
Oruro	79,950	36,548	42,684	718
Potosí	156,870	5,144	116,910	34,816
Tarija	393,650	33,294	339,531	20,825
Santa Cruz	3,598,955	661,258	2,930,688	7,009
Beni	2,631,013	113,074	2,502,840	15,099
Pando	120,672	5,183	114,666	823

Source: National Institute of Statistics (INE, 2015)

Bolivia's cattle-raising systems are largely associated with the subsistence economies of peasant families, with animal resources being grouped together to guarantee sustenance. In valleys and the Altiplano, dairy systems are usually part of the family economy and, very exceptionally, belong to companies or industries. However, both beef and dairy cattle production are found mainly in the Departments of Santa Cruz and Beni, which account for 80% of the country's red meat supply. General data citing the bovine population as the main contributor to food security, can be seen in **Tables 3 and 4** (the latter includes all other domestic animal species).

The main livestock production systems in the Beni are extensive, with cattle being raised in natural grasslands (86%). Zootechnical indexes in farms of this type are low, associated with the two season cycles marked by rainy periods (November-April) and drought (May-October). The climate phenomena known as El Niño and La Niña jeopardize the food security of peasant families, because they threaten the existence of Beni livestock. Livestock losses as a result of certain adverse weather factors, such as floods, can be seen in **Table 5**.

The food security of peasant families is linked to strategies for the conservation of animal genetic resources, which must be included in State Policies to support research on the phenotypic and genotypic characterization of individuals and permit the handling of genetic variation and its protection as world heritage.

5. National Risk Management and Monitoring Strategies to Protect Food Security

5.1. National Early Disaster Warning System (Meteorological and Hydrological Networks)

Due to its diversity of ecosystems and extreme variation of altitudinal, climatic and topographic scenarios, Bolivia has always been susceptible to various modifications and atmospheric alterations that transform the country's soil-climate conditions, therefore its productive conditions. In the past two decades, the recurrence of atmospheric anomalies caused by climate change has hit many parts of the country, generating significant losses in agricultural production, mainly in the sectors of small producers and subsistence farmers, who constitute the most vulnerable rural sector in Bolivian society.

Table 4. Bolivia: Cattle and poultry population, by species, Agricultural Censuses 1950, 1984 and 2013

Species	1950	1984 (1)	2013
Cattle (2)	2,226,629	3,886,463	8,315,504
Sheep	7,223,592	3,156,329	6,267,743
Pork	508,782	571,101	1,415,274
Goats	1,228,856	1,269,003	1,868,512
Camelid (3)	1,178,724	599,864	2,506,435
Horse (4)	622,578	407,426	665,683
Poultry(5)	1,760,191	4,773,635	42,260,347

Sources: National Institute of Statistics (INE, 2015) (1) In the 1984 Census of Agriculture, data from the department of La Paz only comprise the provinces of Franz Tamayo and Abel Iturralde. (2) Includes oxen. (3) Only considers llama and alpaca. (4) Includes horses, donkeys and mules. (5) Includes chickens, ducks and turkeys.

Table 5. Estimated flood losses, subsector cattle of the Province of Beni Bolivia, March 2014

Estimated losses	Number of animals	Amount in USD
Deaths of cattle	289,355	66,435,908
Deaths of horses	3,506	701,200
Deaths of minor species	6,394	319,700
Damage to livestock infrastructure	--	39,964,290
Indirect factors *	--	76,786,370
Animal Rescue Costs	--	37,859,476
Total losses in USD		222,066,944

Source: (FEGABENI, 2014) *Diseases, reduction of animal health indices.

In response to this situation of recurrent crisis, and in order to use preventive actions to mitigate situations that threaten the population's food security, the Bolivian Government, in close coordination with international cooperation, has prioritized the implementation of a National Early Disaster Warning System (NEDWS), involving entities at the Central level of the state, departmental and municipal Risk Management Units (RMU), and technical and scientific bodies that interact in a coordinated way, through standard processes and protocols, to issue warnings with information collected in real time, satellite images and scientific prediction models to manage disaster risk. These mechanisms allow the authorities of the Central, Departmental and Municipal governments to launch preventive and mitigation actions against adverse meteorological, hydrological and other phenomena that affect populations, their livelihoods and agricultural production, which in the long run determine citizens' food security, health and well-being.

NEDWS is a set of procedures and instruments used to monitor a predictable threat or adverse event (abiotic or anthropic), through data collection and processing to generate forecasts or temporary predictions of possible effects. The system's effectiveness is based on the knowledge and prior determination of the existence of various types of risks by ecosystem, the active participation of communities, constant and updated preparation, and an institutional commitment that involves education as an essential factor for raising citizens' awareness and the efficient issuing of warnings. NEDWS

systematically carries out eight steps to reduce both human and economic losses and to protect the livelihoods of those affected (**Figure 2**).

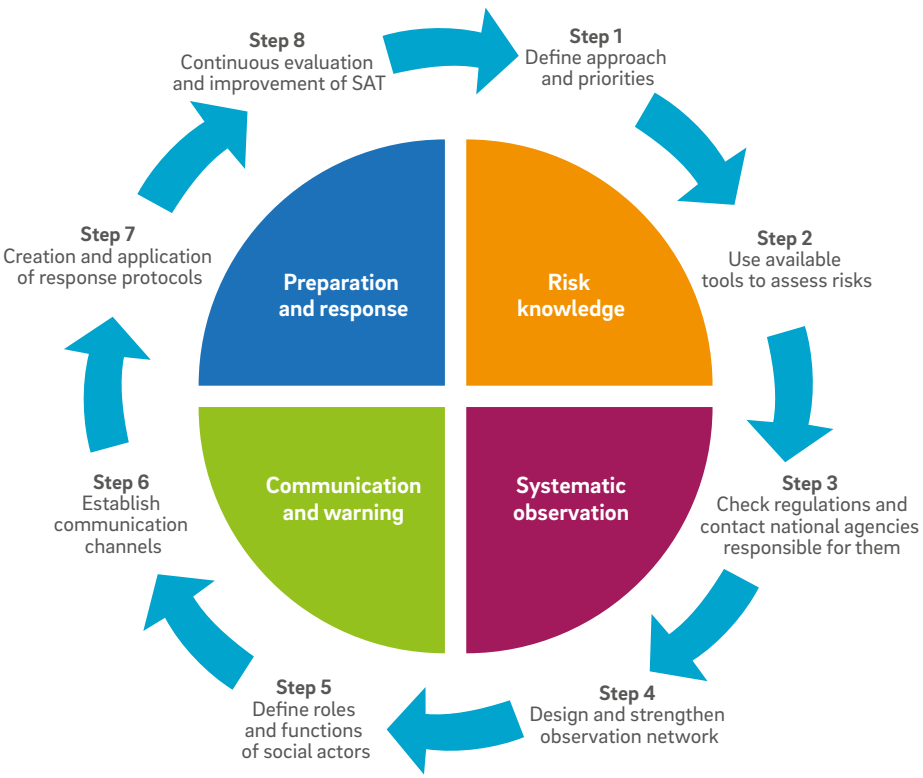
5.2 SNAT Applications to Protect Agricultural Productivity and Food Security in Bolivia

In Bolivia, NEDWS has been recognized since the passage of Law 602 of Risk Management (2014), as part of the SINAGER-SAT Integrated System of Information and Warnings for Disaster Risk Management, a system for the surveillance and monitoring of probable threats to existing vulnerability conditions prior to the occurrence of disasters or emergencies. It provides information on the risk level or scenario, to activate rapidly transmitted prevention and preparation protocols. It also coordinates warning systems for autonomous territorial entities and the monitoring and surveillance systems of scientific technical institutions.

The Viceministry of Civil Defense (VIDECI) is responsible for periodically strengthening NEDWS in conjunction with the various ministries, technical and scientific institutions and RMU, for the analysis of information on threats, vulnerabilities and risk levels or scenarios, surveillance, observation and warning, responsiveness and risk parameters, in order to optimize decision making. Significant technological progress has been made through the generation of available meteorological and hydrological models and the "Dewetra" platform, shared by the National Service of Meteorology and Hydrology (SENAMHI), the Ministries of Environment and Water and the MDRyT and VIDECI, which generates risk scenarios and issues daily Risk Alert bulletins.

Stepped territorialized warning monitoring models are currently being implemented in the country's five main macrowatersheds and rivers, in which monitoring points have been implemented with equipment at hydrometeorological stations, trained personnel from the municipal RMU and the permanent, active involvement of several dozen indigenous communities, who live near the rivers in these basins.

Figure 2. SNAT ideal: elements and steps to follow



5.3 National Observatory on the Country's Food and Nutrition Status

The Agricultural Community Productive Revolution Law (2011) provides for the implementation of an Agro-Environmental and Productive Observatory (APO), a technical entity that monitors, analyzes, generates and disseminates specialized information on the agricultural sector and rural development, to enable the state to make decisions that will guarantee food security and sovereignty and promote the country's sustainable rural development. APO's institutional structure considers the following technical areas:

Price Information System and Internal and External Agricultural Trade

This is a technical management tool for the development of information on food products and their prices, in national and international settings. At the international level, it monitors and analyzes the behavior of commodity prices on the global market.

Analysis and Applied Research for Food Security and Sovereignty

It monitors strategic crops and areas in agricultural production and management and the quality of productive resources, soil, water and national food reserves, in normal and emergency situations.

Systems, Technological Support and Geomatics

It evaluates the various data sources of the agricultural sector, database, texts, plans, and draws up the relational database schemas according to the type of information for public or private use. A Data Warehouse integrates the information generated by APO and the various information sources related to the agricultural sector.

Single Register of Sustainable Family Agriculture (RUNAF)

APO registers and classifies the productive actors organized in sustainable family agriculture and diversified into: Indigenous peasant, intercultural and Afro-Bolivian producer families; Peasant Economic Organizations, Indigenous Peoples and Community Economic Organizations. Those engaged in family agriculture who have registered are assigned a single Operational Register code.

6. Political considerations

6.1 Current Political Situation in Relation to Food and Nutrition Security

To achieve food security and sovereignty, in addition to the policies (DS No. 2167 of the "Food and Nutrition Policy" of 10/30/2014) and State actions (short-, medium- and long-term) urgently requires the participation of science, technology and education in proactive interaction, especially among universities, businesses, farmers, families and the public sector, which will help solve multiple problems of food production and security and provide more scientific, technical, economic and financial assistance. The most pressing need is to use education to combat and solve the problem of undernourishment and malnutrition, by guiding, teaching and encouraging the consumption of foods, for example, nutritious native foods such as quinoa, amaranth, cañawa, tarwi, maize, potatoes and others (fruits, tubers, legumes and vegetables), as well as the fish resources of the Amazon, the Plata and Lake Titicaca basins.

6.2. Current Political Situation Regarding Food Sovereignty

Bolivia has six production laws directly related to food sovereignty, according to the Plurinational Legislative Assembly (2014):

1. Law 071, Rights of Mother Earth, 2010: Its purpose is to recognize the rights of Mother Earth, the obligations and the duties of the multi-national State and society to ensure respect for these rights. Emphasizes the principles of collective welfare, non-commercialization and interculturality.
2. Law 098, Production, Industrialization and Marketing of Quinoa, 2011: Grants national priority to the production, industrialization and community marketing of quinoa, through the technification of

primary production with the respective protection of the areas of cultivation, improvement, conservation, irrigation, postharvest, processing, industrialization and commercialization, as a priority in local, national and overseas markets.

3. Law 144, Productive Community Agricultural Revolution, 2011: Standardizes a process of productive agricultural revolution for food sovereignty, establishing the institutional, political, technological and financial bases of the production, transformation and commercialization of agricultural and forestry products, in a pluralistic economy, prioritizing organic production.

Other related laws are:

4. Law 300, Framework of Mother Earth and Integral Development to Live Well, 2012: Establishes the foundations of integral development in harmony and balance with Mother Earth to live well, guaranteeing the regenerative capacity of components and life systems, and recovering ancestral knowledge in a complementary way to the rights, obligations, duties and objectives of integral development in order to live well.
5. Law 338, Peasant Economic Organizations, Indigenous Peoples and Community Economic Organizations for the Integration of Sustainable Family Agriculture and Food Sovereignty, 2013: Regulates sustainable family farming and diversified family activities carried out by peasant, native indigenous organizations and intercultural and Afro-Bolivian farming families to contribute to food sovereignty.
6. Law 453, Rights of Users and Consumers, 2013: Regulates the rights and guarantees of users and consumers at the national and sectoral level, without limiting the exclusive competence of the municipal level.

6.3 Current Policy and National Climate Change Regulations

Areas of work related to the fight against Climate Change were defined after the United Nations Summit on Environment and Development in Rio de Janeiro in 1992. Bolivia became involved and in April that same year, passed the Environmental Law as the fundamental axis of the policy and the environmental problems derived from disasters (climate change).

The People's Conference on Climate Change and Rights of Mother Earth was held in April 2010, and the Framework Law for Mother Earth and Integral Development for Living Well was passed in 2012. This law refers to the bases and guidelines of "Living well" through the integral development of climate change, and includes six sections, namely: 1) Establishing all types of policies for climate change mitigation and adaptation; 2) Building institutional and technical capacities for monitoring, modeling and forecasting to plan decision-making; 3) Promoting the recovery and application of ancestral knowledge for the development of measures to respond to the impacts of climate change; 4) Building prevention and risk management capacities to cope with climatic events, and 5) Greenhouse Gas Reduction Programs excluding financing mechanisms associated with carbon markets.

Supreme decrees have also been enacted to mitigate and address extreme climate events within the framework of Law 1333 of the Environment. The real problem is that these laws and decrees are a long way from being fulfilled by the population and the state that drafted them. The UN report published in January 2017 states that Bolivia is one of the countries with the least impact on climate change, since greenhouse gas emission is very low (0.03%), compared to other countries. However, it is one of the most vulnerable countries because it suffers this phenomenon most intensely, which increases the frequency and recurrence of extreme adverse events.

Climate change policies are no longer observed. They are weak and contradictory in relation to various economic-development plans that are not environmentally-friendly. Examples of this include the recent creation of a new decree that allows the unconstitutional expansion of the area of coca monocultures in more than 8,000 new hectares, and the plan to build several energy-generating dams to the detriment of ecosystems that are home to thousands of fauna

and flora species, including dozens of native indigenous communities, which will be forced to move without any consideration or planning.

7. Abstract and General Recommendations

Bolivia is a country that is immensely rich in natural resources, contains between 45 and 55% of the world's biological diversity, and is capable of producing food not only for its inhabitants, but for the whole of America. The growth of ecological awareness is a crucial element for achieving the survival of species and productive ecosystems in Bolivia, where hundreds of species interact in small spaces due to the country's biological complexity. Priority actions for achieving agricultural sustainability cannot separate productive aspects from considerations that promote respect for the other ecosystem resources involved in its fields and species. Some potential scenarios for better agricultural production for the following decades are based on scientific research to create capacities to achieve the optimal use of new forms of energy. The development of new land-management models and the rational use of resources would make it possible to focus on climate-change adaptation and mitigation strategies, to boost production and ensure that less of what is already produced is lost.

However, as in most countries in the region, Bolivia faces serious constraints, therefore enormous challenges in ensuring its own Food and Nutrition Security with Sovereignty.

Its main difficulties and general limitations are summarized as follows:

- Public policies and environmental norms that are theoretical and not applied to the current productive reality.
- Current national development model based on the industrialization of natural resources.
- Low levels of nutritional education and poor compliance with food safety standards.
- Inequitable and insufficient access to food.
- Lack of incentives and general support for scientific research on agriculture.

More attention should be focused on the integral development of the following aspects:

- Strict, sincere and respectful compliance with the laws and regulations that promote the care of "Mother Earth".
- Greater efficiency in Natural Resource use and management, especially regarding increasing awareness of water-resource management.
- Optimization of agroecological food processes.
- Increased efficiency and effort in the surveillance of food safety, supported by the dissemination, training and awareness of good food with sovereignty.
- Reduction of postharvest losses and waste.
- Better state policies to support universities and research centers to promote the updating, modernization and efficiency of scientific research, which contributes to improving the agricultural production processes without expanding the agricultural frontier.

References

Aguilar, J. C., J. Comboni, C. Romero & R. Erósteguí (2008). Bolivia: Integrated Economic Analysis. Country Economic Report 2008:6. SIDA, Secretariat for Development Issues.

Asamblea Constituyente (2008). Nueva Constitución Política del Estado. Vicepresidencia de la República de Bolivia. La Paz, Bolivia. 152 pp.

Asamblea Legislativa Plurinacional (2010). Ley No. 070 (Ley de la Educación "Avelino Siñani-Elizardo Pérez"). Gaceta Oficial de Bolivia, 20 diciembre, 2010. La Paz, Bolivia.

Asamblea Legislativa Plurinacional. Cámara de Senadores (2014). Compendio de Leyes Productivas afines a la Soberanía Alimentaria. FO. La Paz, Bolivia. 171 pp.

Benites, D.S. (1992). Degradación de suelos y producción agrícola en Argentina, Bolivia, Brasil, Chile y Paraguay. In FAO, Erosión de suelos en América Latina. Santiago de Chile: FAO.

Blajos, J.; Ojeda, N.; Gandarillas, E.; Gandarillas, A. (2014). Economía de la quinoa: Perspectivas y desafíos. Revista de Agricultura. No. 54.

Cabitza, M. (July 20, 2011). Will Bolivia make the breakthrough on food security and the environment? The Guardian. https://www.theguar¬dian.com/global-development/poverty-matters/2011/jun/20/bolivi-food-security-prices-agriculture

Castañón, B.E. (2013). Las dos caras de la moneda: agricultura y seguridad alimentaria en Bolivia. Fundación Tierra, La Paz. http://www.ftierra.org/index.php?option=com_mtree&task=att_download&link_id=32&cf_id=61

CEUB (2011). Estrategia Universitaria Nacional de Ciencia, Tecnología e Innovación (2012–2015). IV Conferencia Nacional Ordinaria de Universidades, La Paz, Bolivia, noviembre 2011. 90 pp.

DICyT UMSS (2011). Marco Conceptual. La investigación en la Universidad Mayor de San Simón 2012-2021. Vicerrectorado UMSS. Cochabamba, Bolivia. 26 pp.

Dirección General de Planificación (MDRyT) (2010). Plan Estratégico Institucional 2011-2015. Estado Plurinacional de Bolivia, Ministerio de Desarrollo Rural y Tierras. La Paz, Bolivia.

FAO (Organización de las Naciones Unidas para la Alimentación y la Agricultura) (2014). Estado de la Inseguridad Alimentaria en el Mundo. Rome, Italy.

FAO (Organización de las Naciones Unidas para la Alimentación y la Agricultura) (2015). Estado de la Inseguridad Alimentaria en el Mundo. Rome, Italy.

FEGABENI (2014). Estimación de pérdidas y daños económicos en el sector ganadero Beni Bolivia. Trinidad Beni: FEGABENI-AB CREA.

Fundación Milenio (2013). Informe de milenio sobre la economía, Gestión 2012, No. 34. Bolivia. http://www.fundacion-milenio.org/infor¬me-de-milenio-sobre-la-economia-gestion-2012-no-34/

Gallo, G.; A. Campos; F. Hartmann; A. Panduro; H. Romero & A. Trepp (1989). Energía y métodos de producción agropecuaria en Bolivia – 1ra. Parte: Altiplano y Valles, 2da. Parte: Valles Bajos y Llanos", Cap. I: Elementos del estudio. Ministerio de Planificación y Coordinación / Dirección de Ciencia y Tecnología MPC / DICYT-Bolivia, Instituto De Economía Energética IDEE-Argentina, United Nations University UNU-Tokyo.

GCP-FAO (2009). http://www.fao.org. [Online] Informe nacional sobre el estado de los recursos fitogenéticos para la agricultura y la alimentación. Available at: http://www.fao.org/docrep/013/i1500e/Bolivia.pdf Retrieved January 2017.

Gutiérrez, L. & Pereira, J.A. (2015). Caracterización genética de bovinos criollos de "Vallegrande" mediante marcadores autosómicos, mitocondriales y del cromosoma y en la Provincia Florida, Valle Grande Santa Cruz, Bolivia. Doctoral dissertation. Santa Cruz, Universidad Autónoma Gabriel René Moreno.

Ibisch, P. L., S. G. Beck, B. Gerkmann & A. Carretero (2003). 3. La diversidad biológica, pp. 47-88. In: Ibisch, P. L. & G. Mérida (Editores). Biodiversidad: La Riqueza de Bolivia. Fundación Amigos de la Naturaleza, Santa Cruz.

INE (Instituto Nacional de Estadística Bolivia) (2015). Censo Agropecuario 2013 Bolivia. Available at: http://www.ine.gob.bo/pdf/cna_BOLIVIA_final.pdf Retrieved January 2017.

INE.gob.bo. Available at: http://www.ine.gob.bo

INE (Instituto Nacional de Estadistica) (2017). Available at. http://www.ine.gob.bo/

Jemio, L. C. (2015). Producción, superficie sembrada y rendimientos del sector agrícola (2005-2013). Publicación Digital, Blog Desarro¬llo Sobre la Mesa. Published February 18, 2015. Fundación INESAD, Bolivia. http://inesad.edu.bo/dslm/2015/02/produccion-superfi¬cie-sembrada-y-rendimientos-del-sector-agricola-2005-2013/

Killeen, T. J., T. Siles, L. Soria & L. Correa (2005). Estratificación de vegetación y cambio de uso de suelo en los Yungas y Alto Beni de La Paz. Ecología en Bolivia 40(3):32-69.

Killeen, T. J., A. Guerra, M. Calzada, L. Correa, V. Calderón, L. Soria, B. Quezada & M. K. Steininger (2008). Total historical land-use change in Eastern Bolivia: who, where, when, and how much? Ecology and Society 13(1): 1-36. [Online] URL: http://www.ecologyandsociety.org/vol13/iss1/art36/

Malloy, M. (2016). Estado de situación: Bolivia, seguridad alimentaria y economía agrícola. Fundación Alternativas, La Paz.

Moraes R. M. & S. Beck (1992). Diversidad florística de Bolivia. pp. 73 111. M. Marconi (Editor). Conservación de la Diversidad Biológica en Bolivia. CDC Bolivia/ USAID Bolivia, La Paz.

Naciones Unidas en Bolivia (2017). PMA – Programa Mundial de Alimentos. Available at: http://www.nu.org.bo/agencia/programa-mundial-de-alimentos-pma/

Navarro, G. (2002). Conceptos generales y bases metodológicas. pp. 2-49. En: Navarro, G. & M. Maldonado (Editores). Geografía Ecológica de Bolivia - Vegetación y Ambientes Acuáticos. Fundación Simón I. Patiño, Cochabamba.

Navarro, G. S. & W. Ferreira (2007). Leyenda explicativa de las unidades del mapa de vegetación de Bolivia a escala 1:250 000. Rumbol, srl., Cochabamba. 65 pp.

Ormachea, S. E. (2009). Soberanía y seguridad alimentaria en Bolivia: políticas y estado de situación. La Paz, CEDLA. 100 pp.

Prudencio, J. (2014). ¿Renunciar a la seguridad y soberanía alimentaria por comercializar más? Análisis del "Plan del Sector. Desarrollo Agropecuario 2014-2018. Hacia el 2025".

Prudencio, J. (2015). Bolivia: un nuevo modelo de desarrollo agroalimentario basado en las exportaciones agrícolas. http://web.research-4dev.com/images/pdfs/LIBROS/12.pdf

PNUD (Programa de las Naciones Unidas para el Desarrollo) (2008). Informe temático sobre desarrollo humano "La otra frontera": Usos alternativos de los recursos naturales en Bolivia. La Paz.

Tejada, E. (2011). Experiencias exitosas de Gestión de Riesgos de Desastres en el Sector Agropecuario para la Adaptación al Cambio Climático. Organización de Naciones Unidas Para la Agricultura y la Alimentación (FAO), Cooperación Italiana en Bolivia. 160 pp.

Trepp del Carpio, A. (2017). "Variables e hipótesis. Cómputo energético y análisis de los resultados". Capítulo 3 En: Organizatividad y complejidad – La extensión de la termodinámica clásica y de los principios clásicos de la ciencia. Academia Nacional de Ciencias de Bolivia.

Trepp del Carpio, A. (2017). "La ampliación de la ciencia y termodinámica clásicas". Capítulo 4. En: Organizatividad y complejidad – La extensión de la termodinámica clásica y de los principios clásicos de la ciencia. Academia Nacional de Ciencias de Bolivia.

Urioste, M. (2011). Concentración y extranjerización de la tierra en Bolivia. Fundación Tierra, Bolivia. http://www.bivica.org/upload/con¬centracion-tierra.pdf

Urioste, M. (2012). Concentration and "foreignisation" of land in Bolivia. Canadian Journal of Development Studies 33(4):439-457.

Viceministerio de Ciencia y Tecnología (2013). Plan Nacional de Ciencia Tecnología e Innovación del Estado Plurinacional de Bolivia- Sector Desarrollo Agropecuario. Ministerio de Educación. La Paz, Bolivia. 128 pp.

http://bolivianing.com/bolivia

http://labiodiversidadenbolivia.blogspot.com/2015/07

http://www.bolivianland.net/.

http://www.paginasiete.bo/economia/2015/8/2/bolivia-tiene-276-millones-hectareas-cultivables-65194.html 02/08/2015

http://www.ine.gob.bo/pdf/boletin/NP_2015_69.pdf 01 08 2015

http://www.elpaisonline.com/index.php/blogs 18/01/2017).

www.ine.gob.bo/pdf/boletin/NP-2015-64-pdf

www.fao.org/bolivia/fao-en-bolivia/bolivia

http://www.eldeber.com.bo/el-63-de-los-bolivianos-tiene-mala-alimentacion/130406221748. Roxana Escobar, El Deber, August 7, 2013.

www.opinion.com.bo/articulos/2011/0813/noticias

www.cepal.org/es