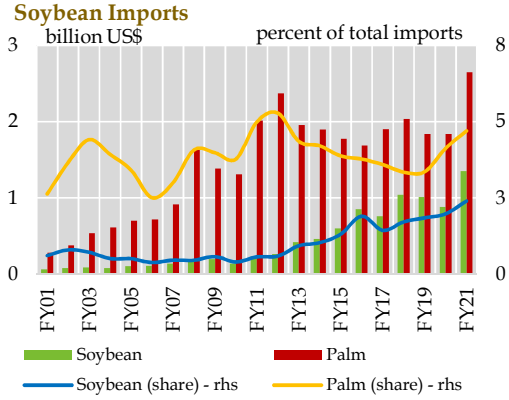
Special Section: Pakistan's Rising Palm & Soybean Imports: Understanding the Drivers and Challenges to Domestic Oilseed Production[1]

Pakistan's reliance on imports for edible oil and oilseed meals to meet domestic demand consumption has been increasing over the past two decades: 86 percent of domestic edible oil consumption in 2020 came from imports up from 77 percent in 2000; in case of oilseed meal, imports contributed 58 percent in 2000 compared to 20 percent in 2000. Within the edible oil and oilseeds category, palm and soybean imports form 90 percent of the total category imports in value terms, and 87 percent in quantity terms. However, policy focus on both these agriculture commodities has been lacking. This special section sheds light on the drivers of rising palm and soybean imports where growing demand pressures from inter alia increasing population, rising per capita consumption and gradual modernization of poultry industry has outpaced the domestic supply which has been eroding mainly on account of weak policy focus on oilseed crops. Whilst discussing overarching constraints to oilseed production in the country, this special section also explores the prospects of palm and soybean where the key finding is that palm does not have much potential in Pakistan in the short to medium term, whereas soybean can be produced at large scale in the medium term if policy support is provided. Lastly, it offers broad policy directions to be explored to arrive at long-term solutions to rising import dependence for edible oil and meals.

S1.1 Introduction

Pakistan's palm and soybean-related imports stood at US$ 4 billion in FY21, rising by 47 percent year-on-year, compared to compound average growth of 12.3 percent in the last 20 years. While in part this increase stems from rising international commodity prices, the rise in palm and soybean imports is not a new phenomenon. The combined imports of palm and soybean have been growing noticeably over the last twenty years, rising to 7.1 percent of total imports in FY21 from 3.2 percent in FY01. **(Figure S1.1)**. Currently, palm and soybean products are among the top 10 commodities (at 8-digit HS Code level) imported by the country. [2]

Trend in Pakistan's Palm and Soybean Imports **Figure S1.1**



Source: Pakistan Bureau of Statistics

[1] This special section draws on discussions with various oilseed related stakeholders, including the Pakistan Oilseed Board (formerly Pakistan Oilseed Development Board); Federal Seed Certification and Registration Department; National Agriculture Research Centre; Ayub Agricultural Research Institute; Sindh Coastal Development Authority (SCDA); Dr Sohail Jehangir Malik, Innovative Development Strategies; Dr Yusuf Zafar, former chairman Pakistan Agriculture Research Council; Dr. A. W. Gandahi honorary consultant to SCDA, Pakistan Poultry Association; All Pakistan Solvent Extractor Association; Pakistan Edible Oil Refiners Association; and International Food Policy Research Institute

[2] Harmonized System (HS) code is an internationally accepted system to codify tradable commodities in various categories and sub-categories, where 2-digit HS code refers to main category and 8-digit HS code refers to most granular sub-category.

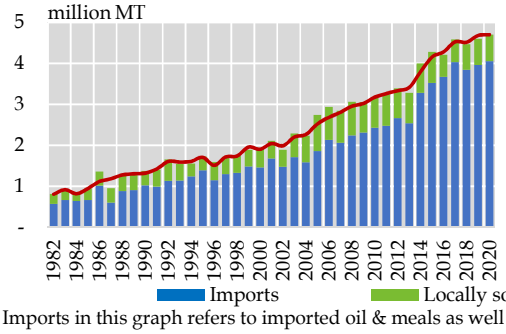
Several demand and supply factors are driving the imports of palm and soybean, which constitute the bulk of Pakistan's total imports of oilseeds and their products in both value and volume terms. In terms of value, palm and soybean products constitute 90 percent of total edible oil and oilseeds imports. In quantity terms, total imports of oilseeds and its products surpassed 7 million metric tons in FY21, 87 percent of which comprised palm and soybean. The remaining 13 percent comprised rapeseed, sunflower, groundnut, copra and other oilseeds and related products.

At the one end, the demand for edible oil and oilseed products has been rising due to increasing population, growing income levels, and the gradual modernization of livestock industry, particularly poultry. At the other end, local oilseed production has been unable to keep pace with increasing domestic demand for edible oil and oilseed products (including meals for animal feed). During the last 15 years, the local production of edible oil has registered negative average annual growth of 1.2 percent, while the demand per capita has increased by 2.3 percent,[3] leading to increasing reliance on imports for both edible oil and meals **(Figure S1.2)[4].**

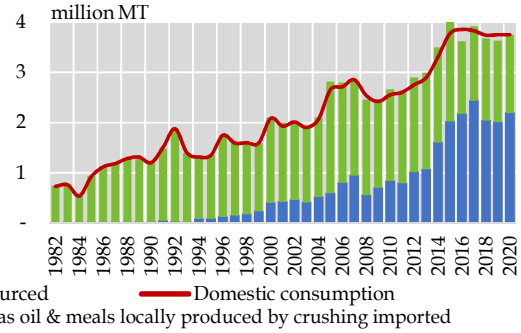
However, Pakistan's growing reliance on palm and soybean is not out of sync with global consumption patterns of edible oil and meal, which is also dominated by palm oil and soybean oil in the edible oil category, and soybean in the meal category (**Figure S1.3a and b**).

Even among countries that are largest producers of rapeseed/canola and sunflower – which are the third and fourth most consumed vegetable oils in the world - palm and soybean oil have noticeable shares in their respective edible oil consumption. This is true even among countries that have low edible oil consumption and are among biggest producers of rapeseed and sunflower **(Figure S1.4).**

Historical Trend of Demand and Supply of Edible Oil in Pakistan **Figure S1.2a**



Historical Trend of Demand and Supply of Oilseed Meal in Pakistan **Figure S1.2b**

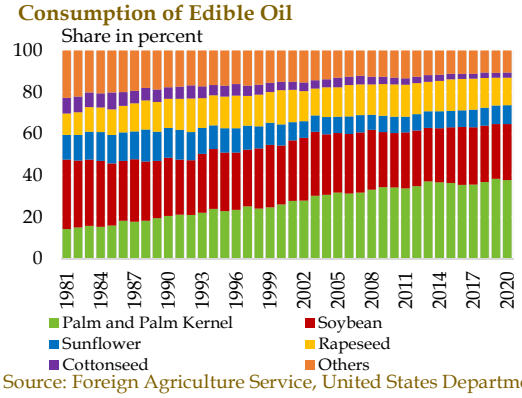


Imports Locally sourced Domestic consumption

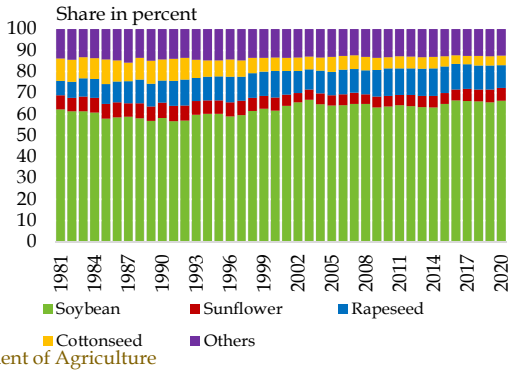
Imports in this graph refers to imported oil & meals as well as oil & meals locally produced by crushing imported oilseeds. Locally sourced only includes oil & meals locally produced by crushing oilseeds grown in Pakistan.
Note: The figure does not account for variation due to beginning and ending stocks.
Source: Foreign Agriculture Service, United States Department of Agriculture

[3] Pakistan Oilseed Development Board (2019). *National Oilseeds Enhancement Program, Umbrella PC-1 for Planning Commission of Pakistan.* Islamabad: Pakistan Oilseed Development Board, MNFSR
[4] In all the figures based on USDA data sets, the years on the horizontal axes represent the Oct-Sep period, with 2020 constituting Oct-19 to Sep-20 period.

Breakdown of Global Consumption of Edible Oil **Figure 1.3a**

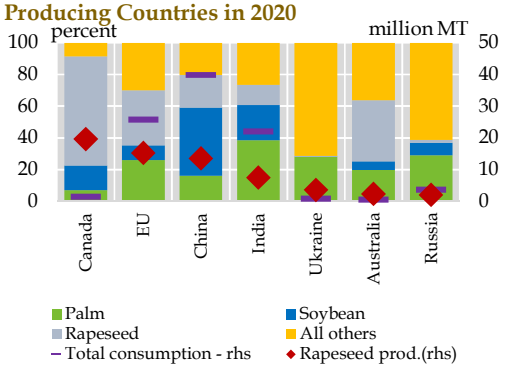


Breakdown of Global Consumption of Oilseed Meal **Figure 1.3b**

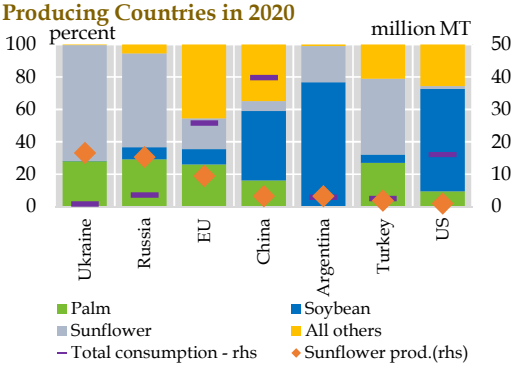


Source: Foreign Agriculture Service, United States Department of Agriculture

Share of Palm and Soybean oil Consumption in Top-7 Rapeseed Producing Countries in 2020 **Figure S1.4a**



Share of Palm and Soybean oil consumption in Top-7 Sunflower Producing Countries in 2020 **Figure S1.4b**



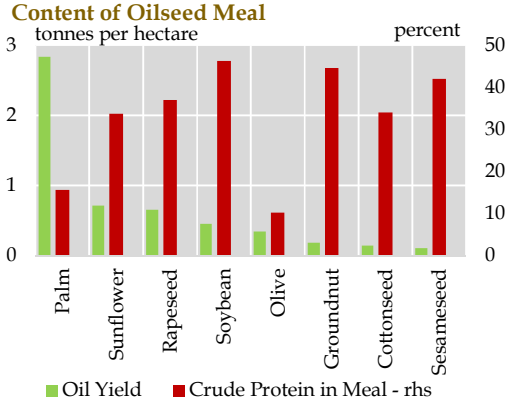
Source: Foreign Agriculture Service, United States Department of Agriculture

This global consumption pattern stems from high resource use efficiency of palm and soybean, measured in terms of oil yield per hectare for oil, and protein yield in the case of meals. The former is important to meet the requirements of growing human population. The latter is important to sufficiently feed livestock (poultry, ruminants and others), since protein-based meals enable faster and healthy growth of livestock animals **(Figure S1.5).**[5]

Contrary to global trends, there has been little focus on palm and soybean in Pakistan. Various five years plans since 1955 have highlighted and proposed the need to focus on soybean and other oilseeds. However, lack of consistent policy has prevented oilseed crops, particularly soybean, from taking off. On the other hand, whilst initial surveys and pilots on palm began in the mid-90s, palm started featuring in policy documents only after 2005. However, so far

[5] Different meals have different nutritional compositions. The protein content in the meal, along with its digestibility and mix of amino acid, dictate its usage in livestock.

Oil Yield of Oilseeds and Protein Content of Oilseed Meal **Figure S1.5**



Source: Our World in Data and INRA-CIRAD-AFZ feed tables

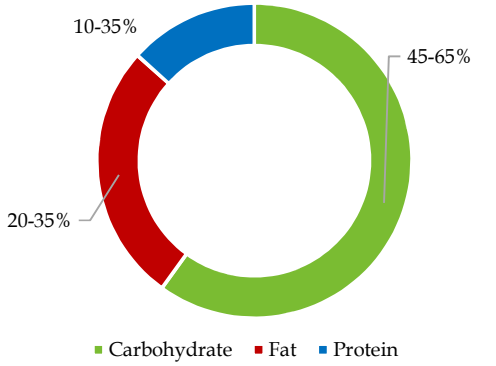
policy efforts with long-term focus have not been undertaken for oil palm plantation. These trends pose the question whether or not Pakistan can grow palm and soybean in the country. Accordingly, this Special Section first looks at the demand drivers of edible oil and oilseeds (**Section S1.2**), including rising population and per capital income, which are expected to further rise over the next 20 years. Supply-side factors are discussed in **Section S1.3** with a focus on overarching challenges to the oilseed sector in Pakistan, stemming from lack of consistent policy and institutional constraints. **Section S1.4** sheds light on the prospects of growing palm and soybean in the country. Drawing on the work of local agricultural research institutes, the section highlights that oil palm plantation does not seem to have potential in Pakistan in the short to medium term of 5-10 years, whereas soybean can be produced at large scale in the medium term if policy support is provided. **Section S1.5** summarizes the findings, and offers broad policy direction needed to be explored for short- and long-term solutions to the problem of rising edible oil & oilseeds import bill.

S1.2 Demand Drivers

Oilseeds are an essential part of the human diet, making them one of the vital crops from the lens of food security. Generally recognized, Acceptable Macronutrient Distribution Range (AMDR) entails that in a healthy diet 35-55 percent of total calories should come from proteins and fats **(Figure S1.6)**. One of the significant sources for both these macronutrients is oilseeds. The two products extracted from oilseeds are edible oil and the residual, which is either used directly as meal or is otherwise processed into oilseed-based meal. Oils are the direct source of fats for human consumption, whereas meals are used as feed for poultry, ruminants and other livestock, and aquaculture, which in turn are primary source of animal protein and other nutrients necessary in the human diet **(Figure S1.7).**

In addition, the oil from oilseeds is used by both food and non-food industries such as biscuits, tea whitener, soap, cosmetics, pharmaceuticals, paint, fertilizer and biodiesel.[6] Due to its pivotal role in dietary needs and use in multiple industrial

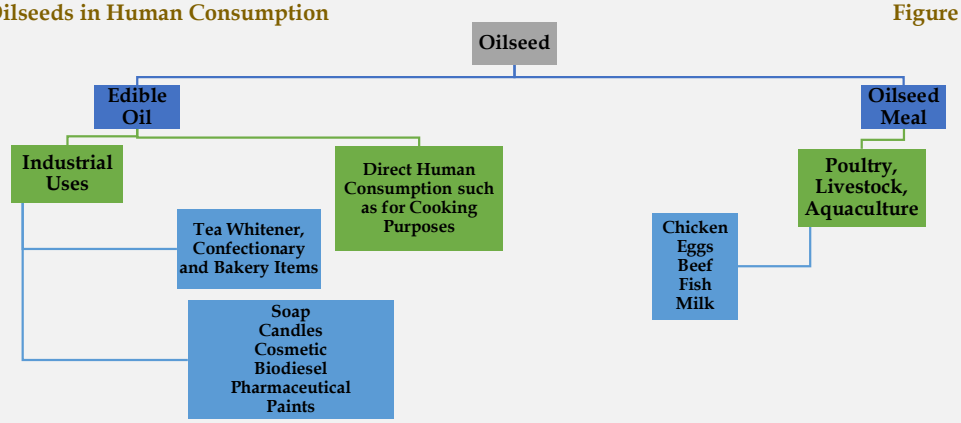
Acceptable Macronutrient Distribution Ranges (AMDR) **Figure S1.6**



Source: National Academy of Medicine, USA

[6]A. Abiodun (2017). "The Role of Oilseed Crops in Human Diet and Industrial Use." In P. Ahmad (eds.) "Oilseed Crops: Yield and Adaptations under Environmental Stress ", New Jersey: Wiley

Oilseeds in Human Consumption **Figure S1.7**



Source: R.J. Mailer (2006). "Oilseeds: Overview." In C. Wrigley, H. Corke, K. Seetharaman, and J. Faubion (eds.), "Encyclopedia of Food Grains (Second Edition)" pp. 221-227.

products, global consumption of oilseeds has increased manifold since the 1980s, with more than 600 million tons consumed in 2019 (**Figure S1.8)**.

Although Pakistan's share in global oilseed consumption is a marginal 1.1 percent, it follows the same growth trend, with domestic consumption up 3.5 times over 1981. The increase is driven by a rise in demand for both edible oils and oilseed meals.

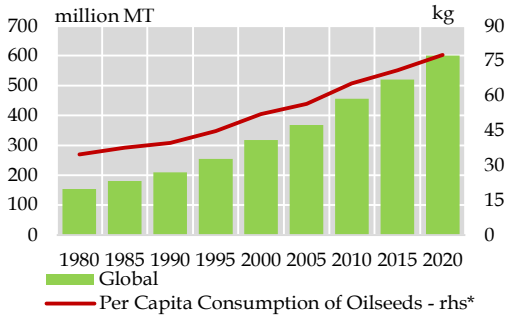
Edible Oils

Edible oil consumption in Pakistan has increased significantly over the last few decades: from 0.7 to 4.7 million tonnes between 1981 and 2020. The main demand drivers are rising population, dietary preferences and increase in per capita income.

Drivers of Growth

Pakistan's rising demand for edible oil is driven in part by high population; the

Global Consumption of Oilseeds **Figure S1.8**



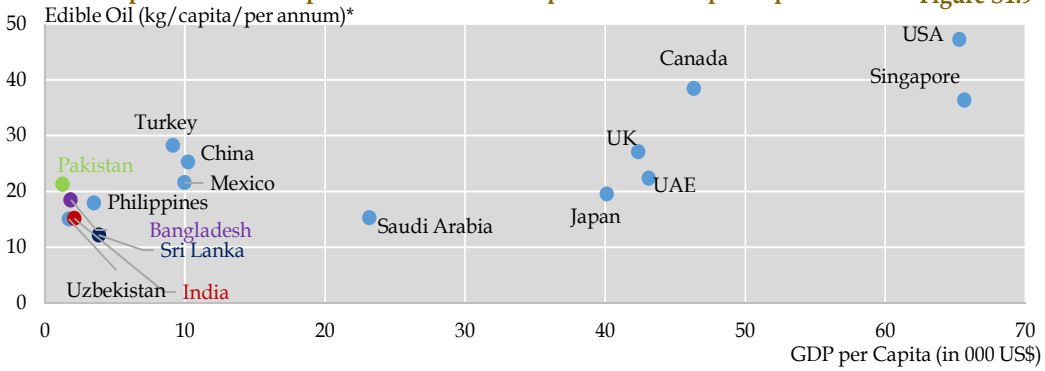
*Calculated by dividing total oilseed consumption data from USDA by total world population data from WB

Source: Foreign Agriculture Service, USDA and World

country is fifth most populous in the world, with population growing at a rate of 2.1 percent over the last two decades.[7] However, while the country's estimated per capita edible oil consumption is lower compared to high income countries like the USA, Canada and Singapore, amongst the countries with similar income levels, Pakistan's per capita oil consumption is comparatively high **(Figure S1.9)**.

[7] World Development Indicators, World Bank

Relationship between Per Capita Edible Oil Consumption and GDP per Capita **Figure S1.9**



*per capita edible oil consumption is calculated using consumption data from USDA and population data from WB

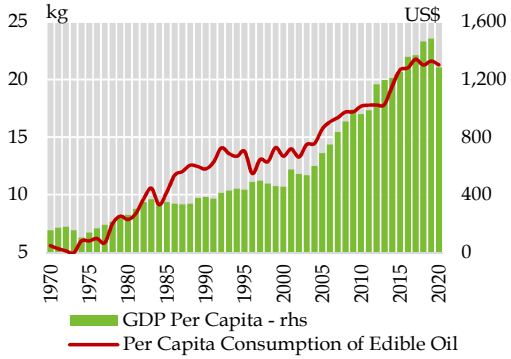
Source: Foreign Agriculture Service, United States Department of Agriculture and World Bank

The country's per capita consumption is also higher than India and Sri Lanka, which have comparable dietary preferences and have relatively higher GDP per capita. Since approximately 96 percent of the edible oil consumed in the country is used for food purposes,[8] this difference in per capita consumption implies consumer preference for higher use of oil in food at household and commercial level.[9]

There has also been growth in per capita consumption of edible oil in Pakistan over the years, growing in tandem with rising GDP per capita since vegetable oils are highly responsive to income growth and one of the cheapest source of fat and protein (**Figure S1.10**).[10]

This trend is reaffirmed by income quintile data from Household Integrated Economic Survey (HIES), as indicated in **Figure S1.11**. However, it is important to note that while

Per Capita Consumption of Edible Oil in Pakistan **Figure S1.10**



Source: Foreign Agriculture Service,USDA and World Bank

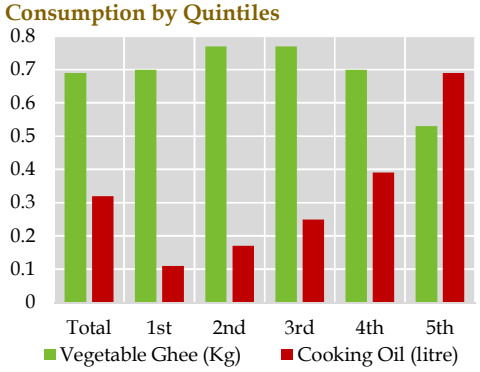
the overall demand increases with the increase in income, the composition of the consumption changes across the income level. For the 3rd, 4th and 5th quintile (top 60 percent), with rising income, per capita consumption of ghee reduces and that of cooking oil increases.

[8] Calculated from USDA datasets. Consumption data includes household, commercial and industrial consumption. Data for commercial usage of edible oil, and food-non-food classification of industrial usage is not separately available.

[9] Anecdotal evidence suggests that demand for oil is also increasing due to growth in fast food chains in urban areas.

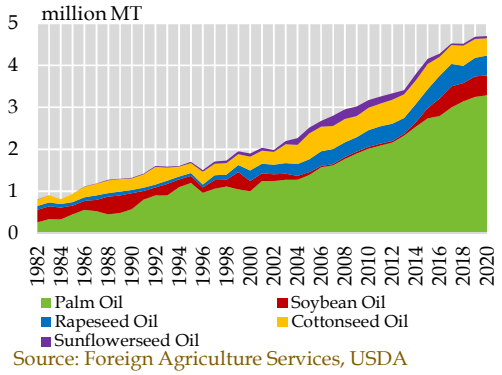
[10] Indian Institute of Palm Oil Research (2015). *Vision 2050*. New Delhi: Indian Council of Agricultural Research.

Pakistan's Monthly Per Capita Consumption by Quintiles **Figure S1.11**



Source: HIES 2018-2019 , Pakistan Bureau of Statistics

Pakistan's Commodity-wise Consumption of Oil **Figure S1.12**



Source: Foreign Agriculture Services, USDA

This suggests that after a certain income level, the gains in household income result in substitution of vegetable ghee with softer vegetable oils.[11] This behaviour can be due to the perceived health benefits attached to soft oil as against the negative effect of trans fat in vanaspati ghee.[12] Despite consumer preferences tilting towards cooking oil in higher income groups, vegetable ghee consumption is higher than that of cooking oil at household level in Pakistan.[13]

Trend in Commodity-wise Consumption of Edible Oils

The higher consumption of vegetable ghee is also reflected in the category-wise data of edible oil consumption. Palm oil dominates, with a 70 percent share in total consumption in 2020 (**Figure S1.12**). Palm oil, a semi-solid oil, is the main ingredient for manufacturing vegetable ghee, for three main reasons. Palm oil and its variants are among the most used products to manufacture various consumer and non-consumer industrial products, ranging from confectionaries and margarines to toothpastes, grease and printing ink. It is also widely used in household cooking and baking, and its stability at higher temperatures makes it suitable for deep-frying as well.[14,15,16] Palm oil is also more

[11] Vegetable ghee is a (fully or partially) hydrogenated blend of hard and soft oil. Hard oils, for instance, palm and coconut oil, are semi-solid at room temperature. In contrast, soft oils such as soybean, sunflower, and rapeseed oil are liquid at room temperature. Through the process of hydrogenation liquid or semi solid fats are converted into solid fats by adding hydrogen.

[12] V. Dhaka, N. Gulia, K.S. Ahlawat and B.S. Khatkar (2011). "Trans fats- Sources, Health Risks and Alternative Approach - A Review", *Journal of Food Science and Technology*, 48(5):534-541.

[13] In comparison, the consumption of desi ghee is much lower. As per HIES 2018-19, desi ghee consumption was 0.01 kg/capita in Pakistan, down from 0.02 kg/capita in 2007-08. Even in rural areas, it fell from 0.03 to 0.01 kg/capita during this period.

[14] O.A. Abiodun (2017). The Role of Oilseed Crops in Human Diet and Industrial Use. In Oilseed Crops, P. Ahmad (Ed.)

[15] K.G. Berger (2003). "Palm Oil." In B. Caballero (eds.). "Encyclopedia of Food Sciences and Nutrition (Second Edition)" Cambirdge, Massachusetts : Academic Press

[16] Fairus, M., Hidzir, M. and H. M. Aspar (2013). The Palm Oil Market in Pakistan. *Palm Oil Developments No.59, p9-11.*

preferable in the country because of its cheaper price. In comparison with soft oils,[17] the price of palm has been consistently lower throughout the peaks and troughs in international edible oil prices (**Figure S1.13**).

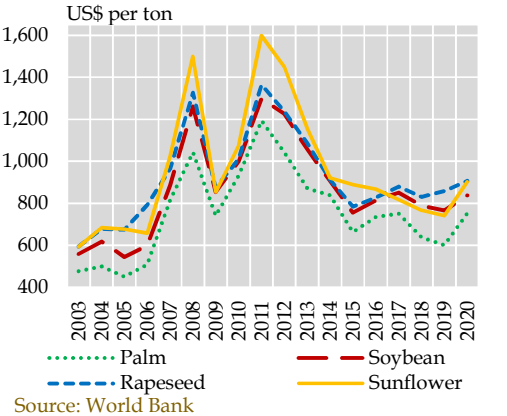
Cross-country comparison shows that like Pakistan, preference for palm oil consumption in India, Sri Lanka and Bangladesh is higher, compared to countries with much higher GDP per capita, where the consumption of soft oils is higher than that of palm oil (**Figure S1.14**). This is because most soft oils, although expensive than palm, contain unsaturated fat, which are comparatively more beneficial for health as they reduce the risk of cardiovascular diseases and improve blood cholesterol levels.[18] On the other hand, since palm oil is rich in saturated fats, the World Health Organization recommends it should be less than 10 percent of total calorie consumption.[19] Consumer awareness, combined with higher income levels and local production of alternative soft oils, are the reasons why palm oil consumption is relatively lower in these countries compared to countries with lower per capita income.

Demand Outlook for Edible Oils

Pakistan's per capita edible oil consumption is already higher compared to economies with similar income levels. In addition, increasing income levels may also translate in increased per capita consumption of edible oil, as will population growth. According to the UN's World Population Prospect 2019, at constant-fertility, the country's population in 2025 is set to reach 245 million, and 328 million by 2040. [20]

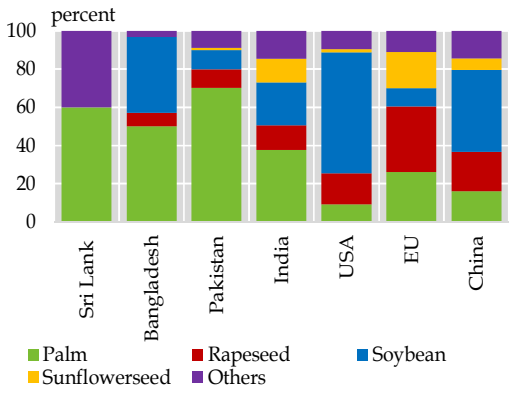
This implies that demand for edible oil will continue to increase noticeably in the coming

International Oilseed Prices **Figure S1.13**



Source: World Bank

Commodity-wise Consumption **Figure S1.14**



Source: Foreign Agriculture Service, USDA

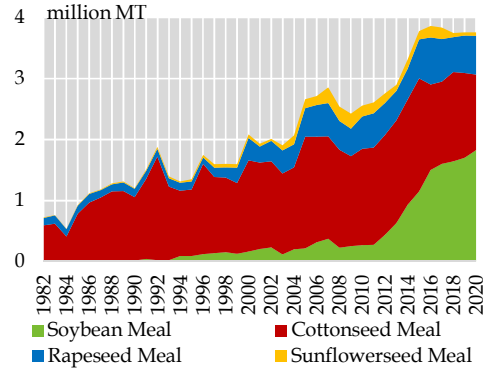
[17] Soft oils are liquid whereas hard oil are semi-solid at the room temperature.
[18] Harvard T.H. Chan, School of Public Health (www.hsph.harvard.edu/nutritionsource/what-should-you-eat/fats-and-cholesterol/types-of-fat/)
[19] World Health Organization (www.who.int/news-room/fact-sheets/detail/healthy-diet#:~:text=Energy%20intake%20(calories)%20should%20be,1%2C%202%2C%203).
[20] Even at low fertility rate, Pakistan's population is forecast to cross 240 million. (UN Department of Economic and Social Affair in World Population Prospects, 2019).

years. According to estimates by Pakistan Oilseed Department, total demand for edible oil in the country is conservatively expected to grow to 5.9 million tonnes in 2025-26, from 4.7 million tons in FY21. [21]

Oilseed Meal

Similar to the trend in demand for edible oil, the consumption of oilseed meal has also been increasing in Pakistan, having more than tripled between 1990 and 2020. As the entire meal consumed in the country is used as a source of plant-based protein in animal feed,[22] the growth in poultry, livestock, and aquaculture are primary drivers behind this surge in oilseed meal consumption, where poultry particularly stands out from the rest.

Commodity-wise Consumption of Oilseed Meal in Pakistan **Figure S1.15**



Source: Foreign Agriculture Services, USDA

The category wise trend indicates that consumption of soybean meal has increased over the years and that of cottonseed meal has declined. In 2020, the share of soybean meal stood at 49 percent whereas only 33 percent of total demand was met by cottonseed meal (**Figure S1.15**).

Demand Drivers of Oilseed Meal

i) Poultry

The increased use of soybean is due to the growth in poultry industry, coupled with high nutritional value of the soybean-based meal. Soybean meal offers better digestibility, quality mix of amino acids and has the highest protein content (around 44-50 percent) compared to all other oilseed meals.[23] These qualities make it a better feed ingredient for chicken in comparison to cottonseed.[24] Due to this limitation, the growth in poultry has not translated into increased use of locally produced, and relatively cheaper, cottonseed meal.

According to Pakistan Poultry Association (PPA) estimates for 2015-16, approximately 9.5 million tons of poultry feed was produced. [25] Of this about 20-30 percent comprised of oilseed meal the composition of which depends on price variances and various dietary factors.[26] This amounts to 2 to 2.8 million tonnes of meal consumption by

[21] Formerly Pakistan Oilseed Development Board (PODB)
[22] USDA dataset shows that approximately 100 percent of oilseed meal in Pakistan are used in feed.
[23] D. L. Hard (2004). "Innovative Developments in the Production and Delivery of Alternative Protein Sources", *Expert Consultation and Workshop on Protein Sources for Animal Feed Industry*. Rome: FAO
[24] S. Świątkiewicz, A. Arczewska-Włosek and D. Józefiak (2016). "The Use of Cottonseed Meal as a Protein Source for Poultry: An Updated Review", *World's Poultry Science Journal*, 72(3), 473-484.
[25] Pakistan Poultry Association (www.pakistanpoultrycentral.pk/poultry-status/, accessed on 28th Oct, 2021)
[26] Pakistan Poultry Association (www.pakistanpoultrycentral.pk/research-and-development/poultry-feed-ingredients-dont-get-confused/, accessed on 28th Oct, 2021)

the poultry industry for 2015-16, approximating to 52 to 73 percent of total meal consumed in the year.[27]

As the primary consumer, with compound average annual growth rate (CAGR) of 8.1 percent for poultry population for the last two decades, the poultry industry remains the leading driver of growing oilseed meal consumption. [28] The industry's growth can also be linked to the increase in per capita chicken consumption (**Figure S1.16**).

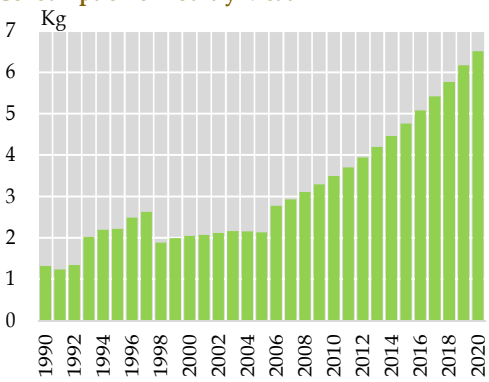
In addition to growing domestic demand for poultry, the poultry industry's modernization and advancement, as indicated by increased exports of chicken meat, has also influenced the demand mix of poultry feed with increased use of oilseed based meal corresponding with the take-off in chicken exports from 2010 onward **(Figure S1.17)**. According to USDA estimates, with modernization, meal inclusion rate of some poultry producers in Pakistan are even approaching the international standard of 35 percent.[29]

Further advancement and growth in the sector may lead to increased demand for soybean meal, in line with the meal consumption pattern of major poultry meat exporting countries. Top poultry exporters, regardless of whether or not they grow soybean crop in significant quantities, have sizable share of soybean meal in their overall consumption (**Figure S1.18**).

ii) Livestock & Aquaculture

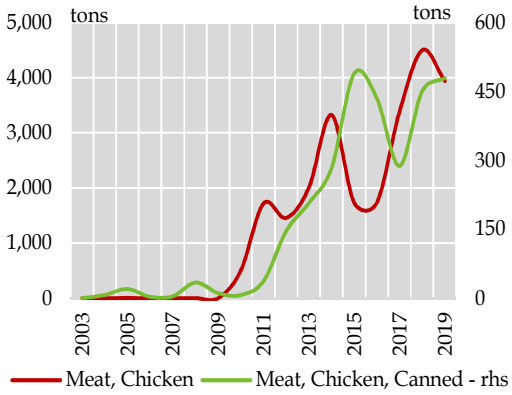
In addition to poultry, growth in per capita beef consumption and increase in population of other livestock animals[30] with a CAGR of 2.6 percent for FY02-21 period[31], are also contributors to the increased demand for oilseed meal in the country (**Figure S1.19**).

Pakistan's Annual Per Capita Consumption of Poultry Meat — **Figure S1.16**



Source: OECD-FAO Agriculture Outlook 2021

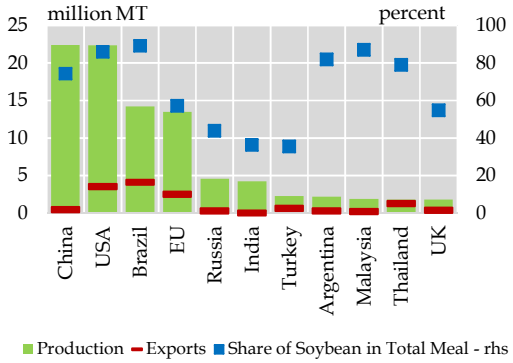
Pakistan's Chicken Exports — **Figure S1.17**



Source:Food and Agriculture Organization, UN

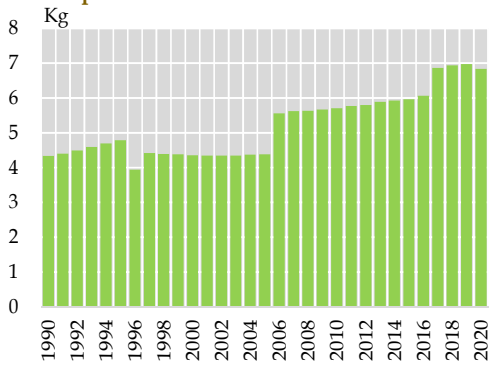
[27] The data for total meal consumed is from USDA data sets.
[28] Pakistan Economic Survey, 2021.
[29] USDA (2016). "*Oilseeds and Products Annual.*" GAIN Report NumberPK1607. Washington, D.C.: USDA
[30] Other livestock includes buffalo, cattle, goat, sheep, camels, asses, horses and mules.
[31] Pakistan Economic Survey, 2021

Use of Soybean Meal in Top Poultry Exporters and Producers **Figure S1.18**



Source: Agri Outlook (2021), OECD-FAO

Pakistan's Annual Per Capita Beef Consumption **Figure S1.19**



Source: OECD-FAO Agriculture Outlook 2021

This is because soybean meal is an important part of livestock feed since it is palatable for cows and has high amount of easily digestible energy.[32]

Currently, the livestock and dairy industry is still largely informal, with the dairy yields of the local breed being 6 to 8 times lower than the breeds in developed countries.[33] However, the livestock sector has started to formalize, with several formal sector dairy and meat brands surfacing over the last 10 years where investments in these sectors by leading local business groups is particularly noteworthy. Looking ahead, the federal government's plans to make Pakistan a hub for Halal meat exports, and focus on artificial insemination, production of proven sires, and other interventions to improve livestock breed aimed at dairy sector development.[34]

In addition, provincial governments are also making policy interventions to formalize and modernize meat and dairy industry (**Figure S1.20**).[35] These policies aim to improve animal nutrition and introduce modern breeding and livestock health care practices. In light of these livestock policy considerations, increasing imports of pure breeding cows and bovine semen (imported for the purpose of improving the genetics of local breeds) also point towards a gradual modernization of the livestock sector (**Figure S1.21**). These trends also point towards increasing usage of soybean meal in livestock feed in line with global feed practices.

Similarly, while aquaculture has historically remained a relatively small sector, the production of fish has also started to grow recently (**Figure S1.22**). However, the country has limited supply of fish meal and fish oil as feed for aquaculture, and going forward, any policy push towards higher production of fish and other aquaculture will

[32] Nutritional Value of Commonly Available Feed and Fodders in India (2012); Gujrat: National Dairy Development Board, India

[33] H. Shahid, O. Shafique and A. Shokat (2012). "Dairy Industry of Pakistan", *European Journal of Business and Management,* Vol 4, No.18.

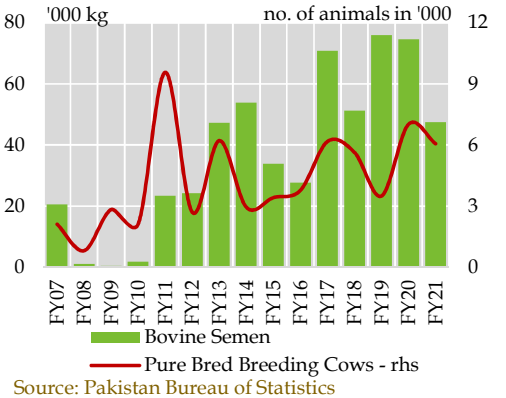
[34] Source: (a) Pakistan Halal Authority (www.pakistanhalalauthority.org.pk/AboutUs.aspx); (b) Planning Commission of Pakistan, 11th Five year plan (https://www.pc.gov.pk/web/yearplan)

[35] FAO (www.fao.org/pakistan/news/detail-events/en/c/1375087/)

Recent Laws and Regulations on Livestock **Figure S1.20**

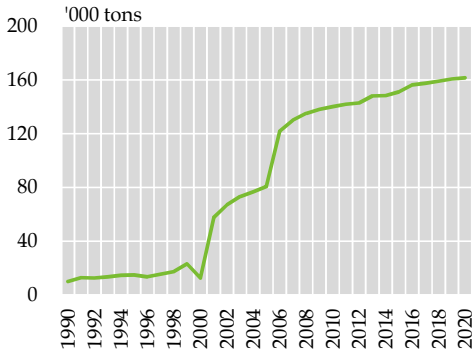
Sindh	Punjab
-Sindh Livestock Breeding Act. 2016 -To introduce Livestock Action Plan under Sndh Agriculture Policy (2018-30)	-Punjab Breeding Act, 2014 -The Punjab Animals Feed Stuff and Compound Feed Act 2016 -Punjab Livestock Policy (to be approved by cabinet) -Minimum Pasteurization Law under Punjab Pure Food Regulations, 2018 to come in force by July 2022
Balochistan	**KPK**
-Balochistan Livestock Policy, 2019.	-KPK Livestock Policy, 2018

Pakistan's Livestock Imports **Figure S1.21**



Source: Pakistan Bureau of Statistics

Production of Fish from Aquaculture in Pakistan **Figure S1.22**



Source: Agricultural Outlook 2021, OECD-FAO

increase the demand for fish feed. This may in turn have to be fulfilled by soybean meal, where it is pertinent to note that Fisheries Development Board has been holding feeding trials with soybean as protein in feed.[36,37]

S1.3 Supply-Side Factors

Over the last six decades, the government has planned, and rolled out various types of programs and initiatives to increase production of oilseed crops in the country. Starting from the first 5-year plan to the most recent one, the importance of increasing oilseeds crop production has been recognized both to reduce import bill, and to improve human and animal nutrition – the latter aimed at increasing livestock productivity.[38] Whilst most proposed measures have revolved around sunflower and rapeseed/canola, soybean has also featured in the plans since 1960s, whereas oil palm plantations have only recently garnered attention (**Table S1.1**).

[36] P. Patil, D. Kaczan, J. Roberts, R. Jabeen, B. Roberts, J. Barbosa, and S. Zuberi (2018). *Revitalizing Pakistan's Fisheries: Options for Sustainable Development.* Washington, D.C.: WB.
[37] MNFSR
[38] Planning Commission of Pakistan, various five year plans (www.pc.gov.pk/web/yearplan)

Oilseeds in Pakistan's Five Year Plans **Table S1.1**

5-year plans	Actions/Strategies
1st: 1955-60	Expanded program to develop suitable varieties of soybean in East & West Pakistan. Emphasis on high yielding varieties of ground nut, rapeseed, linseed & castor.
2nd: 1960-65	Recommends trials to investigate possibilities of growing soybean.
3rd: 1965-70	No mention of oil seeds.
4th : 1970-75	Notes that oilseeds can also be used to fortify existing food by creating food-grain flours. Proposes policies & programs for implementation of evolution, acclimatization, and introduction of high yielding varieties of both existing and new oilseed crops. Recommends support price for soybean. Targets 79% production increase in non-cotton oilseeds over plan period.
5th : 1978-83	Defines long-term objective: contain vegetable oil imports. Increase in cultivation area of oilseed crops and rigorous breeding programs improved variety of seeds for oilseed crops. Prioritized research work on sunflower, soybean, and safflower. First time support price announced for soybean & sunflower. Targets 60% production increase in non-cotton oilseeds over plan period.
6th : 1983-88	Notes difficulty in bringing reforms in oilseed crops. Highlights that soybean provides most promising potential for efficient growth of poultry & livestock. Major emphasis on rapid expansion of oilseed crops for human & animal consumption. Crash program for increased output of edible oil seeds with heavy emphasis on soybean crop. Link farmers with National Commodity Board.
7th : 1988-93	Notes that previous plan failed to improve production of oilseed crops due to absence of comprehensive oilseed project. Proposes incentives to farmers in the form of assured prices and financial/technical assistance. Accelerate research on high yielding variety.
8th : 1993-98	Notes that previous plans did not result in significant improvement in oilseed. Targets breakthrough in oilseeds & doubling of production.
Medium Term Development Framework 2005-10	Targets 50% growth in domestic oilseed production, through: (a) high yielding varieties and improved research/extension services for sunflower/canola; and (b) increasing area under cultivation, such as replacing late sown wheat with sunflower. Large scale plantation of oil palm in coastal areas of Sindh & Balochistan also proposed along with olive in KP & other suitable areas.
11th: 2013-18	Proposes measures to promote olive. Recommends launch of program on research, extension & increased production of soybean. Targets 26% growth in rapeseed and 148% increase in sunflower. Mentions that efforts to be made on palm cultivation but no plans proposed.

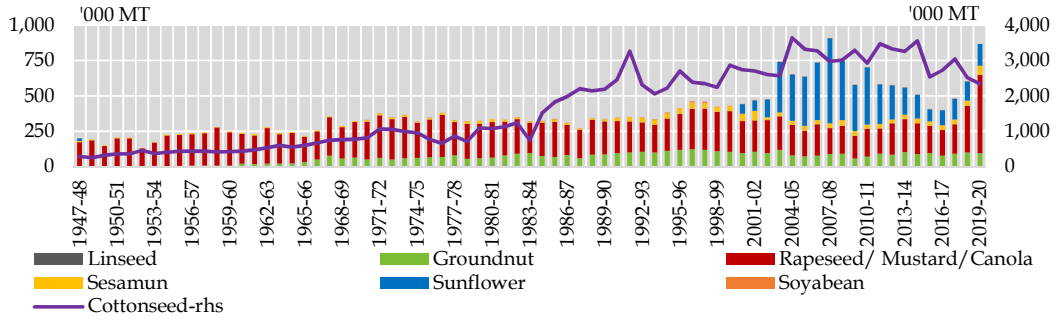
Source: Five Year Plans, Planning Commission, Ministry of Planning Development and Reforms

However, despite various measures recommended in the five years plans, the National Commission on Agriculture, 1988, noted that cultivation of oilseed crops in the country had stagnated in the first four decades since 1947, in sharp contrast to the rest of agriculture sector.[39] The situation has not improved since then. Production of both traditional and non-traditional oilseeds crops has not increased as per the targets set out in the various plans; whereas yields are also weak in comparison to other oilseed producing countries (**Figure S1.23 a,b** and **S1.24**).[40] For instance, in 1989, the government started a 7-year National Oilseed Development Project for the promotion of oilseeds. However, the project faced bottlenecks, such as inadequate seed supply and procurement problems, because

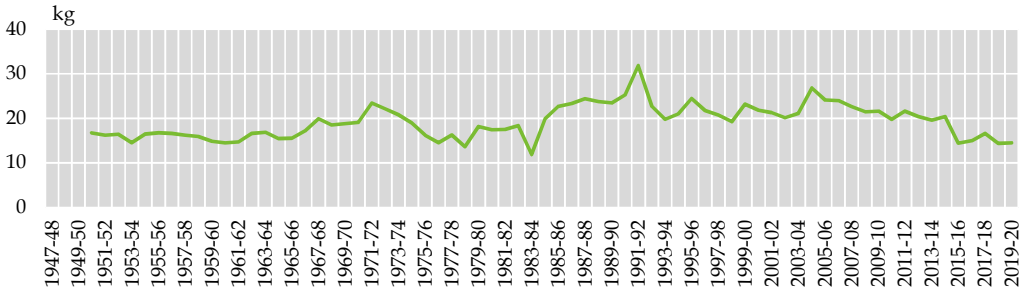
[39] Ministry of Food & Agriculture, 1988, Government of Pakistan, Report of the National Commission on Agriculture,

[40] A traditional crop is an indigenous species native to a specific region or one that was introduced a long time ago and, due to long use, has naturalized and become part of the culture of a community (Maundu, 1997)." Jane Muthoni & D. O. Nyamongo (2010), *Traditional Food Crops and Their Role in Food and Nutritional Security in Kenya*, Journal of Agricultural & Food Information, 11:1, 36-50

Historical Trend in Production of Different Oilseeds in Pakistan **Figure S1.23a**



Historical Trend in Per Capita Availability of Domestic Oilseeds **Figure S1.23b**



Source: Agriculture Statistics of Pakistan , MNFS&R

of which area and production targets could not be met.[41]

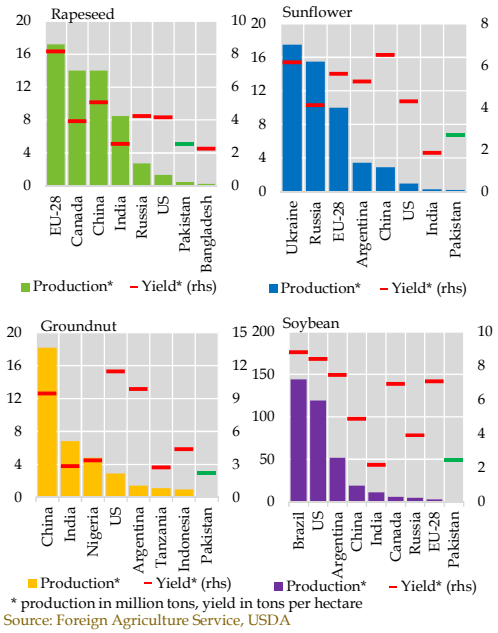
Among the traditional oilseed crops, including cotton, rapeseed, groundnut, sesame, castor and linseed, cotton and rapeseed are the major crops used in edible oil and oilseed meal production. Cotton, being primarily a fiber crop for textile, has the largest area under cultivation among crops that contribute to domestic edible oil production. Accordingly, cottonseed is the biggest contributor to domestic production of edible oil, despite having an oil extraction rate of only 16 percent.

Compared to cottonseed, other locally produced oilseeds have smaller shares in domestic production of edible oil and meals. However, since cotton cultivation has been on a secular decline, the contribution of cottonseed oil to total domestic edible oil consumption has fallen to 8.7 percent in 2020 from 17.2 percent 20 years ago.[42] Similarly, its share in meal produced from domestic oilseed crops dropped to 79 percent in 2020 from 88 percent in 2000, as per USDA data.

[41] Planning Commission of Pakistan, (2020), Rapeseed & Mustard Cluster Feasibility and Transformation Study

[42] Several reasons account for fall in cotton cultivation, including growing farmer preference for sugarcane, pest attacks, and low-quality seeds. For more details, related to decline in acreage and yield of cotton, see the SBP's FY20 and FY21 Annual Reports on the State of Pakistan's Economy.

Cross-Country Comparison of Production and Yield of Major Producers of Edible Oil Crops **Figure S1.24**



* production in million tons, yield in tons per hectare

Source: Foreign Agriculture Service, USDA

Meanwhile, despite having higher oil extraction rates of 42 percent and meal extraction rate of 58 percent, rapeseed's area under cultivation had gradually declined between 1967 and 2016.[43] In recent years, rapeseed's cultivar called Canola is being encouraged in Punjab through a cash subsidy package introduced in FY18,[44] as a result of which acreage and production more than doubled between FY18 and FY19.[45] However, despite these recent positive developments in rapeseed/canola, the area under cultivation of these crops is still small, and edible oil from combined domestic production of rapeseed/canola met only 4 percent of domestic edible oil demand in 2020, as per USDA data.

Compared to cottonseed and rapeseed, groundnut (peanut) and sesame have had much smaller area under cultivation and production in Pakistan. Even though both these crops are classified as oilseeds, they are not cultivated for producing edible oil and meals in Pakistan and in many countries around the world. Instead, their oilseeds are consumed in raw form.

Groundnuts are mostly consumed as roasted peanuts and in confectionary items, with negligible contribution to commercial edible oil production. Moreover, while groundnuts have a high oil extraction rate of 43-55 percent, its oil cannot compete with other edible oil products, as commercial production is not financially feasible due to high prices of groundnuts.[46] Similarly, while sesame also contains 50-60 percent oil and 22 percent protein, its seeds are mostly used in confectionary items.[47]

Among non-traditional crops, three non-traditional oilseed crops - namely sunflower, soybean and safflower – were promoted following the green revolution in Pakistan in 1960s. Of these, safflower gained farmers interest, whereas soybeans cultivation

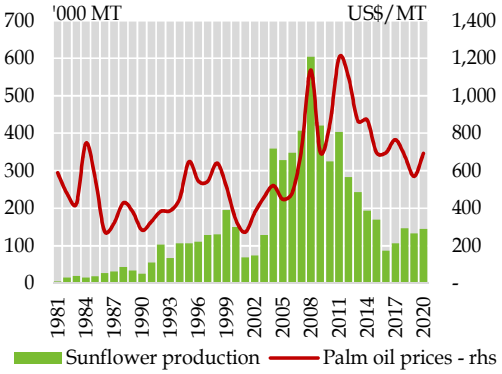
[43] PS&D oilseeds dataset, USDA
[44] USDA (2018). *Pakistan Oilseeds Annual Report* Washington D.C.: USDA
[45] MNFSR (2019). *Agriculture Statistics of Pakistan 2018-19*. Islamabad: MNFSR
[46] Ayub Agricultural Research Institute, Faisalabad, Government of Punjab (www.aari.punjab.gov.pk/varieties_groundnut); Pakistan Agriculture Research Council and www.parc.gov.pk/index.php/en/csi/137-narc/crop-sciences-institue/728-groundnut)
[47] Pakistan Agriculture Research Council (www.parc.gov.pk/index.php/en/csi/137-narc/crop-sciences-institue/727-sesame)

remained restricted to small acreage.[48] Owing to negligible production the combined contribution of these crops to domestic edible oil and meal consumption was close to nil in 2019.[49]

Sunflower, however, was relatively successful and was able to gain area under cultivation. It currently stands as the third highest in acreage and production among all crops that contribute to domestic edible oil production in Pakistan, and second biggest domestic oilseed crop. While sunflower also has high meal extraction ratio of 42 percent,[50] the meal is not particularly nutritious for feed and hence has little demand from feed industry.

While sunflower production remained weak since its introduction, it rose for a brief period from 2001 onward, when international palm oil prices surged, and All Pakistan Solvent Extractors' Association (APSEA) nearly doubled its procurement price to incentivize farmers. However, as international palm oil prices started falling, and edible oil producers shifted back to palm, sunflowers production started tapering off due to reduced acreage (**Figure S1.25**).[51] Currently, oil produced from domestically cultivated sunflower seed contributes only about 1 percent of the total domestic edible oil consumption in 2020, compared to its highest ever share of 7.5 percent in 2008.[52]

Trend in Sunflower Cultivation and International Palm Oil Prices **Figure S1.25**



Source: USDA and World Bank

Overarching challenges to oilseed production in Pakistan

Several factors are behind low production of oilseeds in Pakistan, the fundamental reason of which is the absence of a consistently implemented oilseed policy. This manifests itself in several ways, such as limited research (including on seed and soil) too thinly spread over a large number of institutes; deficiencies in agriculture extension; marketing and procurement challenges leading to weak linkages in value chain; and inefficient oil extraction in villages and small towns. For instance, the absence of support prices and efficient crop marketing and value chain in the case of oilseeds impacts in two ways. At the end, farmers are not incentivized to grow oilseeds, and at the other end middleman have been found to exploit oilseed farmers, such as sunflower, to

[48] M. Aftab, T. Mahmood and H.S Mustafa (2021). *Prospects of Oilseed Crops in Pakistan*. Faisalabad: AARI, Government of Punjab.
[49] According to USDA, sunflower and soybean contributed 11.2 percent to overall edible oil consumption in 2019.
[50] Source: Production, Supply, and Distribution PS&D oilseeds dataset, USDA
[51] Economic Survey of Pakistan 2007-08, 2014-15, and 2015-16
[52] Source: Production, Supply, and Distribution PS&D oilseeds dataset, USDA

paying low price for their produce, making discretionary deductions and delaying payments.[53]

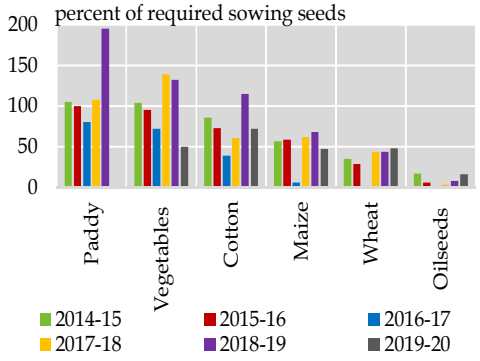
In addition, low farmer profitability amid absence of consistent support price policy for oilseeds and falling prices of palm oil imports have also contributed to falling oilseed production. Lack of policy focus also manifests as limited seed availability, both in terms of varieties suitable to local environment, and the quality seeds available at affordable prices to meet sowing requirements for optimal productivity[54] (**Figure S1.26**).

In addition, there are other constraints to best farming practices, such as critical shortage of oilseed-specific planting, harvesting and threshing machinery, and non-adoption of other recommended production technology.

For instance, in the case of sunflower, use of sub-optimal inputs, such as unbalanced use of fertilizer and cultivation on marginal lands also led to yield decline at a time when falling palm oil prices was leading to lower area under cultivation.[55]

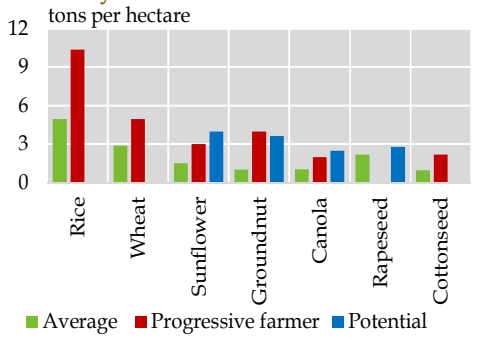
These factors have prevented farmers from achieving the yield potential of oilseeds as tested in trials by various agriculture institutes and the yields achieved by progressive farmers in Pakistan (**Figure S1.27**). Moreover, since different oilseeds compete for land with other crops that are important for food grain sufficiency and exports, the failure to achieve potential yield in major crops present a challenge to oilseeds, as lesser land is available for oilseeds (**Table S1.2**).

Availability of Oilseed and Major Crop Seeds **Figure S1.26**



Source: Federal Seed Certification & Registration Dept.

Average yields achieved compared to progressive farmers' yields **Figure S1.27**



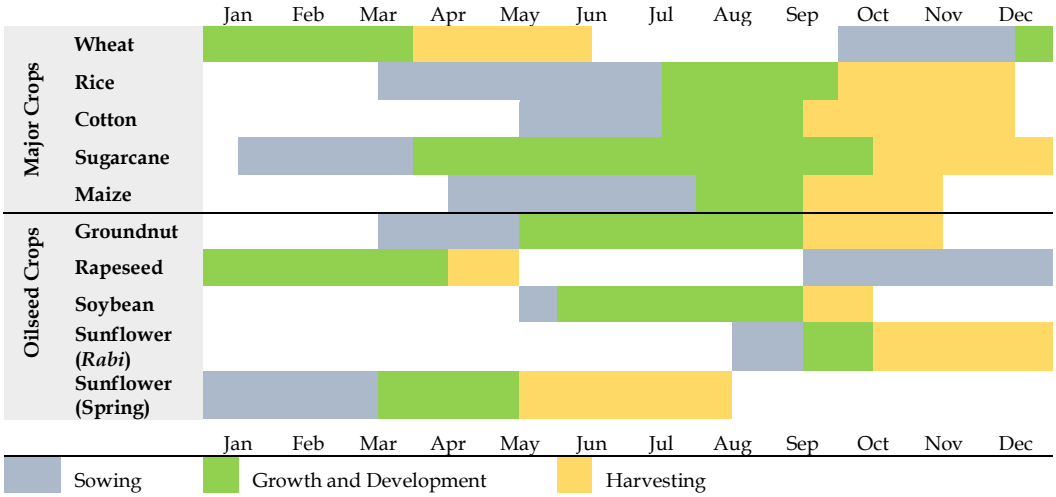
Source: PODB, PARC and Planning Commission

[53] Badar H et al, 2002, Production and Marketing Constraints Limiting Sunflower Production in Punjab (Pakistan), International Journal of Agriculture & Biology.

[54] Source: (a) M. Aftab, T. Mahmood and H.S Mustafa (2021). *Prospects of Oilseed Crops in Pakistan*. Faisalabad: AARI, Government of Punjab; (b) Ministry of Food and Agriculture (1988). *Report of the National Commission on Agriculture* Islamabad: Ministry of Food and Agriculture; (c) Planning Commission of Pakistan (2020). *Rapeseed & Mustard Cluster Feasibility and Transformation Study* Islamabad: Planning Commission of Pakistan

[55] *Ibid*

Crop Calendar of Major Crops and Oilseed Crops **Table S1.2**



Source: National Institute Of Genomics and Advanced Bio-Technology, NARC

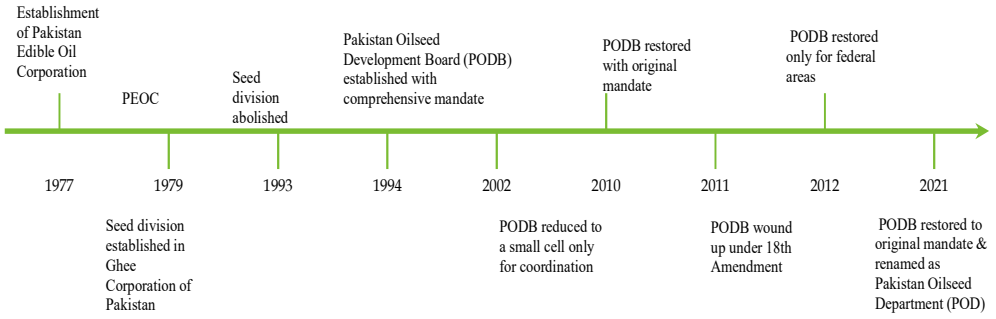
The consistent lack of policy focus on oilseed stems from institutional challenges. The first institution tasked with the development of oilseed crops was Pakistan Edible Oil Corporation (PEOC); which was setup in 1977 but dissolved after two years of spadework. It was replaced by the Seed Division established in Ghee Corporation of Pakistan. The division was abolished in 1993. In 1994, Pakistan Oilseed Development Board (PODB) was set up with a comprehensive mandate to increase oilseed production. After a series of suspension, closure, reduction in mandate[56], and reactivation since 1994, the PODB was restored to its previous status in June 2021, under the new name of Pakistan Oilseed Department (**Figure S1.28**).[57] However, since the 18th Amendment, little support exists to provinces from POD whereas provinces do not have oilseed specific institutions.[58]

S1.4 Prospects of growing palm & soybean in Pakistan

As discussed earlier, Pakistan's growing imports of palm oil and soybean seeds is in line with global consumption pattern where reliance on these two commodities has grown manifold to produce edible oil and oilseed meal purposes. However, so far policy focus on both commodities is lacking.

[56] The mandate included drafting policies, designing projects, raising farmer awareness, encouraging private sector collaboration, training human resources and collaborating with various federal and provincial agriculture departments.
[57] M. Aftab, T. Mahmood and H.S Mustafa (2021). *Prospects of Oilseed Crops in Pakistan*. Faisalabad: AARI, Government of Punjab, and Pakistan Oilseed Department (formerly PODB)
[58] Planning Commission of Pakistan, (2020), Rapeseed & Mustard Cluster Feasibility and Transformation Study

Brief Institutional History of Oilseed Development in Pakistan **Figure S1.28**



Source: M. Aftab et al., (2021), 'Prospects of Oilseed Crop in Pakistan (2nd Edition)', Ayub Agricultural Research Institute and PODB

This section explores the prospects of growing these crops in the country, drawing on surveys, pilot projects and research trials for these crops in Pakistan in the past.

Oil Palm Plantation[59]

To assess the potential of oil palm cultivation in Pakistan, in 1994 the National Agriculture Research Council (NARC) surveyed 3.86 million hectares in Sindh, of which most were coastal districts. The survey assessed the potential on a variety of parameters, including humidity, soil condition, water availability, and existing land usage. The results classified the surveyed area under five main categories, ranging from "well suited" to "not suited" **(Table S1.3).** About 1.65 million hectares were considered suitable for plant production under different degrees of suitability, and the rest of the surveyed area was not recommended.

In light of NARC's survey, the PODB initiated oil palm cultivation in 1998 as pilot project, and by 2007 an estimated 2,200 acres of oil palm was planted in private, public and forest farms located in various areas in Sindh and Balochistan. However, after initial years of promising growth, the pilot project faced various types of management issues and operational bottlenecks. In some cases, the plantations were not maintained or were otherwise neglected; in other areas, seeds were not managed properly at pre-nursery stage. There were also incidents of inadequate fertilizer usage, inefficient water distribution, and attacks by rats. On the whole, the project was not closely monitored, partly because of institutional challenges such as those discussed in previous section.

As a result of these farm management issues, the pilot project was not successful in testing whether or not the theoretical potential

[59] This sub-section is based on discussions with various stakeholders, and draws on four key documents; (a) A. Rashid, M.M. Nizami (1994). *Cultivation of Oil Palm and Coconut in Coastal Areas of Sindh Province.* Islamabad: NARC; (b) A.G. Esnan (2007). *Visit Report on Oil Palm Cultivation in Sindh Province*. Selangor: Malaysian Palm Oil Board; (c) Sindh Coastal Development Authority (2021*). Official presentation on Oil Palm Plantation in the Coastal Zone of Sindh*. Karachi: SCDA; (d) Indian Institute of Palm Oil Research (2015). *Vision 2050* New Delhi: Indian Council of Agricultural Research.

Definition of Suitability Classes (Area Suitability for Palm Plantation in Sindh) **Table S1.3**

	Well suited	Moderately well suited	Moderately suitable	Marginally suited	Not suited
Ratings assigned	4	3	2	1	0
Yield In case of traditional management	High	Moderate to high	Moderate to low	Marginally suited	Little
Soil conditions (physical and chemical characteristics)	Highly Favorable	Favorable	Unfavorable	Unfavorable	Highly unsuited
Fertility level	High	Moderately high	Moderate	Low	Severely low
Drainage	Highly Favorable	Favorable	Unfavorable	Unfavorable	Severely low
Climatic conditions	Highly Favorable	Favorable	Limiting factor	Unfavorable	Severely low
Response to good management	High	Well	Fair	Low	Poor
Yield in case of modern management	Very high	High	Moderate	Low	Poor
Suitable area *(hectares in mn)*	0.00	0.10	0.46	1.09	2.22
Memo: Total area surveyed 3.86 million hectares					

Source: Rashid and Nizami (1994). "Cultivation of Oil Palm and Coconut in Coastal Areas of Sindh Province", PARC

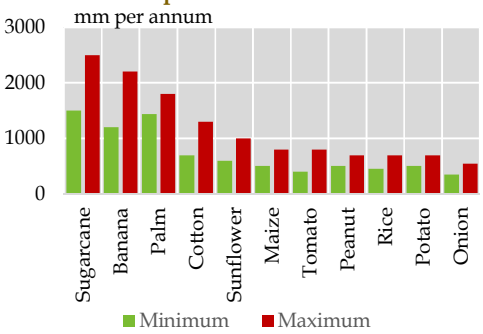
identified by the NARC survey existed in reality. Following their visit to various plantations in Sindh and Balochistan in 2007, the Malaysian Palm Oil Board (MPOB) noted that most trees had slow growth with very low fruiting yield. After making observations of various issues in farm management, the MPOB then concluded that oil palm cultivation in Pakistan was not proven as a commercial crop, using the then existing planting materials and technologies to deal with climate and soil constraints.[60]

However, recent efforts to revive oil palm by Sindh Coastal Development Authority (SCDA) show encouraging results, albeit the SCDA's pilot is on much smaller scale of only 50 acres. The SCDA began the pilot project in 2017, and as of June 2021, the authority has rehabilitated palm plantation on 30 acres and replanted trees in 20 acres. Based on this pilot, the SCDA assesses oil palm as highly successful with fruiting at par with plantations in Malaysia,[61] subject to fulfilment of certain conditions, such as good farm management, and sufficient irrigated water supply, which is a crucial factor in the assessment of palm potential in Pakistan.

Compared to high yielding oil palm regions in Malaysia and Indonesia, which receive an average rainfall of 2,000 mm on annual basis, coastal areas in Pakistan receive 32.1 mm per year on average.[62] However, since the per

[60] Esnan, A.G, 2007, Visit Report on Oil Palm Cultivation in Sindh Province, Malaysian Palm Oil Board.
[61] The pilot's results have also been acknowledged by Malaysian and Chinese experts. Source: Sindh Coastal Development Authority, 2021, Government of Sindh, official presentation on Oilpalm Plantation in the Coastal Zone of Sindh
[62] Source: Salma, S et al.,(2012), ' Rainfall Trends in Different Climate Zones of Pakistan', Pakistan Journal of Meteorology, Vol. 9, Issue 17.

Water Requirement of Different Crops **Figure S1.29**



Source: Irrigation Water Management: Irrigation Water Needs, FAO

acre water requirement of oil palm is lower than that of sugarcane and banana plantations currently grown in Sindh's coastal belt (**Figure S1.29**), the SCDA suggests relying on irrigated water to explore the potential of oil palm plantation. Irrigated water supply is also being harnessed to expand oil palm plantations in India.[63]

In addition to oil palm's potential along the over 200-kilometer coastline in Sindh, up to 500 kilometers of coastline in Balochistan also offers potential for oil palm plantation subject to availability of water through canal system.[64] However, detailed scientific studies with successful pilots to assess the potential in Balochistan have not been conducted. At the same time, the technical assessment for land suitability in Sindh is also outdated. The last assessment was done in 1994 by the NARC, which noted that progress in agriculture techniques (such as introduction of new more resistant varieties in respect of climate and soil) or change in environment (such as water drainage, irrigation water) would necessitate reassessment of land suitability every 10-15 years.[65]

In the absence of updated scientific surveys and pilots, domestic oil palm planation does not seem to have potential in the short to medium term. However, in recognition of Pakistan's growing demand for palm oil in the long term, there is a need for fresh comprehensive technical assessments and surveys of potential areas in consultation with international oil palm.

If results from fresh technical surveys are encouraging, then palm plantation may be piloted at a large scale. However, in order to ensure that pilot projects are able to test the theoretical potential, good farm management would be critical. In addition, a strong palm-specific institutional set up may be needed to work in close collaboration with leading private sector investors, in line with the palm introduction and development strategy adopted by Malaysia and Indonesia (**Box S1.1**). To that end, given China's growing overseas investments in agriculture — including palm — a government-to-government or government-to-business partnership with China may be explored under agriculture collaboration of China Pakistan Economic Corridor, for fresh technical assessment and for large-scale pilot plantations.[66]

[63] Indian Institute of Palm Oil Research, 2015, Vision 2050, Indian Council of Agricultural Research
[64] M. Aftab, T. Mahmood and H.S Mustafa (2021). *Prospects of Oilseed Crops in Pakistan*. Faisalabad: AARI, Government of Punjab
[65] Rashid A, Nizami M.M. 1994; Cultivation of Oilpalm and Coconut in Coastal Areas of Sindh Province, National Agriculture Research Centre
[66] Source: (a) G. Elizabeth and F. Gale (2018), 'China's Foreign Agriculture Investments', EIB-192,

Box S1.1: Brief history of development of oil palm in Malaysia, Indonesia, and India

Oil palm does not have a long history of being a commercially successful native crop in Southeast Asia and South Asia. It was introduced to Malaysia and Indonesia in late 19th and early 20th century,[a] by colonial governments and western companies who brought various palm varieties from West and Central Africa, which at the time were world's leading palm oil exporter. Since the development of palm is a long-term project with long gestation period, it took various types of consistent government-led efforts with private sector involvement in Malaysia and Indonesia to become dominant producers,[b] India has recently started following the same trajectory.

Malaysia[c]

Palm plantations in Malaysia increased in the 1920s as an alternative to rubber plants. However, it wasn't until the government undertook concerted efforts that the country emerged as a leader in palm oil. In 1956, the government formed the Federal Land Development Authority (FELDA) to distribute lands to farmers; connect them with international markets; transform smallholdings into bigger clusters; and incentivize foreign investors and researchers to invest in oil palm. In 1968, the government created the Malaysian Agriculture Research and Development Institute to link Tropical Production Institute in London with local palm researchers and support FELDA in achieving its goals. In addition, companies from Malaysia also actively hired scientists and experts from West Africa to facilitate its transition as a major palm producer.

Indonesia[d]

After some initial success between 1916 to 1938, Indonesia's palm plantations could not grow due to poor farm management. However, with the shift in ownership of farms from the government to semi-public and private entities, production started to rise. In 1978, the government introduced the Nuclear Estate Scheme, with company farms and mills in the centre and periphery farms cultivated by small growers. Companies were responsible for developing farm infrastructure, while the government funded food and housing expenses in the initial years. Also, farmers' credit cooperatives were formed to improve growers to finance at lower cost access and cost of bank credit. In recent years, the government's role in the sector has decreased to providing enabling regulations with private sector taking the lead.

The start of palm cultivation in India[e]

To lessen its palm oil imports, Indian government has been promoting palm cultivation as an irrigated crop by preparing strategies and offering funding for plantation and irrigation with research support from the Indian Institute of Oil Palm Research. Since 1991-92, India's central government has made various interventions at frequent intervals under public and public-private partnership (PPP) modes, each with higher goals for research and production. In 2014-15, a National Mission on Oilseed and Oil Palm was constituted to exclusively focus on increasing the productivity and cultivation of oil palm, under joint funding by central and state governments. Of the 1.93 million hectares currently identified by Indian government as suitable for oil palm cultivation, these measures have resulted in an increase in area under palm cultivation from 8,585 ha in 1991-92 to 0.32 million ha in 2019 in 15 Indian states. Currently, India is aiming to strengthen public-private partnership to increase oil palm production, including in areas of

Economic Research Service, USDA; (b) D. Freeman, et al (2008). Holslag, J. (2009). China's foreign farming policy: can land provide security? *Asia Paper, Vol. 3 (9)* Brussel: Brussel Institute of Contemporary Studies, Universiteit Brussel.

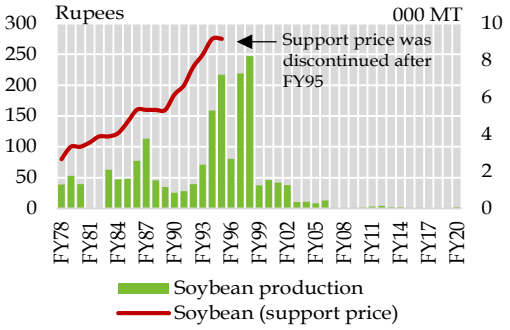
refinement and commercial exploitation of tissue culture technology for better palm varieties; establishment of new seed gardens and processing mills.

References

[a] Malaysian Palm Oil Board (www.palmoilworld.org/about_malaysian-industry.html)
[b] Production, Supply and Distribution data from USDA
[c] V. Giacomin (2018). "The Transformation Of The Global Palm Oil Cluster: Dynamics Of Cluster Competition Between Africa And Southeast Asia (c.1900–1970)" *Journal of Global History,* 13 pp. 374-398.
[d] A. Baudoin, P. Bosc, C. Bessou, and P. Levang (2017). Review of the Diversity of Palm Oil Production Systems in Indonesia: Case Study of Two Provinces: Riau and Jambi. Working Paper 219. Bogor, Indonesia: Center for International Forestry Research; and J. F. Mccarthy (2009). "Policy Narratives, Landholder Engagement, and Oil Palm Expansion on the Malaysian and Indonesian Frontiers", *The Geographical Journal*, Vol. 175, No. 2, pp. 112–123.
[e] Indian Institute of Oil Palm Research (2019). *Annual Report.* New Delhi: Indian Institute of Oil Palm Research, Indian Council of Agriculture Research; Department of Agriculture, Cooperation and Farmers Welfare (2016). *Status Paper on Oil Palm*. New Delhi: Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare.; National Food Security Mission (2018). Brief Note on Oil Palm. New Delhi: National Food Security Mission.

These efforts will require long-term planning and execution because if fresh scientific surveys prove oil palm's potential in Pakistan, then even in the most optimistic scenario, palm plantation may not start yielding adequate quantities of oil before 10-15 years. This is because research, trials, setting up of institutions, project planning etc. is a long-term endeavor requiring consistent efforts, where finding the most suitable variety alone can take about 10 years. Palm tree itself, whilst a perennial crop, usually attains maximum fruiting in 4th to 7th year onward, and continues to give fruiting up to 15-30 years depending on a variety of factors. [67]

Soybean Support Price and Production in Pakistan **Figure S1.30**



Source: PBS and Planning Commission of Pakistan

Soybean

While soybean had been informally cultivated in the region previously, the crop was formally introduced in 1969 onwards when various varieties were approved for commercial cultivation. Although policy measures for soybean crop had been recommended since the first five-year plan in 1955, support price for the crop was not announced until 1978. However, despite the introduction of support price, which was discontinued after FY95, the crop's progress remained weak, with highest ever production being limited to only 8,200 metric tons (**Figure S1.30**). This was due to the

[67] Source*: (a)* H. Herdis, H. A. Negoro, N. Rusdayanti and S. Shara (2020). "Palm Oil Plantation and Cultivation: Prosperity and Productivity of Smallholders", *Open Agriculture,* vol. 5, no. 1, pp. 617-630; (b) Indian Institute of Palm Oil Research, 2015, Vision 2050, Indian Council of Agricultural Research

absence of coherent research and production policy for soybean vis-à-vis farmer awareness, non-existent value chain, seed development, production technology and procurement policy.[68]

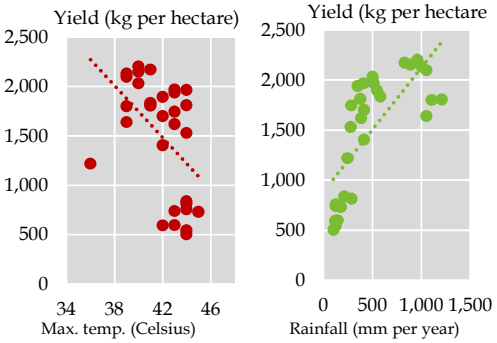
Following the increase in demand for soybean meal by feed industry, the pace of research has recently started to pick up, where the biggest crop-specific challenge is the availability of sowing seeds suitable in Pakistan's climatic conditions.

Soybean is mainly grown in mild climatic conditions with frequent rainfalls and requires low pH soils. On-farm studies carried out in different parts of the Punjab province shows negative relationship between crop yield and temperature, and positive relationship between yield and rainfall (**Figure S1.31**). Cross-country comparison also shows that soybean thrives in milder climate regions.[69] This warrants development of seed varieties that are better suited to the climatic conditions of country's major cultivable regions, particularly south Punjab and Sindh.

In light of this, a heat tolerant variety called Faisal Soybean has been developed and piloted by Oil Research Institute (ORI) Faisalabad in 2018-19. The pilot divided the province of Punjab in to five broader geographical zones, categorized as Eastern North Punjab, Western North Punjab, Central Punjab, Eastern South Punjab and Western South Punjab. While the pilot's results in Eastern and Western South Punjab were not encouraging, those in north and central Punjab are promising (**Figure S1.32**).

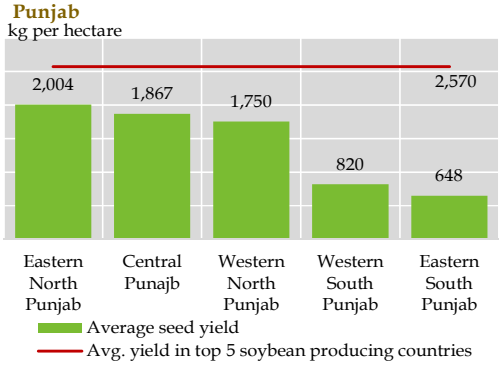
The tested variety in these regions is a 120-day crop, as against 180-day crops in Brazil and the US, which will allow farmers to follow wheat-soybean-wheat cropping rotation in rainfed areas, and rice-soybean-rice or cotton-soybean-rice in irrigated

Correlation of Avg. Soybean Yield in Punjab w.r.t. Temperature and Rainfall **Figure S1.31**



Source: Ayub Agriculture Research Institute

Zone-wise Soybean Yield Achieved in Pilot Projects in Punjab **Figure S1.32**



Source: ARI (2021) and USDA

[68] Hafiz Saad et al., (2021), "Crop Diversification Through Soybean Cultivation in Punjab", Director of Oil Seeds, Ayub Agricultural Research Institute, Government of Punjab

[69] Even in neighboring India, 83 percent of soybean has been produced in milder climate regions of Madhya Pradesh and Maharashtra (Source: The Soybean Processors Association of India).

areas.[70] This is an important development because the previous locally developed varieties had longer duration and were difficult to fit into different cropping pattern.

In addition to above mentioned pilots, the NARC has recently developed a short duration variety (NARC-2020) that matures in 90 days with production potential up to 1000 kg per acre.[71] If marketed successfully, it could also help increase soybean production in the country.

The potential areas of Eastern North Punjab, Central Punjab and Western North Punjab identified by ORI have a total of around 9.5 million hectares (or 23.45 million acres)[72] under cultivation, where a variety of crops are currently grown in these areas including major crops (e.g. wheat and rice), and fruits (e.g. citrus).[73] Similarly, according to NARC's estimates (**Table S1.4**) about 1 million acres of cultivatable area in Pothwar region of Punjab, Khyber Pakhtunkhwa and Gilgit-Baltistan can be potentially used for growing the currently available varieties of soybean in the country, including inter-cropping with maize, which has been tested successfully even in semi-arid areas.[74]

This implies that in the medium term, at conservative estimates of 1 ton per acre grown at only 0.5 million acres out of total suitable areas identified by ORI and NARC, Pakistan can potentially grow 0.5 million tons, which is 20 percent of the country's FY21's soybean import quantity.[75] However, to realize this potential, the overarching challenges to oilseed crops discussed in previous sections would need to be addressed. Particular focus is needed to increase farmer awareness; introduce best farm management practices; efficient

Potential Area for Soybean Cultivation **Table S1.4**

Province	Area/Cropping System	Estimated Area Availability (thousand hectare)
Punjab	Rawalpindi division	202
	Riverine area (Mianwali, Bhakkar, Layyah, Muzaffargarh, D.G. Khan and Rajanpur)	1
Sindh	Lower Sindh (Thatha and Badin, Sangharh etc.)	20
Khyber Pakhtunkhwa and GB	Peshawar, Mardan, Malakand and Hazara Division and Tribal districts	202
Total		**426**

Source: Soybean Promotion for Reducing Soya meal and Edible Oil import in Pakistan, NARC, concept paper

[70] (a) M. Aftab, T. Mahmood and H.S Mustafa (2021). *Prospects of Oilseed Crops in Pakistan*. Faisalabad: AARI, Government of Punjab; (b) M. Amjad (2014). *Oilseed Crops of Pakistan.* Islamabad: Pakistan Agricultural Research Council

[71] Source: National Agricultural Research Council, 2021, Soybean Promotion for Reducing Soya meal and Edible Oil import in Pakistan, Concept Paper, unpublished

[72] Source: Land Utilization Statistics Annual Area by Division & Districts in The Punjab for the Year 2019-20, Crop Reporting Services, Government of Punjab

[73] ORI also recommends other areas to explore soybean potential, including Nawabshah, Hyderabad, Tharparkar and Thatta in Sindh; Mardan, Nowshera, Sawabi, Malakand, Swat, Mansehra and Kohistan in KPK, and Kalat and Khuzdar in Balcohistan

[74] Ali Raza, et al.,(2021), 'Land productivity and water use efficiency of maize-soybean strip intercropping systems in semi-arid areas: A case study in Punjab Province, Pakistan', Journal of Cleaner Production

[75] Memo: Pakistan's total soybean seed import in FY21 was 2.5 million tons

procurement mechanisms; and make oilseed cultivation a profitable endeavor for farmers and other stakeholders. In addition, the availability of desired quality and quantity of soybean's sowing seeds is critical to reap this potential since soybean requires much higher quantities of sowing seeds at the rate of 30-35 kilogram of per acre compared to 2-3 kg/acre in the case of sunflower and rapeseed/ canola.[76]

S1.5 Final Remarks

Pakistan's demand for edible oil more than doubled in the last two decades from 2 million tons in 2001 to 4.7 million tons in 2020. Similar growth was witnessed over the two decades preceding 2000. At this rate, the demand for oilseed can be expected to rise significantly over the next 20 years, driven by rising population, and modernization of poultry, livestock and aquaculture industries to cater to exports and to meet rising domestic meat consumption. Moreover, growth in per capita income can be expected to increase per capita consumption of both edible oil, and of poultry, livestock and aquaculture products. The latter, in turn, will drive the demand for oilseed meals, particularly soybean, whose demand had grown by 7.9 times between 2002 and 2020.[77]

In the short to medium term, a policy focus on increasing the production of canola and sunflower is necessary, and currently in the process of being rolled out. In Punjab, for instance, Oil Seed Promotion Initiative taken in FY18 revolves around preparing crop calendars for sunflower and canola, fixing district wise targets, trainings to master trainers of agriculture extension departments and private seed companies, and provision of subsidies.[78] Moreover, under the federal government's Agriculture Emergency Programme, a National Oilseed Enhancement Programme (NOEP) is in the process of being implemented in collaboration with provincial agriculture department with Pakistan Oilseed Department as execution agency.

Key measures planned under the five-year NOEP are: productivity enhancement of wheat, rice and sugarcane to vacate up to 3.25 million hectare of land for the cultivation of canola, sunflower and sesame; increasing the yield and area under acreage of cotton to produce 15 million bales, which will increase the supply of cottonseed oil; and increasing the yield of sunflower and canola. By achieving the target of 15 million bales in next five years, 0.459 million tons of cottonseed oil will be produced. Similarly, other cultivation related measures under the NOEP are expected to yield another 2.8 million tons of edible oil. This is expected to reduce import bill of edible oil by US$ 584 million.[79]

These initiatives are in line with the National Food Security Policy 2018, which had proposed reducing area under rice, sugarcane and other crops to increase production of oilseeds, pulses and

[76] M. Aftab, T. Mahmood and H.S Mustafa (2021). *Prospects of Oilseed Crops in Pakistan*. Faisalabad: AARI, Government of Punjab
[77] Production, Supply and Distribution datasets of USDA.
[78] M. Aftab, T. Mahmood and H.S Mustafa (2021). *Prospects of Oilseed Crops in Pakistan*. Faisalabad: AARI, Government of Punjab
[79] Source: (a) Pakistan Oilseed Development Board, 2019, Ministry of National Food Security and Research, National Oilseeds Enhancement Program, Umbrella PC-1 for Planning Commission of Pakistan; (b) Pakistan Oilseed Department (formerly PODB), 2021, official presentation on Oilseed situation in Pakistan

horticulture, and introducing support price for oilseeds to promote import substitution rather than subsidizing export of wheat and sugar.

Focus on canola and sunflower is an important solution for the short to medium term, considering the fact that sunflower and rapeseed/canola already have roots in the country. As discussed earlier, palm offers no potential in the short to medium term, whereas the ability to reap soybean's potential over the medium term hinges on a variety of factors, including availability of seed, farmer awareness and adequate procurement policy that prioritizes farmer profitability.

In addition to focusing on sunflower and rapeseed/canola production in the short to medium term, the government may also consider gradual implementation of import and demand management measures. These include customs duty on imported seed and oil, and taxes on ghee aimed at encouraging sourcing of domestic sunflower and rapeseed for edible oil production, albeit price prescriptions are understandably complex, especially when domestic production is unable to meet local demand. Efforts to increase nutritional awareness may also help in reducing overall edible oil consumption in cooking.

However, given Pakistan's rising demand outlook over next 20 years, investments to increase production of sunflower, canola and cottonseed oil should not be expected to contribute significantly to the country's needs in the long-term. The oil and protein yield per hectare of canola, sunflower and sesame are significantly lower than that of palm and soybean, which is an important consideration in light of scarcity of land, water and other resources. Accordingly, the production efficiency of oil palm and soybean have made these the most consumed crops in the world as both oils and meals. Over the long-term, therefore, there is an urgent need to invest in research, development, promotion, production and procurement mechanism for oil palm plantation and soybean crops.

The urgency for long-term planning stems from the fact that significant breakthroughs and sufficient production of newly introduced crops requires comprehensive planning and execution spreading over years across various aspects of farming. These aspects include research on seed and soil; seed availability; farmer awareness and profitability; agriculture extension; effective farm machinery; farm machinery; and establishment of efficient and reliable procurement and supply chain. In other words, any new crop has to be made successful to attract farmers' interest for long-term organic growth of the crop production.

Agriculture production policy depends on a variety of complex and interwoven factors. These include nutritional requirements; diverse agro-ecological zones and production systems; climate, soil, water and other sowing conditions; and dietary preferences, which are also affected by culture and history. These factors imply that no country can become completely self-sufficient in all agriculture commodities, nor can any country grow all the crops it consumes. While being cognizant of these factors, the realities of growing edible oil imports warrant concerted deliberations among federal and provincial governments, and related stakeholders from private and public sector to assess whether or not Pakistan has the potential of growing palm and soybean. If indeed there is potential to grow palm and soybean, then unlike attempts in the past, consistent policy and institutional support needs to be provided to make that transition successful.