UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Sustainable Cuba

Sectoral Strategy

FOR TECHNOLOGICAL AND ENTERPRISE UPGRADING OF FERTILIZERS AND AGRICULTURAL MACHINERY

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INCLUSIVE AND SUSTAINABLE INDUSTRIAL DEVELOPMENT

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Sustainable Cuba

April 2017

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Executive Summary

UNIDO is supporting Cuba's efforts in investment and strategic-alliance promotion to strengthen its industrial capabilities and competitiveness in priority industrial sectors. As agreed with the Cuban authorities, the aims to be achieved are improvements to the business environment, industrial competitiveness, the attraction of foreign investment and sustainability. The project is closely in line with the internationally recognized Sustainable Development Goals (SDGs). In particular, SDG 2, which aims at achieving food security, improving nutrition and promoting sustainable agriculture, as well as SDG 9, which promotes building resilient infrastructure, inclusive and sustainable industrialization and innovation, are enhanced by the project.

The project **Technological and Enterprise Upgrading Programme on Agrochemicals and the Agricultural Machinery Production Sector (Industrial Upgrading and Modernization in Cuba)** was developed at the request of the Ministry of Industry of Cuba and financially supported by a voluntary contribution from the Russian Federation, through the UNIDO Industrial Development Fund.

A major reason for supporting the project arises from the difficulties experienced by the agriculture and agricultural machinery sectors in Cuba in satisfying the local demand for staple foods. The booming tourism industry adds additional pressure to this shortage and local farmers are not fully able to supply the high-quality food requested by international tourists. To overcome this shortfall in the food supply, Cuba is importing many agricultural products, which has created additional demand for trade and foreign exchanges and added to Cuba's dependency on them.

The project on Industrial Upgrading and Modernization in Cuba (Cuba IUMP) therefore aims to help solve numerous interlinked issues. Through the industrial upgrading and modernization of fertilizer and agricultural machinery sectors project in Cuba, the local supply of high-quality food will be strengthened. The direct beneficiaries of this project, namely farms, enterprises and cooperatives, are better equipped and, thus, able to use their capacities more efficiently. The local population and tourists benefit indirectly from the project through high-quality food, which will be produced in Cuba and therefore, be locally embedded. Moreover, it contributes to better nutrition and balanced diet. On the macroeconomic level, the project helps to decrease dependency on imports by strengthening agriculture and industry, thus reducing a negative balance of trade.

Summarizing the above, the main goal of the project is to compare and match the food demand from the different stakeholders with the required inputs from industrial sources (for example, fertilizers and agricultural machinery). This enables the necessary conclusions to be drawn, in order to provide suggestions to make a significant improvement in the situation by using a system of defined priorities. It also contributes to capacity building, allowing Cuba to apply the same methodology elsewhere.

The present sectoral analysis is a major milestone in achieving the project goals because it enables the identification of the improvement levers. The study initially concentrates on fertilizers and their related industries. The needs of these industries with regard to the application of fertilizers on the land, including the preparatory steps, have to be considered when identifying and analysing the associated challenges facing the agro-machinery industry. Finally, the challenges and opportunities for the agro-machinery industry are identified.

Based on the analysis of crop production and imports while considering existing strategic cooperation, this sectoral analysis of fertilizer and agro-machinery production has developed a specific niche strategy. This niche strategy considers the elements shown on the right:

- A timely implementation of a complete "fertilization system" based on liquid fertilizers, including its scientific basis and the installation of equipment and processes within the project budget;
- The application of Cuban know-how enhanced by international best practice;
- The replacement of current imports;
- The compliance with urgent market demands and with the associated and most recent intentions/decisions of the relevant Cuban authorities;
- The pragmatic development of two production units, and the complete fertilization processes including the distribution and application of the fertilizers.

Based on an overall analysis of prioritized and important crops, the present sectoral analysis suggests a fertilization system, which consists of liquid fertilizers with soluble bases, for example, calcium and magnesium, and, additionally, substitutes for Bayfolan. The fertilization system complies with the specific needs of Cuba and is not in conflict with the strategic cooperation measures currently being negotiated with the fertilizer and the agro-machinery industry. The sectoral analysis specifies the fertilizers identified, together with their specific capacity requirements for the selected crops. The results of the sectoral analysis will be used within the framework of the final study to design the required plant capacities. This will then determine the necessary feasibility, engineering works, and procurement activities.

The present sectoral analysis has led to the research and selection of an appropriate strategy, and, therefore, the inception phase of the project is complete.

Chapter 1

Overview of the Supporting Project

The overall objective of the project "UNIDO Technological and Enterprise Upgrading Programme Focused on Agrochemical and the Agriculture Machinery Production Sector" (Cuba Industrial Upgrading and Modernization Programme, Cuba IUMP) is to contribute to the inclusive and sustainable industrial development of Cuba, and to improve food security.

The overall objective of the project "UNIDO Technological and Enterprise Upgrading Programme Focused on Agrochemical and the Agriculture Machinery Production Sector" (Cuba Industrial Upgrading and Modernization Programme, Cuba IUMP) is to contribute to the inclusive and sustainable industrial development of Cuba, and to improve food security. This will be achieved through the upgrading and modernization of the industrial-fertilizer and agricultural-machinery sectors, which will enhance the industrial performance and competitiveness of pilot enterprises operating in these sectors within the existing industrial hubs. Local populations and tourists will both benefit from improvements in the quality and quantity of a more nutritious food supply.

The direct beneficiaries of the project are industrial enterprises, hubs and cooperatives of the fertilizer and agricultural-machinery industrial-sectors, as well as national technical expertise and enterprise-support institutions, ministries and other institutions. Indirect beneficiaries will include the final consumers – both local populations and tourists – who will have improved and sustainable access to high-quality products meeting their demand and requirements in the short-term. Moreover, the industrial and enterprise community of Cuba will benefit from established enterprise support services in the mid-term.

Figure 1: Cuba sostenible – The project cycle

Figures 2 and 3: The official UNIDO Country Programme launch ceremony in Havana

The project's main counterparts are the Ministry of Foreign Trade and Investment of the Republic of Cuba (MINCEX) and the Ministry of Industry of the Republic of Cuba (MINDUS). A project advisory group was established during the project's inception phase. Its members include representatives from the following institutions: the Cuban Ferrous Metallurgy and Machine-Building Enterprise Group (GESIME); the Centre for Engineering and Chemical Research (CIIQ), Development Specialist; the Cuban Chemical Industry Enterprise Group (GEIQ); the Cuban Ministry of Industry (MINDUS); the Development Centre for Agricultural Machinery (CEDEMA); and the Ministry of Foreign Trade and Investment (MINCEX).

The programme will be implemented via three main modules, as listed in Figure 4.

1. First, based on a sectoral analysis, a strategic action plan for the Cuban priority fertilizers and agricultural machinery industrial product lines/subsectors will be built.
2. Second, enterprise diagnosis and industrial upgrading of selected pilot manufacturing enterprises operating within the identified priority subsectors/existing hubs will be conducted.
3. Third, the human and technical capacities of national counterpart institutions will be strengthened. As a result, expertise in the provision of enterprise diagnosis and industrial modernization, sectoral analysis, and other best practices will be achieved.

Figure 4: Main modules of the programme

1.1 Rationale for the supporting projet

In November 2014, the Cuban Minister of Foreign Trade and Foreign Investment, H.E. Rodrigo Malmierca, sent a request letter to UNIDO for the formulation of a Country Programme (CP) for Cuba 2015-2018. The letter was delivered personally to the director general by the Cuban Vice-Minister of Industries, H.E. Eloy Martinez, during the last ISID Forum organized by UNIDO in November 2014. From 2 to 6 February 2015, a Cuban delegation comprising seven high-level government officials visited UNIDO headquarters and several locations in Austria. The delegation requested that UNIDO develop technical assistance programmes that matched national priorities and priority sectors.

UNIDO is supporting Cuba's efforts in investment and strategic alliance promotion, aimed at strengthening its industrial capabilities and competitiveness in priority industrial sectors. This is being done through the formulation and implementation of a Country Programme Framework, in line with the economic and industrial transformations decided on by the government, and with the UNDAF signed for 2014-2018. The Country Programme Framework (CPF) focuses on three main outcomes, which have been agreed with the Cuban authorities:

a. improving the business environment and sustainability;
b. improving industrial competitiveness; and
c. attracting foreign investment.

The UNIDO Country Programme Framework for the period of 2016-2020 was signed by the UNIDO Director General, Mr. Li Yong and Cuba's Minister of Industry, Mr. Salvador Pardo Cruz, on 2 December 2015 in Vienna, Austria, at the 16th Session of the UNIDO General Conference.

One of the priority CPF areas, in accordance with the main outcomes agreed with the Cuban government is the development of an industrial upgrading and modernization programme (IUMP) focusing on priority agrochemicals and agricultural-machinery production sectors. The UNIDO Country Programme Mission to Cuba was held between 29 June and 3 July 2015, and included negotiations with key national stakeholders and several interested potential donors. During the mission, high-level officials from the Ministry of Foreign Trade and Investment, the Ministry of Industry (MINDUS), and representatives from the Cuban Ferrous Metallurgy and Machine-Building Business Group (GESIME), the Cuban Chemical Industry Business Group (GEIQ), and other interested stakeholders, endorsed the project concept of a technological and enterprise upgrading programme – referred to as the project in the rest of this document – focusing on the agrochemical and agricultural-machinery production sectors (Cuba IUMP).

This project, which is supported by the government of the Russian Federation, was officially launched at the International Industrial Exhibition and Congress, "Cuba Industria 2016", which took place at the Havana International Conference Centre and Exhibition Complex, "PABEXPO", from 20-24 June 2016.

On 30 September 2016, following the endorsement of the project document by the local governments of Camagüey and Holguin Provinces, and its final approval by the Ministry of Foreign Trade and Investment (MINCEX), the first project advisory group meeting was held at the United Nations Office in Havana. This set out a work plan for the implementation of the current strategic sector analysis for the project.

1.2 Structure of the Supporting Project

UNIDO is proposing technical assistance encompassing a comprehensive approach at macro (policy), meso (institutional) and micro (enterprise) levels, with an overall aim of allowing domestic manufacturers to produce and market innovative, cost effective, safe, reliable, and quality agricultural inputs, in sufficient volumes for the local market.

UNIDO's previous experience shows that in order to upgrade agro-value chains, production in some energy-intensive sectors - such as the fertilizer industry or metal works for agricultural machinery - requires a comprehensive analysis of the value chain. Doing this develops an understanding of the overall trends in industrial reorganization and identifies leverage points for policy and technical interventions.

Figure 5: The UNIDO industrial upgrading and modernization approach *(Source: UNIDO, Industrial Upgrading and Modernization Programme, 2013)*

Accordingly, the key feature of the proposed technical assistance is its three-step implementation, which is built up in a comprehensive manner and consists of the three modules specified below.

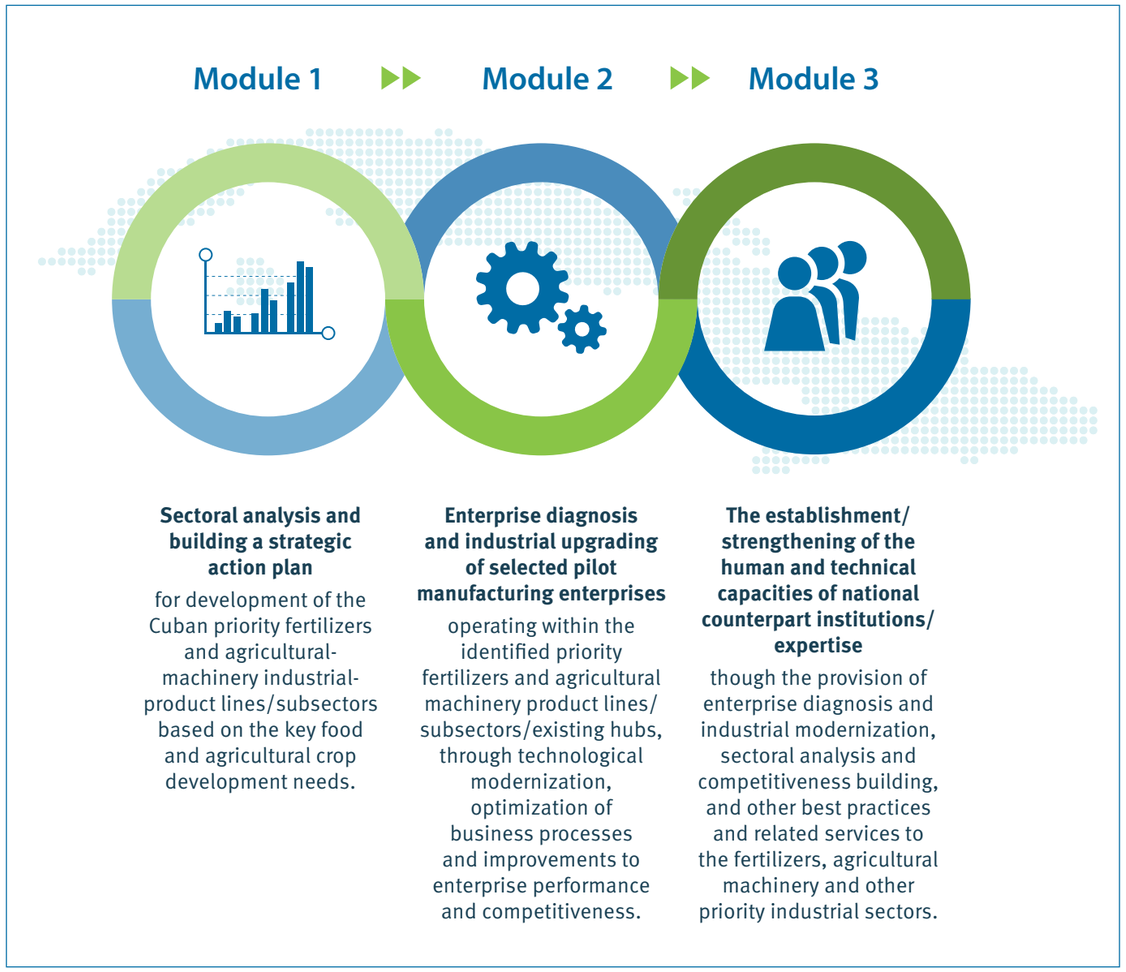


Figure 6: Three-step implementation of the proposed technical assistance project

Chapter 2

Introduction to the Sectorial Analysis

Approximately 80% of demand for food in Cuba is met by imports, which is striking in view of Cuba's abundant natural resources, including soil and water, and the availability of human and technological capital. Furthermore, increases in tourist numbers and expected growth provides some foreign currency, but this is not sufficient to fund the much needed modernization and rises in demand.

The industry of Cuba was at its economic peak in 1989, and ahead of the region in all social indicators. Following this, though, as a result of a drastic reduction in trade and frequent changes in domestic economic policies, GDP fell by 35% between 1989 and 1993. In 1999-2001, structural reforms towards the services sector were reflected in a growing proportion of services exports and noticeable progress in Cuban efforts to promote closer relationships with other Latin American and Caribbean countries. The country saw some progress in making structural reforms, such as those aimed at productive activity in non-state sectors. Notwithstanding, the state continued to play a predominant role in the economy and the private sector with 3,700 agricultural cooperatives and the 147,000 private farmers continued as a viable option, supported by the state.

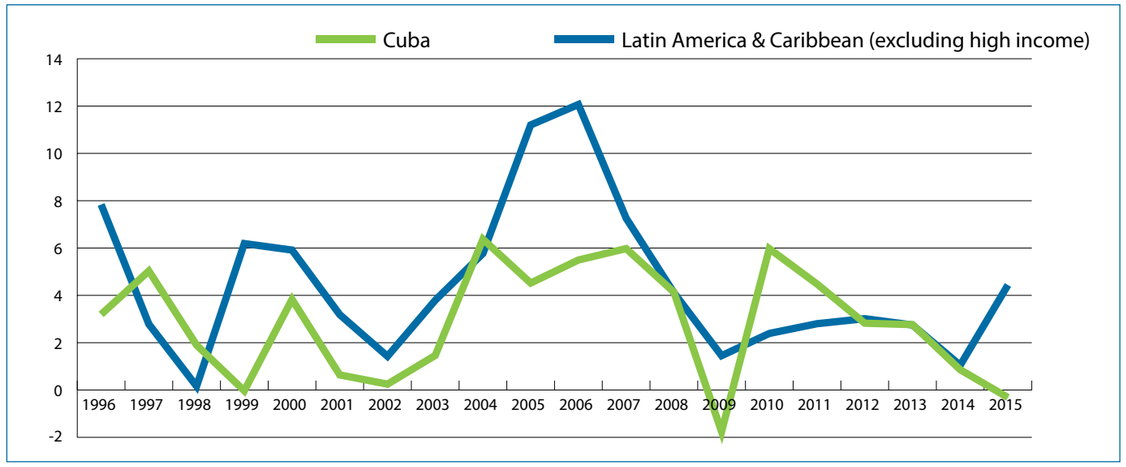


Figure 7: GDP growth in Cuba, Latin America and the Caribbean (annual %) *(Source: World Bank data (2015))*

In 2004-2007, GDP increased at an annual average of 9.2%, mainly due to trade with Venezuela, as well as economic aid and price subsidies. Improvements were also observed in social services during the same period.

Despite an improved socio-economic situation in the period mentioned above, the country was adversely affected by the global economic crisis of 2008-2009[1]. The rate of GDP growth decelerated, from 7.3% in 2007 to 4.1% in 2008, exports stagnated at 21% of GDP and the balance of trade turned negative: -2.9% of GDP in 2008. Trade in products and services was affected due to lower demand. Domestically, inefficient manufacturing operations, lack of sufficient financing to upgrade the manufacturing base and infrastructure issues were significant challenges.

Since 2011, a process of structural transformation has taken place, including reforms in economic and administrative organization. However, the structural reforms have not significantly improved the macroeconomic indicators, something that can be attributed to other factors influencing economic performance. As a result, despite partial recovery after the global crises, growth slowed to 2.7% in 2013, with an average of 2.5% in 2009-2013.

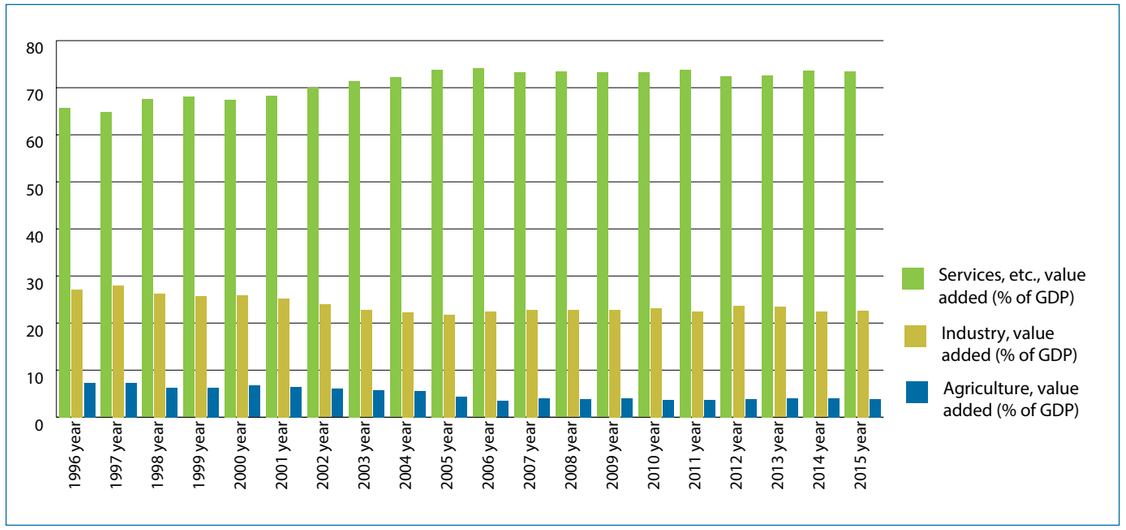


Figure 8: Value added by sector in Cuba as % of GDP (1996-2011) *(Source: World Bank data (2015))*

In 2010, agricultural output decreased by 5%, and it grew by 0.5% in 2012, resulting in it remaining stagnant as a percentage of GDP from 2007 to 2013. Agricultural value-added, as a percentage of GDP, continued to decrease, from 9.6% in 1996 to 4.9% in 2011. The contribution of industry value-added also diminished, from its value of 27.8% in 2000 to 20.5% in 2011. Contrary to other sectors, the contribution of the services sector has been steadily increasing: from 66% of GDP in 1996 to 74% in 2011.

The services sector is mainly dominated by the tourism industry and medical services. Cuba's tourism industry remains one of the major activities contributing to both GDP and employment generation. The relative importance of Travel & Tourism's total contribution to GDP in Cuba has constantly risen since 2010, as shown in Figure 9.

[1] Carmelo Mesa-Lago, Pavel Vidal-Alejandro, "The impact of the Global Crisis on Cuba's Economy and Social Welfare", J. LAt. Amer. Stud. 42, 689-717, Cambridge University Press, 2010.

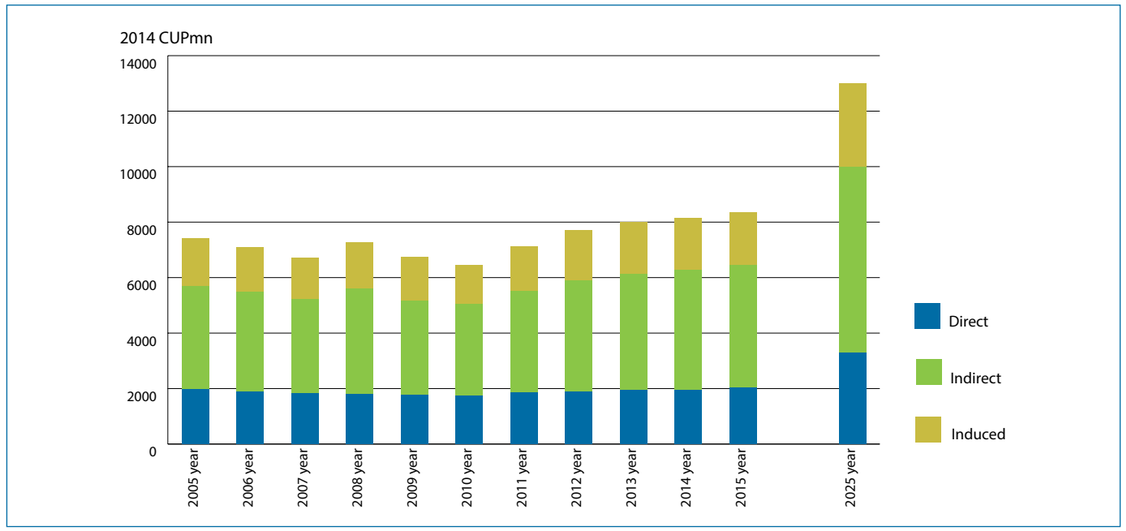


Figure 9: Total Contribution of Travel & Tourism to GDP *(Source: World Travel & Tourism Council (WTTC) (2015): Travel & Tourism Economic Impact 2015 Cuba: https://www.wttc.org/-/media/files/reports/economic%20impact%20research/countries%202015/cuba2015.pdf)*

In 2011, the tourism sector started growing constantly, and reached a direct contribution to GDP of CUP2,023.6mn (2.6% of total GDP) in 2014[2].

Cuba's principal exports are raw sugar, refined petroleum, rolled tobacco, packaged medication and nickel mattes. Its main imports are refined petroleum, wheat, corn, poultry, meat and concentrated milk.

Cuba's main industrial challenges are shown below:

MAIN INDUSTRIAL CHALLENGES
Increase Cuban industry's share of GDP: in 2013, industry accounted for only 13.7% of GDP.
Decrease import dependency: 58% (2013).
Diversify its exports: nickel, pharmaceuticals, sugar, beverages, and Cuban cigars, represent over 80% of industrial exports in 2013.
ADDITION INDUSTRIAL CHALLENGES
Most activities are based on natural resources with little manufacturing value-added, and low technology products accounting for 70% of industrial GDP.
There is insufficient utilization of the installed industrial capacity, and a need for the modernization of the existing technological infrastructure.
The need to increase power generation using renewable energy sources. In 2014, less than 5% of the total energy generated comes from renewable energy sources.
There are underdeveloped linkages between the different actors in value chains, and poor business efficiency and productivity.

Figure 10: Major industrial challenges in Cuba

[2] Carmelo Mesa-Lago, Pavel Vidal-Alejandro, "The impact of the Global Crisis on Cuba's Economy and Social Welfare", J. LAt. Amer. Stud. 42, 689-717, Cambridge University Press, 2010.
World Travel & Tourism Council (WTTC) (2015): Travel & Tourism Economic Impact 2015 Cuba: https://www.wttc.org/-/media/files/reports/economic%20impact%20research/countries%202015/cuba2015.pdf

2.1 Agricultural industry and food production, trends and challenges

Since the economic crises, the agricultural industry and the overall system in Cuba has faced significant challenges, threatening food security. Growth in the agricultural sector has been insufficient, and domestic food production levels have traditionally been well below domestic consumption needs.

The major constraints preventing the development of the agricultural sector in Cuba, identified according to the preliminary information available, are listed in Figure 11 below.

Figure 11: Major constraints preventing the development of the agricultural sector in Cuba

As a result, the majority of demand for food is met by imports, which is striking in view of Cuba's abundant natural resources, including soil and water, and the availability of human and technological capital. Furthermore, increases in tourist numbers and expected growth provides some foreign currency, but this is not sufficient to fund the much needed modernization and rises in demand. Also, expanding tourist numbers increases the demand for quality food, exacerbating an already high reliance on food imports[3].

Cuba has an agricultural area of 6 240.3 Mha, 2 733.6 Mha out of them are under crops[4]. In 2015, Cuba's agricultural sector employed about 19% of the labour force. In Cuba as a whole, agriculture is now practiced by some 40,000 urban workers, on an area estimated at 33,500ha. It includes 145,000 small farm plots, 385,000 backyard gardens, 6,400 intensive gardens and 4,000 high-yielding so-called organopónicos. Agricultural production volumes, however, are not sufficient to meet the domestic demand.

[3] Feinberg, R./ Newfarmer, R. (2016): Tourism in Cuba. Riding the wave toward sustainable prosperity. https://www.brookings.edu/research/tourism-in-cuba/ [03.04.2017]

[4] Cuba's Staistical Year Book 2015.

2.2 Major mineral fertilizers production and consumption trends

Domestic production of mineral fertilizers like nitrogen, phosphate and potash-based products is at low levels, while consumption is steadily increasing. As a result, demand is mostly met by imports.

Major issues identified by the key producers of fertilizers in Cuba are listed in Figure 12.

Figure 12: Major issues related to fertilizers in Cuba

The major public enterprises producing fertilizers in Cuba are, currently, the October Revolution Camagüey and Rayonitro companies. Their production capacities are shown in the table below.

NAME	MAIN PRODUCTS	ANNUAL PRODUCTION CAPACITY
FERTILIZER COMPANY, OCTOBER REVOLUTION CAMAGÜEY	Ammonium nitrate fertilizer	120,000 tons
	Calcium nitrate solutions	480,000 liters
	Nitric acid	160,000 tons
FERTILIZER PRODUCTION PLANT, RAYONITRO, MATANZAS	Granular NPK fertilizer mixed	150,000 tons

Table 1: Major Cuban fertilizer producers and their production capacities *(Source: Questionnaire responses received during the UNIDO Cuba Country Programme Formulation mission conducted from 29 June to 3 July 2015)*

All the above-mentioned public enterprises producing fertilizers are associate members of the Cuban Chemical Industry Enterprise Group (GEIQ – *El Grupo Empresarial de la Industria Química*), which promotes domestic fertilizer production.

The situation described in Figure 12 is not only valid for Cuba; it is also evident in other countries in Latin America.

The lack of in-country production of fertilizers is illustrated by the graph. It is clear that improvements in Cuba's fertilizer industry would decrease its import dependency.

[5] Questionnaire responses received during the UNIDO Cuba Country Programme Formulation mission conducted 29 June-3 July 2015.

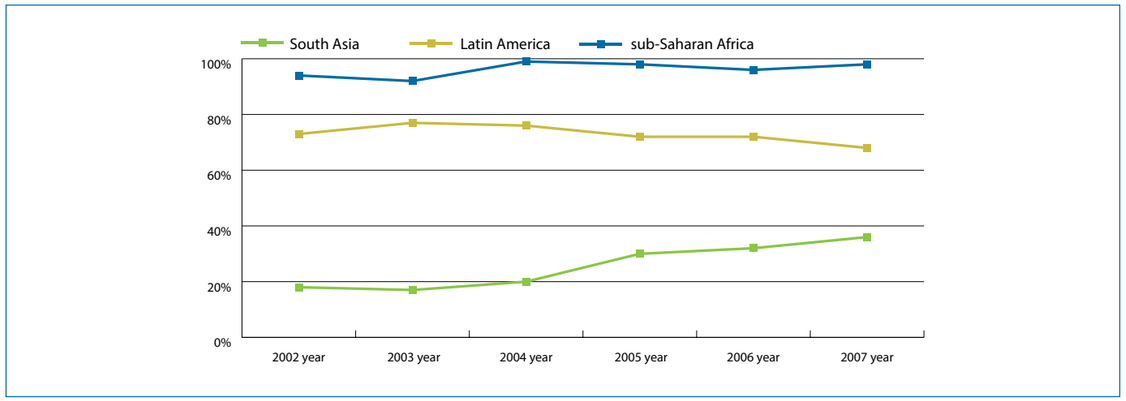


Figure 13: The high dependence of developing regions on imported fertilizer (imports as a percentage of consumption) *(Source: Torero, Maximo: The Fertilizer Market at the Global Level. At: IFA International Fertilizer Conference, 2015. http://www.ifa.ie/wp-content/uploads/2015/05/IFPRI-Presentation-wp.pdf [31.03.2017])*

2.3 Agricultural machinery

Limited production of machinery and equipment/implements in Cuba have made it necessary to import substantial quantities of agricultural machinery and implements.

The major challenges for the Cuban agricultural-machinery sector which are limiting the development of the country's agricultural sector are:

MAIN CHALLENGES
Limited availability of equipment and implements in the domestic market.
Dependence on imports of costly mechanized agricultural machinery and implements.
Inefficient utilization of existing capacity and low productivity at the existing local facilities/hubs which produce agricultural equipment and implements aimed at better serving food/crop-growing activities.
Lack of business and management best practices, and technical capacity, hindering industrial efficiency and the competitiveness of local operators.
Limited support to the industry from technical, research and professional training institutions.

Figure 14: Major challenges for the Cuban agricultural-machinery sector

The major domestic producers of agricultural machinery and implements are public-sector entities, united under the Cuban Ferrous Metallurgy and Machine-Building Enterprise Group (GESIME - El Grupo Empresarial de la Industria Sidero Mecánica).

The country's major producer of agricultural machinery is the public-sector enterprise, "Heroes del 26 de Julio," which is located in Holguin and currently employs about 1,100 people.

AGRICULTURAL EQUIPMENT PRODUCED	QUANTITY OF PRODUCTION IN 2015
TRACTORS	115
VARIOUS TYPES OF TRAILERS	925
TRACTOR IMPLEMENTS	165
TOOLS AND SYSTEMS	3,206

Table 2: Quantity of agricultural machinery produced by the enterprise, Heroes del 26 de Julio, in 2015 *(Source: Questionnaire responses received during the UNIDO Cuba Country Programme Formulation mission conducted between 29 June and 3 July 2015)*

Chapter 3

Sectoral Analysis of Crop Supply and Demand

This sectoral analysis is based on Cuba´s current situation, and on the goal of identifying fertilizer priorities to be supported within this project. This requires a clear view of the current main crop imports, as well as important crops, which could take advantage of fertilizer industry developments. Moreover, any changes in this area will influence the development of the agricultural machinery sector.

A second condition for the prioritization of fertilizers has to be considered: the world market for fertilizers is competitive and multinational companies can benefit from economies of scale, thus offering low prices on world markets (for example, the market for urea). Entering the market requires huge investments if an entrant is to compete with the leading players in the sector. Given these circumstances, and considering Cuba´s interests and investment capability, this type of approach is not targeted. However, a niche strategy has considerable potential and could further advance the fertilizer and agricultural machinery sectors in Cuba.

The fertilizer industry in Cuba is currently structured as shown in Figure 15 below.

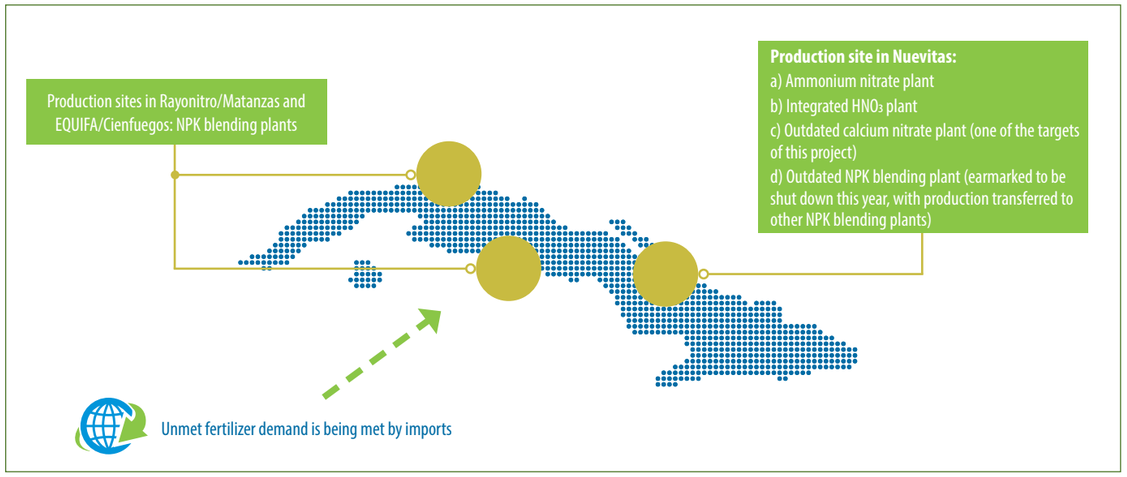


Figure 15: Current structure of the fertilizer industry in Cuba

Accordingly, it is a task of this project to identify, within this niche strategy, promising types of fertilizers that fulfil the requirements listed in Figure 16 below.

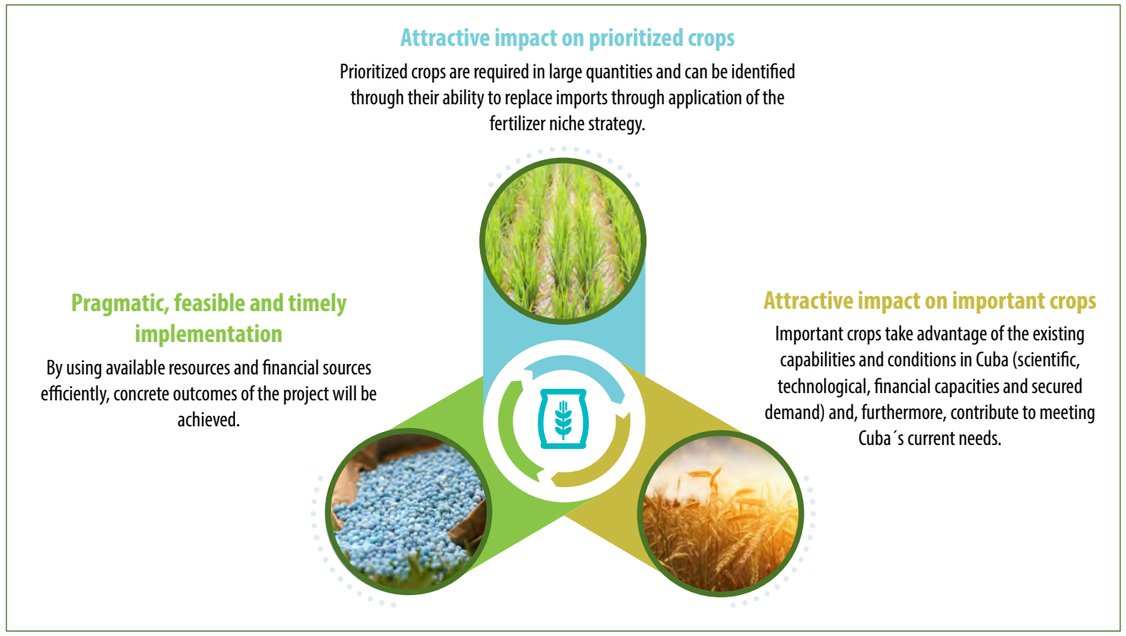


Figure 16: Requirements of the fertilizers proposed in the project

This step-by-step approach and careful selection of fertilizers will contribute to the success of the project.

With a broader understanding of the agricultural situation of Cuba in mind, the following table provides an initial overview. It compares Cuba with other countries, thereby benchmarking it in terms of production, fertilizer consumption and employment of machinery.

The following definition clarifies the concept of fertilizer consumption. Fertilizer consumption (% of fertilizer production or kg/ha of arable land)[6] measures the quantity of plant nutrients used per unit of arable land. Fertilizer products cover nitrogenous, potash, and phosphate fertilizers (including ground-rock phosphate). Traditional animal nutrients and plant-based manures are not included.

For the purpose of data dissemination, the FAO has adopted the concept of a calendar year (January to December)[7]. Some countries compile fertilizer data on a calendar-year basis, while others do it on a split-year basis. Arable land includes land defined by the FAO as land under temporary crops (double cropped areas are counted once), temporary meadows for mowing or for pasture, land used for market or kitchen gardens, and land temporarily fallow.

In Cuba, large areas are subject to agricultural cultivation. Compared with other countries, the use of fertilizers and agricultural machinery is medium-to-low. The project aims at increasing these numbers, thus contributing to a reliable and secure supply of food.

[6] World Bank 2015: www.wdi.worldbank.org/table/3.2
[7] Food and Agriculture Organization, electronic files and web site.

	AGRICULTURAL LAND			AVERAGE ANNUAL PRECIPITATION	LAND UNDER CEREAL PRODUCTION		FERTILIZER CONSUMPTION		AGRICULTURAL EMPLOYMENT		AGRICULTURAL MACHINERY	
	% of land area		% irrigated	milimeters	hectares thousands		% of fertilizer prod.	kg/ha of arable land	% of total employment		tractors per 100 sq. km of arable land	
	2000-02	2012-14	2012-14	2014	2000-02	2012-14	2012-14	2012-14	2000-02	2012-14	2000	2009
Argentina	47	54	..	591	9826	12185.7	267.3	36	1	0.5	89.6	87.7
Australia	58	53	0.6	534	17486	17973.1	379.3	54.2	4.4	2.6	..	..
Austria	35	33	1.9	1110	813.4	825.5	..	103.9	5.5	4.3	2394.8	2390.3
Croatia	21	27	0.9	1113	718.2	496.3	50.7	251	13.1	8.7	27.3	49.4
CUBA	63	60	..	1335	320.6	361.7	566.5	58.2	21.7	18.6	216.6	203.2
Czech Rep.	55	55	0.4	677	1568.2	1412.3	333.2	128.8	4.9	2.7	298.2	262.3
Denmark	63	62	9.3	703	1527.9	1450.9	..	120.5	3	2.3	540.2	486.3
India	61	60	36.8	1083	94470.9	98618	157.2	165.1	59.9	49.7	128.5	128.5
Spain	59	53	14.4	636	6724	6258.8	117.5	151.4	5.9	4.2	671.4	831.2
WORLD	38	38	..	..	658438.8	720666.3	91.2	138	36.1	..	190.8	..
Low income	37	39	..	..	50215.2	69290.9	810.7	13.5	..	..	..	..
Lower middle income	47	44	..	..	221689.9	243300	135	121.8	54.1	43.9	93.1	93.1
Upper middle income	35	35	..	..	240254.5	261805.4	88.4	177.2	36.4	..	104.9	..
High income	38	36	..	..	146279.2	146269.9	72.4	137.7	4.4	3.8	468.2	..
East Asia Pacific	51	49	..	..	155373.4	176674.9	102.2	344.3	40.6	..	..	..
Europe & Central Asia	30	29	..	..	155575.2	151713.7	54.7	78.3	11.8	7	329.7	329.7
Latin America & Caribbean	36	38	..	..	47385.8	56141.8	293.7	127.9	18.2	14.2	119.7	..
Middle East & North Africa	35	33	..	..	26746.2	27187.2	22.7	90	..	..	163.6	163.6
North America	26	26	..	..	68735.9	71976	71.3	126.6	2.5	..	236.6	251.2
South Asia	57	57	..	..	124555.1	132820.3	163.4	158.5	59.2	49.2	116.2	116.2
Sub-Saharan Africa	43	42	..	..	80067.2	104152.4	564.6	16	..	..	..	..

Table 3: International benchmarks for agricultural production and employment (*Source: World Bank http://wdi.worldbank.org/table/3.2*)

3.1 Selected crops

Enhanced food supply for the Cuban population, as well as for the tourism industry, requires an in-depth review of the production and imports of the various crops. The following tables provide an overview of the crops produced in Cuba and allow the identification of staple foods. From this starting point, the ratio of the production of certain crops to their imports is examined in order to show the potential for domestic production. This potential can be increased through the selection of fertilizers, which is an integral part of this study.

PRODUCTION/YEAR	2010	2011	2012	2013	2014	2015	AVERAGE 2010-2015
CROPS 1	2.250.000	2.280.000	2.337.000	2.239.000	2.507.056	2.633.600	2.374.443
TUBER CROPS AND ROOTS	1.515.000	1.445.000	1.452.000	1.580.500	1.670.864	1.743.400	1.567.794
of which potato	191.500	165.600	130.933	106.700	53.308	123.938	128.663
of which sweet potato	384.743	311.900	335.319	396.347	512.825	506.839	407.996
of which malanga	137.400	132.100	153.782	185.922	269.590	246.472	187.544
of which other	801.357	835.400	831.966	891.531	835.141	866.151	843.591
PLANTAIN & BANANA	735.000	835.000	885.000	658.500	836.192	890.197	806.648
fruit plantain	249.200	250.000	195.496	150.336	203.225	234.471	213.788
cooking banana	485.800	585.000	689.504	508.164	632.967	655.726	592.860
VEGETABLES	2.141.035	2.200.000	2.112.000	2.406.500	2.498.960	2.424.163	2.297.110
tomato	517.040	601.000	557.100	678.000	454.112	551.007	559.710
onion	111.737	143.500	118.244	126.876	112.779	107.171	120.051
peppers	44.545	55.057	62.202	73.336	60.543	69.034	60.786
of which other	1.467.713	1.400.443	1.374.454	1.528.288	1.871.526	1.696.951	1.556.563
CEREALS	778.863	920.400	1.002.000	1.098.800	1.013.495	781.058	932.436
paddy rice, humid	454.400	566.400	641.600	672.600	584.800	418.037	556.306
corn	324.463	354.000	360.400	426.200	428.695	363.021	376.130
of which other	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
LEGUMINOUS PLANTS	80.439	133.000	127.100	129.800	135.545	117.556	120.573
beans	80.439	133.000	127.100	129.800	135.545	117.556	120.573
TOBACCO	20.500	19.900	19.500	24.000	19.800	24.500	21.367
CITRUS FRUITS	345.000	264.500	203.700	166.900	96.810	115.384	198.716
of which sweet orange	178.263	122.900	93.837	85.110	36.103	40.159	92.729
of which grape fruit	137.660	112.000	84.741	63.979	41.421	56.268	82.678
of which lemon	6.060	6.600	6.475	5.025	7.925	6.579	6.444
of which other	23.017	23.000	18.647	12.786	11.361	12.378	16.865
OTHER FRUITS	762.045	817.000	964.900	925.000	884.464	942.675	882.681
of which mango	203.595	185.000	286.385	285.526	177.834	260.076	233.069
of which guava	71.581	85.000	103.191	124.964	180.397	158.720	120.642
of which pomaceous fruit	135.707	135.000	178.558	197.842	139.531	202.499	164.856
of which other	351.162	412.000	396.766	316.668	386.702	321.380	364.113
CACAO	1.709	1.510	2.027	1.425	2.188	1.500	1.727

Table 4: Current average crop-production levels in Cuba[8]

[8] National Office of Statistics and Information ONEI (Oficina Nacional de Estadística e Información), Statistics Year Book, 2015.

PRODUCTION/YEAR	2010	2011	2012	2013	2014	2015	AVERAGE 2010-2015
CROPS 1	20.338	15.974	13.140	6.291	8.185	15.233	13.194
TUBER CROPS AND ROOTS	20.063	15.974	13.140	6.291	8.185	15.233	13.148
of which potato	20.063	15.974	13.140	6.291	8.185	15.233	13.148
of which sweet potato	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
of which malanga	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
of which other	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
PLANTAIN & BANANA	275	N.A.	N.A.	N.A.	N.A.	N.A.	275
fruit plantain	275	N.A.	N.A.	N.A.	N.A.	N.A.	275
cooking banana	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
VEGETABLES	867	553	688	518	391	329	558
tomato	20	20	N.A.	N.A.	N.A.	N.A.	20
onion	547	384	452	394	391	329	416
peppers	300	149	236	124	N.A.	N.A.	202
of which other							N.A.
CEREALS	1.211.154	1.273.340	1.061.497	1.104.439	1.273.499	1.303.039	1.204.495
paddy rice, humid	425.298	560.540	353.785	335.295	463.638	487.179	437.623
corn/maize	785.856	712.800	707.712	769.144	809.861	815.860	766.872
of which other							N.A.
LEGUMINOUS PLANTS							N.A.
beans	42.300	73.700	33.618	33.621	N.A.	N.A.	45.810
TOBACCO	88	68	93	N.A.	N.A.	N.A.	83
CITRUS FRUITS	Citrus imports are not reported						
of which sweet orange							
of which grape fruit							
of which lemon							
of which other							
OTHER FRUITS							
of which mango							
of which guava							
of which pomaceous fruit							
of which other							
CACAO							

Table 5: Import levels for the crops shown in Table 4[9]

[9] Source FAOSTAT_data_1-19-2017-3 and Source ONEI.

Where no figures are provided (i.e. the table shows N.A. - not available), there are no significant imports occurring. Several conclusions can be drawn from the data provided in the tables above. The comparison of production and import quantities of the various crops leads to the following conclusions, as listed in Figure 17 below[10]:

1. Maize and rice imports are the highest priority crops with average imports of 766kt/year and 437kt/year, respectively.
2. Beans, with average imports of 45kt/year, and potatoes, with average imports of 13kt/year, including the import of seeds can also be identified as important crops.

Figure 17: Comparison of production and import quantities of the various crops leads

CROP	POTATO	BANANA/FRUIT	TOMATO	ONION	RICE	MAIZE	BEANS
PRODUCTION (T/YEAR)	128.663	213.021	559.710	120.053	556.306	376.130	100.573
IMPORTS (T/YEAR)	13.148	275	20	416	437.623	766.872	45.810
IMPORTS/PRODUCTION (%)	10,22%	0,13%	0,00%	0,35%	**78,67%**	**203,88%**	45,55%

Table 6: Relation between imports and production

The Table 6 above shows the relation between imports and production, and identifies rice and maize as priority crops for import replacements.

In the case of bananas and tomatoes, a trend towards self-sufficiency can be observed. Recent data confirms that this trend also applies to potatoes, beans, onions, garlic and broccoli, for which import levels are already very low (‹1000 tons/year). It can be assumed that, based on existing resources, this process will continue. The main destination for vegetable imports is the tourism sector, especially because of the high-quality specifications required by hospitality facilities. The demand from the growing tourism sector is of such importance that Cuba has recently decided to invest strongly in the greenhouse cultivation of vegetables.

The above prioritization shows that rice and maize could be the dominant consumers of fertilizers, if imports could be reduced. Regardless of the influence of other elements like soil conditions, weather, types of machinery, fuel, etc., appropriate fertilizers in additional quantity could make a strong contribution to improving local production and reducing imports.

The figures above are estimates for full import replacement, which will not be the case. Accordingly, for planning purposes, an appropriate fraction, representing an increase over the years will need to be considered.

[10] Comments CIIQ.

3.2 Prioritized crop: rice

This prioritized crop is a basic component of the Cuban diet. On average, each Cuban consumes almost 60kg of rice each year.

Cuban farmers are seeking to increase the area covered by rice fields to 250,000 hectares, in order to improve the production of this grain and the high cost of imports from the international market. At present, 85% of the work in rice fields in Cuba is managed and administered through cooperatives, although 91,000 hectares are managed by people who were recently given the land by usufruct. There are also twelve companies from the Agro-industrial Grain Group of the Ministry of Agriculture mostly engaged in the production of seeds, plus other farms that together comprise about 18,000 rice producers.

The objective was to produce 538,000 tons of rice by 2016, an output level that would equal the national record reached in 1986. Even so, national demand will not be totally met, this level of production would greatly reduce the island's considerable cereal imports. In the last two years, national production satisfied only about 50% of the national demand for rice. Taking into account demand, and the international price (about US $500/t), increasing domestic production is a priority.

The following data is provided in Cuba's Statistical Yearbook for 2015:

IMPORTS	UNIT	2012	2013	2014	2015
RICE					
QUANTITY	t	353.785	335.295	463.638	487.179
VALUE	MP	195.009	181.98	270.224	239.843

The varieties of cereal and the technologies used in rice fields have improved in recent years and yields are similar to those in countries with considerable experience in that sector of production. The government considers food production to be a strategic objective.

3.3 Prioritized crop: maize

Corn is used for three fundamental purposes: human food, feed and/or fodder, and as a raw material for large quantities of industrial products, thus making it a prioritized crop. Maize is considered a staple food in many developing countries in Latin America, and offers hundreds of different possibilities in terms of its use. As a result of its high concentration, it is used in intensive feed systems for poultry, dairy cattle and beef cattle. The structure of the mature grain, based on dry matter, is approximately 77% starch, 2% oil, 5% pentosan, 9% protein, 2% sugar and 2% ash. Ashes from corn kernels contain calcium, magnesium, phosphorus, aluminium, iron, sodium, potassium and chlorine salts.

Historically, small farmers have harvested maize crops without using technology or sophisticated irrigation systems. Even though the climate is undergoing a change, the opportunities for growing maize are strong. Therefore, it is important to guarantee the production of this human and animal food, which – unlike other perishable agricultural products with better prices and higher yields – can be stored all year in the form of grain, flour or corn starch.

It is unquestionably a profitable investment due to its high yields. Even the organic crop residues can be mixed with the sweet residues from sugar production and serve as food for pigs, cows, horses, sheep and goats. Birds fed with corn increase their meat and egg yields.

National corn production and imports are shown in the following table, taken from Cuba's Statistical Yearbook for 2015. The table shows the growing tendency to import maize in the last four years, and that only 30% of the domestic demand is being satisfied.

	UNIT	2012	2013	2014	2015	DIFF. 2015-2012
IMPORT	t	707.712	769.144	809.861	815.860	108.148
NATIONAL PRODUCTION	t	360.400	426.200	428.695	363.021	2.621
NATIONAL DEMAND	t	1.068.112	1.195.344	1.238.556	1.178.881	110.769
NATIONAL PRODUCTION/DEMAND	%	33.74	35.66	34.61	30.79	-2.95

Table 7: Growing tendency to import maize in the period 2012-2015

3.4 Important crop: beans

Beans are an important crop and constitute – similarly to rice – a staple food in the Cuban diet. Due to this importance for Cuba, the comprehensive development programme for agriculture aims to eliminate imports of beans within the next two years. Despite the potentially negative impact on production from global changes in weather, increases in areas of bean production, throughout the country, are being promoted.

Based on the 2015 Statistical Yearbook, the following table presents data on the area devoted to this crop, the national production, and the yield achieved in recent years. It can be noted that the yields increased as a result of the application of scientific and technological improvements, as well as agricultural work being carried out more conscientiously, in accordance with the technical instructions for growing this crop.

BEANS	2010	2011	2012	2013	2014	2015
TOTAL AREA (HA)	112.712	123.914	123.434	119.775	129.911	98.712
STATE SECTOR (HA)	6.363	7.082	5.76	6.509	6.564	8.771
PRIVATE SECTOR (HA)	106.349	116.832	117.674	113.266	123.347	89.941
YIELD (T/HA)	0.71	1.07	1.03	1.08	1.04	1.19
NATIONAL PRODUCTION (T)	80.439	133	127.1	129.8	135.545	117.556

Table 8: Areas of bean harvest and production[11]

Experimental results obtained in the country indicate that higher yields can be obtained. At a business level, the lack of areas for cultivation, the low level of technology transfer and assimilation, the limited availability of quality seeds for the total area to be planted, inefficient harvests and post-harvest management, etc., can be identified as factors limiting production. It is worth mentioning that there are agro-ecological structural conditions and a comprehensive set of research results that, if applied, would allow national production to be increased.

Promotion of this crop should be based on a policy that ensures sustainable territorial self-sufficiency, through which grains are used for consumption and for generating new seeds. Moreover, the establishment of an extension programme which will allow producers to attend training sessions, and the enhancement of the national research plan in order to develop new varieties and technologies is recommended.

[11] ONEI (National Office of Statistics and Information), Statistics Year Book 2015.

3.5 Important crop: vegetables

In 2003, the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) launched a joint worldwide initiative to promote fruit and vegetables for health[12]. A strong movement which promotes the consumption of these important crops has also emerged in Cuba. Production is carried on outdoor areas and in greenhouses, with tomatoes, peppers and cucumbers being the most common vegetables to be grown under greenhouse conditions.

The Ministry of Agriculture and its Agricultural Business Group has responsibility for the protected crop sector and considers greenhouse production a high priority. There are currently special efforts underway to substantially increase greenhouse production with its significant higher yields, which are discussed further in Section 4.1 below. The impact of this is fundamental in assuring the vegetable supply to the local population and tourists over the whole year.

On the other hand, Cuba's National Movement of Urban Agriculture, which emerged in 1997, has a distinctive agro-ecological character. It also focuses on a multidisciplinary and participatory approach. The FAO refers to the Cuban invention known as "organopónicos", to describe the technology, as well as the gardens under cultivation, on which organic substrate is used for growing crops on poor soils in small urban spaces[13].

The urban and peri-urban agriculture of Cuba is moving forward to achieve its objectives in the 169 municipalities of the island. This movement comprises more than 300,000 producers who account for about 75% of the fresh vegetables and condiments used in the country.

The aim is to ensure that every Cuban consumes 400 grams of vegetables and fruits a day, in accordance with the "Dietary Guidelines for the Cuban population over two years of age", produced by the Ministry of Public Health of the Republic of Cuba.

At present, efforts are underway to incorporate a further 1,400 hectares into this movement, which will complement the 10,000 hectares envisaged for "organopónicos" gardens[14] and intensive gardens.

The use of more soluble and ecologically-friendly fertilizers is a challenge for the industry if it is to meet the needs and requirements of this important sector which provides vegetables, medicinal plants and fruits throughout the year.

3.6 Food, health and the ecological footprint

The Food and Agriculture Organization of the United Nations promotes "eating well for good health," thereby suggesting that not only the availability of food determines the health of human beings, but also the very composition of the food itself. Thus, the lack of food, an inadequate variety or more food than people actually need may cause health issues. The FAO states, that many of these problems can be prevented by eating a varied, nutritionally adequate diet[15].

Vegetables and fruits are rich in vitamins and minerals, and belong to the maintenance and repair food group in the food pyramid. They contain a large amount of water, which accounts for about 80% of their weight. Most vegetables are low-calorie foods; they usually do not exceed 50 calories per 100 grams. Because of this low calorific value, vegetables should be present in a large percentage in an anti-obesity diet.

As a result of these properties, it is advisable to consume them frequently, every day. A portion is recommended at every meal, with as much variety as possible. Along with fruits, vegetables occupy the second level down in the food pyramid. Attempts have been made to change this to place fruits and vegetables at the top of the pyramid[16].

[12] WHO http://www.who.int/dietphysicalactivity/fruit/en/ [30.03.2017]

[13] FAO http://www.fao.org/ag/agp/greenercities/en/GGCLAC/havana.html [30.03.2017]

[14] www.fao.org/3/a-i3696e/i3696e01.pdf

[15] Menza, V./ Probart, C. (2013): Eating well for good health. http://www.fao.org/docrep/017/i3261e/i3261e.pdf [30.03.2017]

[16] Irish Department of Health: https://www.thejournal.ie/new-food-pyramid-3122514-Dec2016/ [30.03.2017]

Moreover, in cooperation with the FAO, the Barilla Centre for Food and Nutrition has designed an environmental pyramid, showing that the ecological footprint of vegetables and fruits is the lowest, compared with other dietary components[17].

In addition, the FAO mentions the availability of foods, and their respective costs, as the prevailing factors in the choice of food. The project in Cuba aims to produce good-quality food locally, in large quantities. As a result, the project will contribute to the good health of the local population and visiting tourists.

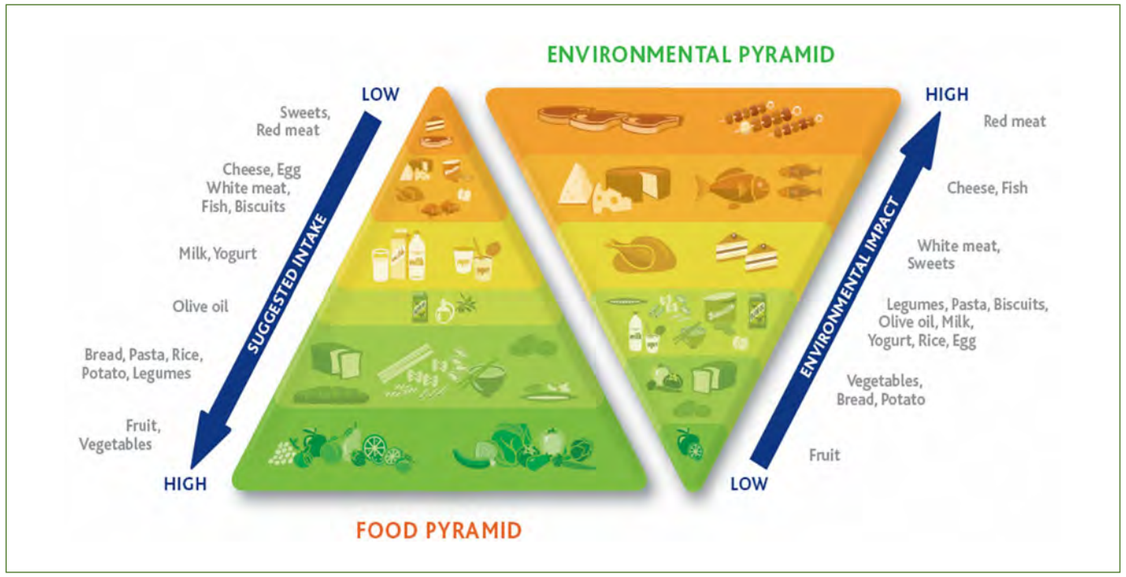


Figure 18: Barilla Centre for Food and Nutrition's environmental pyramid

[17] Andrea Poli The Food Pyramid and the Environmental Pyramid: http://www.fao.org/ag/humannutrition/25396-02b25569cfe3b55b6da39c3dacc6a26.pdf [30.03.2017]

Chapter 4

Sectoral Analysis of the Supply and Demand of Fertilizers

The next steps lead to the analysis of common fertilizer applications for crops. In addition, the behaviour of the agro-industrial sector at the international level has to be taken into account. According to the FAO, the global use of fertilizer could rise above 200 million tons in 2018; 25% more than the value recorded in 2008[18].

Worldwide fertilizer consumption across geographic regions in 2013, according to the International Fertilizer Association (IFA), is shown in the chart below. There is an increasing trend towards the use of NPK carriers. The comparison of Cuba with other regions reveals the low use of nitrogen, as a fertilizer, in Cuba.

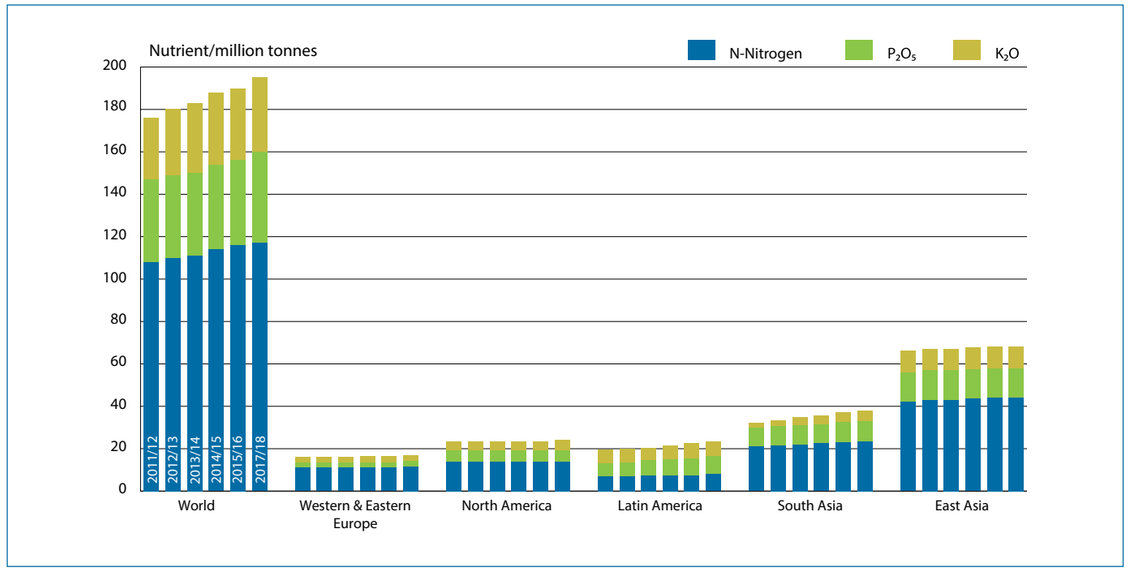


Figure 19: Fertilizer consumption in the main consuming regions of the world[19]

[18] Food and Agriculture Organization (FAO), Report "World fertilizer trends and outlook to 2018".

[19] Torero, Maximo: The Fertilizer Market at the Global Level. At: IFA International Fertilizer Conference 2015. http://www.ifa.ie/wp-content/uploads/2015/05/IFPRI-Presentation-wp.pdf [31.03.2017]

In Cuba the main carriers, namely urea, ammonium nitrate, ammonium phosphates and potassium chloride are commonly used for most crops. Products supplying microelements are primarily intended for specific crops or deficiencies detected as a result of edaphic analyses.

Two fundamental products are developed within this line, taking into account their production volumes: ammonium nitrate and granulated mixed fertilizers, also known as bulk physical blends or bulk blending technology.

Another product is calcium nitrate, a solution with a concentration between 49 and 51% mainly destined for protected crops (vegetables and fruits). At present, its demand is around 480 kilolitres per year and this is projected to increase by up to 2,000 kilolitres per year.

Among the products expected to be strengthened in the Chemical Programme are liquid fertilizers in general (NK and NPK solutions, which may be enriched with micronutrients and secondary sources). In this line, it is also of interest to develop chemical fertilizers with marked ecological effects, following the international trend of adding macro or microalgae which can supply substances that enhance the effect of the main nutrients on the soil, thus allowing a reduction in the amount of basic fertilizing materials needed.

The following Table 9 shows the main products, and their respective volumes, manufactured in Cuba in the past five years.

In this same period, the main imports of fertilizers were as shown in the Table 10.

PRODUCT	UNIT	2011	2012	2013	2014	2015
AMMONIUM NITRATE	Mt	45.2	59.2	63.7	58.6	58.5
COMPLETE FERTILIZERS	Mt	39.8	30.4	21.8	32.1	44.4
OF THEM: Mixed		1.2	25.1	21.8	32.1	44.4
Granulated		38.6	5.2	-	-	-

Table 9: Fertilizer and nitrogen-compound manufacturing in Cuba, 2011-2015

FERTILIZERS (EXCEPT CRUDE FERTILIZERS)	UNIT	2012	2013	2014	2015
VALUE	MP	161.008	138.396	175.396	110.398
UREA					
Amount	t	85.592	66.461	154.819	56.222
Value	MP	42.523	30.068	70.916	23.829
AMMONIUM SULPHATE					
Amount	t	14.794	15.105	18.143	18.498
Value	MP	5.608	5.75	6.869	6.689
POTASSIUM CHLORIDE					
Amount	t	54.108	46.156	67.685	56.339
Value	MP	34.066	22.982	29.489	23.640
POTASSIUM SULPHATE					
Amount	t	555	793	320	427
Value	MP	406	624	356	400

Table 10: Main imports of fertilizers in Cuba, 2012-2015

The monetary spend (USD) in the last years (2010-2015), in terms of total fertilizer imports, is shown in the following table, obtained from the Harmonized Product Classification System (ONEI).

NO.	PRODUCT	AVERAGE VALUE (LAST 5 YEARS)
1	UREA, EVEN DISSOLVED	41,621,668.13
2	POTASSIUM CHLORIDE	27,544,243.47
3	GRANULATED FERTILIZERS	16,319,354.53
4	MIXED FERTILIZERS	14,358,117.70
5	SUPERPHOSPHATES	11,960,610.04
6	REST OF THE POTASSIUM-BASED MINERAL OR CHEMICAL FERTILIZERS	6,946,653.47
7	DIAMMONIUM HIDROGEN PHOSPHATE (DAP)	6,499,994.65
8	AMMONIUM SULPHATE	4,422,952.83
9	AMMONIUM NITRATE (WITH NO MORE THAN 0.2% OF COMB. MATTER)	747,776.21
10	POTASSIUM SULPHATE	612,999.71
11	COMPLEX FERTILIZERS	198,828.41
12	AMMONIUM NITRATE (WITH MORE THAN 0.2% OF COMB. MATTER)	189,358.03
13	SODIUM NITRATE	118,457.58
14	AMMONIUM DIHYDROGENE ORTHOPHOSPHATE (MAP)	77,623.42
	TOTAL	**131,618,638.18**

Table 11: Monetary spend (USD) in 2010-2015 in terms of total fertilizer imports

4.1 Impact of prioritized crops on fertilizer production

The following two sections (4.1 and 4.2) set out the methodology used to determine the capacities for the two production plants proposed. Calculations have been done for plants producing calcium nitrate and CBFERT, which is a potential substitute for Bayfolan; and rice was taken, as an example crop, to demonstrate the methodology.

The forecasted import demand figures, in 2016, for grains provided by the Grain Agro-industrial Group (GAIG – Grupo Agroindustrial de Granos) allows the calculation of a specific fertilizer demand for rice, in kg per ton of crop. This specific demand is then used in the following section to calculate the overall demand for calcium nitrate and Bayfolan.

For maize, data collection is more complex, since there are no fertilizer imports for maize, and, as a result, a breakdown of the required fertilizer mix is not available. The reason for this is that despite the huge production and import volumes of maize, fertilizers were not imported to assist its cultivation because the required funds were used to purchase other prioritized food supplies instead. In the relevant sections below that deal with more detailed capacity calculations, appropriate assumptions about the fertilizer mix have been made.

FERTILIZER DEMAND (KG) FOR 1 T OF CROP	CROP RICE
POTASSIUM CHLORIDE - KCL	15,00
ZINC SULPHATE - ZnSO4	0,20
TRIPLE SUPERPHOSPHATE - TSP	16,00
UREA	62,00
BAYFOLAN (T)	0,72
BIOBRAS 16	11,93
AVERAGE YIELD OF T/HA	4,19

Table 12: Fertilizer demand for rice crops

4.2 The impact of important crops on fertilizer production

Considering government policy to significantly enhance vegetable cultivation in greenhouses (protected crops) initially by 153 ha, and later by 200 ha, the figures in Table 13 are given for greenhouse applications. They allow the calculation of demand for liquid calcium nitrate and the Bayfolan/CBFERT.

The calculation is for illustration purposes and is based on an assumed current vegetable mix consisting of tomatoes and peppers, each taking half of the additional greenhouse area of 153 ha.

Available data suggested a yield of 150t/ha for tomatoes and 90t/ha for peppers. This methodology will be extended for other protected crops with appropriate hectare allocations in the complete study.

FERTILIZER DEMAND (KG) FOR 1 T OF CROP	CROP: VEGETABLE MIX (TOMATOES, PEPPERS)
H_3PO_4	5,93
HNO_3	15,14
$Ca(NO_3)_2$	22,64
$MgSO_4$	0,65
KNO_3	0,31
K_2SO_4	17,90
NH_4NO_3	0,00
BAYFOLAN FORTE	0,38
TURBA RUBIA	9,17
AVERAGE GREENHOUSE YIELD OF T/HA	TOMATOES: 150 T/HA, PEPPERS: 90 T/HA

Table 13: Estimated fertilizer demand for 1 T of crop (vegetable mix)

4.3 Fertilizer consumption based on production and import requirements

Tables 14 and 15 show the estimated combination of import replacements for the priority crops with additional required fertilizer capacities. The model is based on the above identified import amounts plus a currently observed undersupply in % (which is currently set at 0).

Moreover, the table considers – for demonstration purposes only – the full replacement of rice imports, and calculates the relevant fertilizer demands as the theoretical upper limit for any plant capacity considerations. More detailed consumption plant capacity calculations will be carried out integrating realistic import replacement assumptions and reasonable growth factors, which are always considered for new investments. These calculations will additionally consider the advantages of the "new" fertilizers relying mainly on domestic raw materials.

The table also considers current average fertilizer demands/ton of crop as determined in the two tables above, and calculates, as a best estimate, additional required fertilizer volumes for "prioritized crops" and "important crops" – at average conditions (soil, yield, efficiency, etc.)[20].

The same methodology was applied to estimate the fertilizer demand for a greenhouse-grown vegetable mix consisting of tomatoes and peppers, shown in the following table. In the specific chapters to be produced in the second stage of the project, this calculation will be extended to a greater number of vegetable products, as requested by the overall protected crop programme.

The methodology for the prioritized and important crops outlined above is important for the second stage of the project, in which the accessible market with its demand capacities is being determined.

Finally, the plant capacities, which are the basis of the two engineering projects, with their inherent feasibility calculations for calcium nitrate and CBFERT are suggested.

CBFERT production is innovative in itself: its production offers a unique window of opportunity as a substitute for Bayfolan.

The figures applied, "average fertilizer demand/ton of crop," consider specific values, as averages, across Cuba, which includes allowances for unfavourable soil conditions, compared with other Latin-American soils.

The resulting figures are based on currently used fertilizers and fertilizer mixes, and do not yet contain suggestions for replacements of other imported fertilizers with locally produced fertilizers, which would require additional market and plant capacities to be considered.

[20] The grain institute determines the demand for 2016.

CROPS		PRIORITY CROP	
		RICE, WET	
production			556,306
+ imports	mt/y	I	437,623
current supply gap	%	CSG	0%
= total demand	mt/y	AD	993,929
MAIN FERTILIZER 1		KCl [3]	
specific consumption [1]	tMF1/tProduct	mf1	0.02
required total demand = (AD)*mf1	mt/y	RTD-MF1	14,909
MAIN FERTILIZER 2		$ZnSO_4$	
specific consumption [1]	tMF2/tProduct	mf6	0.0002
required total demand = (AD)*mf2	mt/y	RTD-MF6	201
MAIN FERTILIZER 3		TSP/0-46-0 [4]	
specific consumption [1]	tMF3/tProduct	mf2	0.0160
required total demand = (AD)*mf3	mt/y	RTD-MF2	15,903
MAIN FERTILIZER 4		UREA	
specific consumption [1]	tMF4/tProduct	mf3	0.0620
required total demand = (AD)*mf4	mt/y	RTD-MF3	61,624
MAIN FERTILIZER 5		BAYFOLAN	
specific consumption [1]	tMF5/tProduct	mf5	0.0007
required total demand = (AD)*mf5	mt/y	RTD-MF5 [2]	712
MAIN FERTILIZER 6		BIOBRAS 16	
specific consumption [1]	tMF6/tProduct	mf4	0.0119
required total demand = (AD)*mf6	mt/y	RTD-MF4	11,861

Tables 14 and 15: Estimated combination of import replacements for the priority crops with additional required fertilizer capacities

[1] Based on grain institute data determining the demand 2016;
[2] Potential remplacement by CBFERT;
[3] Potassium Chloride;
[4] Triple Superphosphate.

CROPS		VEGETABLE MIX (tomatoes / peppers)	
production			18,360
+ imports	mt/y	I	
current supply gap	%	CSG	0%
= total demand	mt/y	AD	18,360
MAIN FERTILIZER 1		H_3PO_4	
specific consumption	tMF1/tProduct	mf1	0.0059
required total demand = (AD)*mf1	mt/y	RTD-MF1	109
MAIN FERTILIZER 2		HNO_3	
specific consumption	tMF2/tProduct	mf2	0.0151
required total demand = (AD)*mf2	mt/y	RTD-MF2	278
MAIN FERTILIZER 3		$Ca(NO_3)_2$	
specific consumption	tMF3/tProduct	mf3	0.0226
required total demand = (AD)*mf3	mt/y	RTD-MF3	416
MAIN FERTILIZER 4		$MgSO_4$	
specific consumption	tMF4/tProduct	mf4	0.0007
required total demand = (AD)*mf4	mt/y	RTD-MF4	12
MAIN FERTILIZER 5		KNO_3	
specific consumption	tMF5/tProduct	mf5	0.0003
required total demand = (AD)*mf5	mt/y	RTD-MF5	6
MAIN FERTILIZER 6		K_2SO_4	
specific consumption	tMF6/tProduct	mf6	0.0179
required total demand = (AD)*mf6	mt/y	RTD-MF6	329
MAIN FERTILIZER 7		Baifolan Forte[1]	
specific consumption	t MF7 / t Product	mf7	0.0004
required total demand = (AD) * mf7	mt / y	RTD-MF7	7
MAIN FERTILIZER 8		Turba rubia	
specific consumption	t MF8 / t Product	mf8	0.0092
required total demand = (AD) * mf8	mt / y	RTD-MF8	168

[1] Bayfolan can be potentially replaced by CBFERT.

4.4 Summary and strategic outlook

Figure 20: Main elements of an outline approach for a niche strategy

The text in previous sections provides an outline approach for a niche strategy, according to which, the elements shown in Figure 20 should be taken into account.

The project will try to take advantage of Cuba´s specific capabilities to capitalize on the opportunities presented. This applies especially to the newly developed, innovative CBFERT, which is a complex fertilizer with significant export potential.

The above tables, which specify the fertilizer mix for prioritized and important crops and the conditions of the above niche strategy outlined, suggest closer consideration of Calcium Nitrate and Bayfolan as high-value liquid fertilizers. Furthermore, it is worth noting that, for the pragmatic and rapid conversion of the niche strategy, Cuba already possesses a solid R&D base, extending even to trial production volumes, and has some application-based experience with two most important fertilizers, as detailed below:

1. **Liquid calcium nitrate**, with a production plant already delivering product to customers. This urgently requires complete refurbishment including significant quality, supply chain and application-consultancy improvements.
2. **Bayfolan**, whose substitute, **CBFERT**, has already been developed, and needs wider implementation.

The second stage of the project is partially dedicated to considering liquid calcium nitrate and CBFERT in more detail.

This approach was discussed with the Ministry of Agriculture of Cuba (MINAG), and resulted in a request not only to see the two new fertilizers offered to the market, but to develop a "system" of liquid fertilizers that would:

- include calcium and magnesium as soluble bases, and
- consider the production of the two fertilizers and all linked activities.

Developing linked activities is of the utmost importance, because it would allow a superior solution to be offered to end customers, who would be persuaded to use the fertilizers in their production processes.

Offering interlinked activities represents a major challenge, as it requires much better functioning of the whole value chain. To overcome current weaknesses, several steps are essential, as shown in Figure 21.

These activities are considered essential to give the products (soluble fertilizers based on Ca, Mg, etc. sources, and CBFERT as Bayfolan substitute) market-entry support in order to obtain reasonable "time to market" conditions.

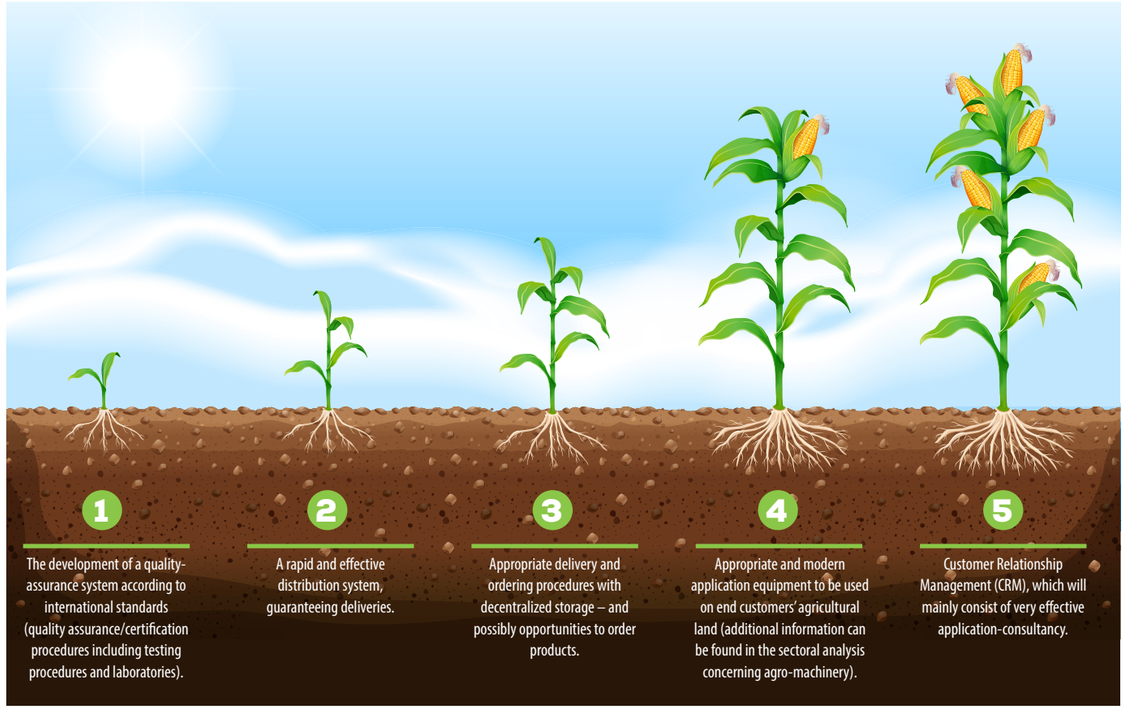


Figure 21: Steps required to overcome weaknesses to offer interlinked activities aimed at persuading customers to use ferttilizers in their production processes

Chapter 5

Sectoral Analysis of the Domestic Agro-Machinery Sector

Equipment and machinery production, in terms of its design and the amount required, follows the demand of crops, fertilizers and fertilization processes, as identified in the above outlined strategy. This was the reason why the issues relating to crops and fertilizers were analysed first. However, the importance of agricultural machinery can not be underestimated, since it is an integral part of the developed fertilizer niche strategy. In the end, the implementation of this strategy will also depend on appropriate application equipment for fertilizers.

Domestic machinery production, in particular the production of simple agricultural equipment, as a result of globalization of the market, is no longer positioned as it was before. Product performance with respect to application needs, based on design and associated application advantages, along with secure delivery, will be decisive.

The domestic agro-machinery industry relevant to this project is based on a newly created structure, and currently involves the players listed in Table 16 below.

PLAYERS
The Directorate General of Agricultural Engineering (MINAG);
The Department of Mechanization, Irrigation and Drainage (MINAG);
The holding company, "HOLMECA – empresa mecánica" (MINDUS), developed to take advantage of synergies and facilitate structural measures, which has resulted in it combining the activities of the following enterprises: • The enterprise "Heroes del 26 de Julio", with its diversified agro-machinery programme, including equipment for fertilization/fertigation; • The enterprise KTP, located in the same area, which specializes in equipment for sugar cane, including newly developed harvesters;
The Research and Development Institute, CEDEMA, responsible for providing the necessary designs, which will, later, be produced in the above enterprises (MINDUS).
The National Institute of Irrigation and Mechanization Research (IAGRI) within MINAG.

Table 16: Players involved in the domestic agro-machinery industry

HOLMECA is currently involved in a negotiation process to significantly improve its manufacturing base, working with Chinese partners. This will, in particular, allow "Heroes del 26 de Julio" to significantly improve its manufacturing/machining equipment and, at the same time, integrate a new business: the installation of an assembly line for tractors. It is expected that this partnership will also provide the training required to use the new equipment, including for the equipment-related manufacturing processes, as well as the introduction of a quality process extended to all manufacturing departments (foundry, forging, machining, welding and assembly). Since this training depends strongly on the delivered equipment, it is usually included with deliveries of equipment in international contracts, and it is assumed that the chosen partner suppliers are capable of offering this as part of the package. A vocational training capability, operated as a separate department to the production may, therefore, become an important part of the sustainable performance and quality-improvement efforts of "Heroes del 26 de Julio".

Since this partnership will be supported by a loan from the Chinese partners, the aim should be to optimize its benefits, possibly by the transfer of agricultural-equipment related know-how. A similar situation arises for Nuevitas as a result of negotiations with GIAP (the Research and Design Institute of Industry and Nitrogen Products of Organic Synthesis), a partner from the Russian Federation. This UNIDO project will not interfere with any ongoing discussions with other partners. However, in the case of the particular request made by HOLMECA, this project will also advise on key areas of partnership where HOLMECA is seeking assistance.

HOLMECA´s enterprise, "Heroes del 26 de Julio", is highly relevant in terms of providing the necessary equipment in the outlined niche strategy. The Table 17 illustrates the production segments it covers.

SECTORS AND PRODUCTS	2009	2010	2011	2012	2013	2014	2015
EQUIPMENT AND IMPLEMENTS FOR CULTIVATING CROPS	639	541	422	405	740	718	346
AGRICULTURAL TOWS	94	290	317	16	54	60	38
PLOUGHS	739	7,996	5,763	208	222	412	258
HARROWS	377	812	1,279	150	161	164	401

Table 17: Selected manufacturing outputs for agricultural products[21]

5.1 Fertilization and fertigation equipment for liquid fertilizers

The above segment, "Equipment and implements for crops," also includes the sub-segment "Fertilization and fertigation equipment for liquid fertilizers," which is an important component of the outlined niche strategy. In accordance with MINAG´s recommendation to develop a complete system concerning the optimized application of liquid fertilizers, improvements to existing equipment solutions, and the application of modern technology, using best-practice principles, will play an important role.

However, it has to be borne in mind that the domestic agro-machinery industry suffers from several weaknesses. Despite some domestically-developed designs, the agro-machinery industry has lost its position in the market, for the application of solid granulated fertilizers on fields, to international competitors.

The domestic agro-machinery industry can supply simple equipment for the application of liquid fertilizers, but consideration needs to be given to whether this equipment can meet the challenges of modern fertilization/fertigation by assessing dosing requirements, measuring soil and nutrition demands, etc., avoiding over-fertilization, and the ability to meet the needs for cost-effective application of, what can

[21] Source: ONEI.

be, very expensive fertilizers. The logic of liquid-fertilizer use determines the conditions that must be observed when upgrading the associated agricultural machinery.

In order to achieve this goal, it may be advantageous for HOLMECA to consider additional partnerships on technology, production and sales (including potential exports to achieve a "critical size" for production and marketing).

With regard to such partnerships, experiences in comparable markets have already been exchanged with HOLMECA. The scope for potential cooperation to overcome current weaknesses was outlined, and appropriate support, drawing on the international position of UNIDO, offered.

The areas for improvement identified are shown in Figure 22 below.

Figure 22: Areas of improvement identified for agricultural machinery upgrade

In meetings with CEDEMA it was confirmed that an appropriate development programme is possible, in which over-fertilization should be prevented and cost-effectiveness assured. Moreover, there is a need to adapt the equipment, taking into account the needs and requirements of the stakeholders and production inputs listed in Table 18 below.

▶▶ The selected market segments (for example, greenhouse farming;
▶▶ The selected crops;
▶▶ The types of selected customers (for example, small, medium or large farms).

Table 18: Needs and requirements of the stakeholders and production inputs for equipment adaptation

Following these considerations, CEDEMA is prepared to undertake appropriate development work for which a specification will be developed within this project, under the condition that it provides an equipment concept that meets current best-practice requirements. Through capacity building, this project will provide appropriately designed contributions to meet the needs for the niche strategy set out above.

Based on the niche strategy outlined, the development and manufacturing capabilities of the above enterprises were analysed. The result was that the required equipment – as part of the complete "system" value chain of liquid fertilizer application (see above) – can be developed in CEDEMA – including the mechanical parts which can be produced, assembled and distributed in form of complete deliveries, ready for use by Heroes del 26 de Julio. Whether further cooperation opportunities should be sought will depend on the final design and set up of the equipment. This could be the case for the delivery of products, or if controlling, measuring and dosing adjustments are required.

One of the tasks of the project is to develop a clear specification regarding technological objectives by considering application requirements and design criteria. These are the basis for a development order to be provided to CEDEMA, which will consider the manageability of the specified requests.

Accordingly, the objective for CEDEMA will be to develop the fertilization/fertigation equipment that is best suited to applying the suggested liquid fertilizer programme, in accordance with international best practice.

Conclusion

Sectoral Analysis

The project **"Technological and Enterprise Upgrading Programme on Agrochemicals and Agricultural Machinery Production Sector"** aims to reduce food shortages in Cuba. Local producers are currently not able to fully satisfy domestic demand, which has added to the import dependency of Cuba. By the end of the project, strengthened institutions and producers will be able to produce healthier food of better quality, and in higher quantities, to serve the needs of the native population and growing tourism sector.

The present sectoral analysis is an important step towards achieving this goal. The analysis clarifies and quantifies the challenges for the fertilizer industry which need to be addressed by the UNIDO project. The study carefully examined the relationship between the production of food and the production/use of fertilizers, with special consideration of the potential to substitute for current imports. Moreover, a quantified relationship between the production of crops, demand of crops, and the fertilizers required, using average specific consumptions and yields, has been established.

The analytical studies performed resulted in the development of the niche strategy outlined above, promoting the development and implementation of liquid fertilizer production and application systems, and considering the elements listed in the fololwing table:

- The response to market demands for staple foods, as well as for, the strongly-promoted greenhouse cultivation
- A fast and pragmatic conversion of the opportunities presented into realistic implementation, based on available know-how
- Replacement of imports, and the associated expenditure, by domestically produced fertilizers, based on locally-available raw materials
- The opportunity to develop a proprietary position for Cuba, which may even lead, in the future, to it being an exporter, potentially working with an appropriate partner
- Reasonable investments, allowing a timely implementation of the niche strategy developed

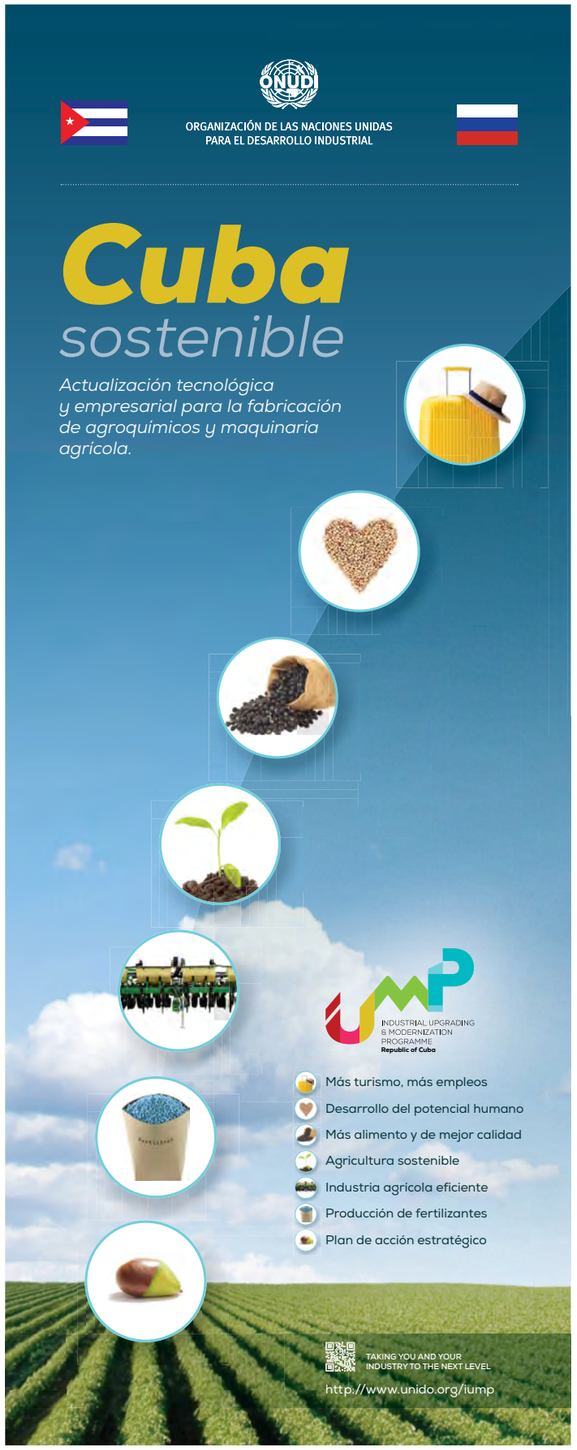
As a result, a road map for investment implementation of the intended calcium nitrate and CBFERT, as liquid fertilizers, can be drawn from the study.

The study reveals the potential of a liquid fertilizer system. The innovative approach of using CBFERT as an alternative to Bayfolan represents a current window of opportunity, from which the project will benefit. Another major opportunity arises from the interest of the Cuban authorities in fostering the construction of greenhouses, which will increase demand for the fertilizers identified, and for agricultural machinery.

Important and prioritized crops which will benefit from the newly designed fertilizer system have been identified, which will help minimize import dependency. The production of beans, maize, rice and vegetables, in particular, will be supported throughout this project. This is in line with the FAO's nutritional recommendations for healthy living. Moreover, the supporting project contributes to the achievement and implementation of the Sustainable Development Goals (SDGs), in particular SDGs 2 and 9.

Acronyms

AD	Additional demand
Ca	Calcium
$Ca(NO_3)_2$	Calcium Nitrate
CEDEMA	Research and Development Institute (Centro de Desarrollo de la Maquinaria Agrícola)
CPF	Country Programme Framework
CP	Country Programme
CRM	Customer Relation Management
FAO	Food and Agriculture Organization of the United Nations
GAIG	Grain Agro-industrial Group (Grupo Agroindustrial de Granos)
GDP	Gross Domestic Product
GIAP	Research and Design Institute of Industry and Nitrogen Products of Organic Synthesis
GESIME	Cuban Ferrous Metallurgy and Machine Building Enterprise Group (El Grupo Empresarial de la Industria Sidero Mecánica)
GEIQ	Cuban Chemical Industry Enterprise Group
ha	Hectare
HNO_3	Nitric Acid
H_3PO_4	Phosphoric Acid
HQ	Headquarter
IFA	International Fertilizer Industry Association
IAGRI	National Institute of Irrigation and Mechanization Research
IUMP	Industrial Upgrading and Modernization Programme
KCl	Potassium Chloride
kg	Kilogram
KNO_3	Potassium nitrate
K_2SO_4	Potassium Sulphate
$MgSO_4$	Magnesium Sulphate
mf	Main fertilizer
MINAG	Ministry of Agriculture of Cuba
MINDUS	Ministry of Industry of the Republic of Cuba
MINCEX	Ministry of Foreign Trade and Investment of the Republic of Cuba
Mg	Magnesium
MP	Mega Pesos (1.000)
N.A.	Not Available
NH_4NO_3	Ammonium Nitrate
NPK	Nitrogen-Phosphorous-Potassium
ONEI	National Office of Statistics and Information (Oficina Nacional de Estadística e Información)
R&D	Research and Development
RTD	Required Total Demand
SDG	Sustainable Development Goal
t	Tons
TSP	Triple Superphosphate
UNIDO	United Nations Industrial Development Organization
WHO	World Health Organization
y	Year
$ZnSO_4$	Zinc Sulphate


ONUDI
ORGANIZACIÓN DE LAS NACIONES UNIDAS
PARA EL DESARROLLO INDUSTRIAL
Cuba
sostenible
Actualización tecnológica
y empresarial para la fabricación
de agroquímicos y maquinaria
agrícola.
INDUSTRIAL UPGRADING
& MODERNIZATION
PROGRAMME
Republic of Cuba
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Desarrollo del potencial humano
Más alimento y de mejor calidad
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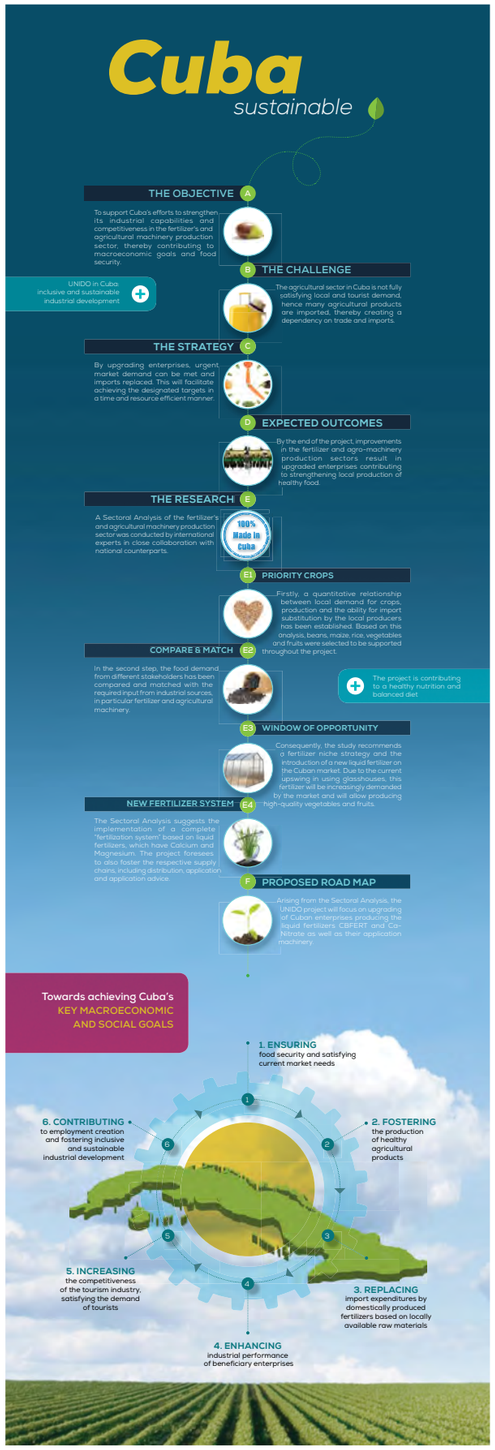
Cuba
sustainable
THE OBJECTIVE A
To support Cuba's efforts to strengthen its industrial capabilities and competitiveness in the fertilizer's and agricultural machinery production sector, thereby contributing to macroeconomic goals and food security.
UNIDO in Cuba
inclusive and sustainable
industrial development
B THE CHALLENGE
The agricultural sector in Cuba is not fully satisfying local and tourist demand, hence many agricultural products are imported, thereby creating a dependency on trade and imports.
THE STRATEGY C
By upgrading enterprises, urgent, market demand can be met and imports replaced. This will facilitate achieving the designated targets in a time and resource efficient manner.
D EXPECTED OUTCOMES
By the end of the project, improvements in the fertilizer and agro-machinery production sectors result in upgraded enterprises contributing to strengthening local production of healthy food.
THE RESEARCH E
A Sectoral Analysis of the fertilizer's and agricultural machinery production sector was conducted by international experts in close collaboration with national counterparts.
100% Made in Cuba
E1 PRIORITY CROPS
Firstly, a quantitative relationship between local demand for crops, production and the ability for import substitution by the local producers has been established. Based on this analysis, beans, maize, rice, vegetables and fruits were selected to be supported throughout the project.
COMPARE & MATCH E2
In the second step, the food demand, from different stakeholders has been compared and matched with the required input from industrial sources, in particular fertilizer and agricultural machinery.
The project is contributing to a healthy nutrition and balanced diet
E3 WINDOW OF OPPORTUNITY
Consequently, the study recommends a fertilizer niche strategy and the introduction of a new liquid fertilizer on the Cuban market. Due to the current upswing in using glasshouses, this fertilizer will be increasingly demanded by the market and will allow producing high-quality vegetables and fruits.
NEW FERTILIZER SYSTEM E4
The Sectoral Analysis suggests the implementation of a complete "fertilization system" based on liquid fertilizers, which have Calcium and Magnesium. The project foresees to also foster the respective supply chains, including distribution, application and application advice.
F PROPOSED ROAD MAP
Arising from the Sectoral Analysis, the UNIDO project will focus on upgrading of Cuban enterprises producing the liquid fertilizers CBFERT and Ca-Nitrate as well as their application machinery.
Towards achieving Cuba's
KEY MACROECONOMIC
AND SOCIAL GOALS
1. ENSURING
food security and satisfying current market needs
2. FOSTERING
the production of healthy agricultural products
3. REPLACING
import expenditures by domestically produced fertilizers based on locally available raw materials
4. ENHANCING
industrial performance of beneficiary enterprises
5. INCREASING
the competitiveness of the tourism industry, satisfying the demand of tourists
6. CONTRIBUTING
to employment creation and fostering inclusive and sustainable industrial development

Inclusive and Sustainable Industrial Development

INDUSTRIAL UPGRADING & MODERNIZATION PROGRAMME

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

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