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State-of-the-Art of olive sector in Pakistan
A review report

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Abstract. Pakistan has remained heavily dependent on imported edible oils due to the persistent gap between domestic production and consumption, making the development of alternative oilseed crops a national priority. In this context, olive cultivation has emerged as a promising sector owing to the country's favorable agro-climatic conditions and the increasing support provided through public sector and international cooperation initiatives. The study provides a comprehensive overview of the olive sector in Pakistan, examining its historical development, current status, and future potential. It further examines the role of government interventions, international collaborations, and the strengthening of the olive value chain. The role of projects implemented with international partners, especially within the framework of Italy-Pakistan cooperation, is also highlighted. Moreover, the study discusses the major challenges limiting the sector's expansion, including technical, institutional, and market-related constraints, while emphasizing opportunities for sustainable growth, rural development, and import substitution. Overall, the present work presents olive cultivation as a strategic sector capable of contributing to economic development, agricultural diversification, and long-term sustainability in Pakistan.

Keywords. Olive sector – Value chain – Sustainable agriculture – Rural development.

État des lieux du secteur oléicole au Pakistan : Rapport de synthèse

Résumé. *Le Pakistan demeure fortement dépendant des importations d'huiles alimentaires en raison du déséquilibre persistant entre la production nationale et la consommation, faisant du développement des cultures oléagineuses alternatives une priorité nationale. Dans ce contexte, l'oléiculture s'est imposée comme un secteur prometteur grâce aux conditions agroclimatiques favorables du pays et au soutien croissant apporté par les soutiens publics et les initiatives de coopération internationale. L'étude offre une vue d'ensemble du secteur oléicole au Pakistan en analysant son évolution historique, sa situation actuelle et son potentiel futur. Elle examine également le rôle des interventions gouvernementales, des collaborations internationales, ainsi que du renforcement de la chaîne de valeur oléicole. Le rôle des projets mis en œuvre avec des partenaires internationaux, notamment dans le cadre de la coopération italo-pakistanaise, est également mis en évidence. Par ailleurs, l'étude aborde les principaux défis limitant l'expansion du secteur, notamment les contraintes techniques, institutionnelles et commerciales, tout en soulignant les opportunités de croissance durable, de développement rural et de substitution aux importations. Dans l'ensemble, ce travail présente l'oléiculture comme un secteur stratégique capable de contribuer au développement économique, à la diversification agricole et à la durabilité à long terme au Pakistan.*

Mots-clés. *Secteur oléicole – Chaîne de valeur – Agriculture durable – Développement rural.*

I – Overview of the olive sector in Pakistan

Pakistan has remained a major importer of edible oil since the early 1970s due to a persistent imbalance between domestic production and consumption. Currently, approximately two-thirds of the national demand is met through imports, placing a significant burden on the country's foreign exchange reserves. Despite numerous policy initiatives aimed at boosting oilseed production, the

sector has largely failed to achieve self-sufficiency. Domestic production contributes only 13-15% of total consumption, while 85-87% is fulfilled through imports. Meanwhile, per capita edible oil consumption has increased substantially from 5.31 kg in 1973-1974 to around 20 kg in 2018 and is projected to reach 22 kg by 2028. This growth is expected to raise total demand to approximately 6.5 million tons, compared to the current local production of less than 0.5 million tons, thereby further widening the demand-supply gap and increasing the import bill (Business Recorder, 2022).

In this context, exploring alternative and sustainable sources of edible oil has become a national priority. The olive tree (*Olea europaea* L.), an evergreen species native to the Mediterranean basin, including southeastern Europe, West Asia, and North Africa, represents a promising option. According to the Food and Agriculture Organization (FAO, 2018), the global area under olive cultivation reached 10.5 million hectares in 2018, reflecting a 26% increase since 2000, while total production rose by 35% to over 21 million tons. These trends highlight the growing economic importance and adaptability of olive cultivation worldwide.

Pakistan possesses considerable agro-climatic potential for olive cultivation, particularly in regions such as Balochistan, Khyber Pakhtunkhwa, and Punjab. Recognizing this potential, the government has initiated several efforts to promote the olive sector as part of a broader strategy to reduce dependence on imported edible oils. At the federal level, the Pakistan Oilseed Department POD (formerly Pakistan Oilseed Development Board) plays a central role in policy formulation, coordination, and research promotion for oilseed crops, including olives. However, there remains a critical need to revitalize the sector through integrated and transformative approaches that incorporate both conventional and non-conventional oilseed crops.

International collaboration has significantly contributed to the development of the olive sector in Pakistan. In particular, the OliveCulture Project, implemented by CIHEAM Bari in partnership with national institutions such as POD, represents a key initiative aimed at strengthening the olive value chain. Since the 1980s, the Italian Government has supported olive promotion in Pakistan, and current efforts focus on a holistic, multidisciplinary approach encompassing nursery development, orchard management, harvesting and post-harvest practices, capacity building (including youth and women engagement), marketing, branding, and compliance with international standards.

To ensure the effective implementation of these initiatives, it is essential to conduct a comprehensive assessment of the existing olive sector in Pakistan. Such an analysis should consider the outcomes of previous national and international efforts, including the introduction and adaptability testing of exotic cultivars, as well as advancements in cultivation and processing techniques. Reviewing the historical development of the sector alongside current practices will provide valuable insights for stakeholders, enabling better integration of ongoing activities and more informed strategic planning for future growth.

II – National and international initiatives

The Government of Pakistan, in collaboration with several international development partners, has played a pivotal role in promoting olive cultivation and processing in the country. Public sector institutions, working in close coordination with international agencies, have provided substantial

financial support, technical assistance, and capacity-building initiatives targeting researchers, academic institutions, farmers, and industry stakeholders across the olive value chain. These efforts have facilitated the introduction of high-yielding olive cultivars, the transfer of advanced production technologies, and the provision of modern tools and olive oil extraction machinery, contributing significantly to the sector's development.

Over the past two and a half decades, numerous projects have been implemented to support the expansion of olive cultivation and the strengthening of its value chain in Pakistan. A detailed overview of these initiatives is presented below, while a chronological summary of the major projects, primarily funded at the federal level, is provided in Table 1.

a) Keeping in view the large presence of wild olives in different ecological zones of Pakistan with various morphological and ecological types, the Ministry of Food, Agriculture and Livestock (MinFAL), through the Pakistan Oilseed Development Board (PODB) launched in 1986 a project to graft about 5.5 million wild plants, but less than 1% plants went into production. Notwithstanding the limited success of the grafting efforts, the favorable performance of some olive plants, occasionally introduced from Mediterranean countries by researchers, officials, and travelers, demonstrated the species' adaptability and indicated the potential for its successful cultivation in Pakistan.

b) The pioneer structured initiative was taken in 1986 with the assistance and funding from the Italian Government of the "*Fruit, Vegetable and Olive Project*." (1986-1989), implemented by AGROTEC with the Pakistan Agricultural Research Council (PARC). Some experimental trials with the exotic olive germplasm were established in the provinces and at the National Agriculture Research Center (NARC). It is worth mentioning that olive was not a main component of the project, nevertheless the basis was laid down for introducing cultivation by exploring the suitability of country's agro-ecology zones. The scientific and technical response was positive, but the real outcomes would have been ensured by a regular follow-up post-project.

c) PODB during 2005 launched the project captioned as "*New plantation of Olive in Khyber Pakhtunkhwa, Potohar and Balochistan, and maintenance of olive orchards established by POD"* at the cost of Rs. 39.185 million. PODB also developed 150 acres of model olive farm at Sangbhatti, Mardan and planted about 20,000 olive plants. It also established germplasm unit on 10 acres comprising of 1,000 olive plants of different varieties imported from Italy and other countries, incurring a cost of Rs. 38.0 million.

d) The Italian Government resumed the dedicated support for the development of olive on modern way, in consideration of the relevant failures of the grafting, and financed the project "*Promotion of the production and marketing of olive oil in Pakistan*", implemented by the Istituto Agronomico per l'Oltremare & PODB from 2007 to 2008. The Project identified suitable areas for olive growing and published the "Atlas of suitable areas for olive growing in 14 Districts in Khyber Pakhtunkhwa (KP) (formerly North-West Frontier Province, NWFP) and Balochistan", and a market study to understand oil consumption and market dynamics.

e) The Pakistan Italian Debt Swap Agreement (PIDSA) awarded in 2012 to the Ministry of National Food Security and Research the project captioned as "*Promotion of Olive Cultivation for Economic Development and Poverty Alleviation*". The project, with the cost of PKR 382 million, was executed through PARC coordination system in KP, Baluchistan, Federally

Administered Tribal Areas (FATA) and Punjab provinces. The project represents the first significative investment in the country for the development of the olive sector, aiming to increase the local production of edible oils by cultivating olive specially to utilize culturable waste lands and expand the cultivation of olives in selected/identified areas through new plantations in these provinces. The project achieved several important outcomes that significantly contributed to the initial development of the olive sector in Pakistan. Large-scale olive plantation activities were carried out at farmers' fields across Balochistan, KP, Punjab, FATA, and the Islamabad Federal area, resulting in the establishment of olive orchards over a considerable cultivated area. In parallel, extensive efforts were made in plant propagation and nursery management through the distribution of a high number of olive cuttings to support future plantation activities and strengthen local nursery production systems. Capacity-building activities were also implemented through training sessions and field days aimed at improving farmers' and technicians' knowledge of olive cultivation practices. The project further supported the maintenance of mother orchards, rehabilitation of previously established olive orchards, and development of related infrastructure. Moreover, adaptability and varietal trials were conducted at numerous locations across different provinces to evaluate the performance of olive varieties under diverse agro-climatic conditions. Awareness and promotional campaigns were continuously conducted through print and electronic media to enhance public understanding of olive cultivation and its economic potential. Overall, these interventions played a fundamental role in introducing and promoting olive cultivation in Pakistan and established the basis for future expansion and investment in the sector.

f) The Italian Government, extending the support for the development of olive sector in a consequential and consistent manner, financed the regional project "*Technical assistance and support to line ministries in the agricultural sector with emphasis on olive production/AFNEPAK*" (in Pakistan, Afghanistan and Nepal) implemented by the Istituto Agronomico per l'Oltremare (IAO) & PARC, from 2012 to 2016. The project was approved with the overarching objective of strengthening the agricultural sector, with particular emphasis on the development of olive cultivation and olive oil production, while contributing to the improvement of rural livelihoods. The project aimed to comprehensively develop Pakistan's olive sector by identifying regions with natural suitability for cultivation, creating opportunity cost models, establishing a national olive registry, and collecting meteorological data to support informed decision-making and market analysis. It sought to strengthen human resources through training of technicians and farmers, provide technical support for farm-level production systems including cultivar adaptability and cultivation practices, and promote the formation and capacity-building of farmers' associations and related organizations. Additionally, the project focused on enhancing olive oil quality and value addition through best practices and laboratory training, while promoting olive production and consumption via targeted outreach, technical assistance, and engagement with government, NGOs, communities, and private investors. The project achieved its objectives only partially, as activities were suspended by the counterpart, and the project remains administratively open. Many of the planned interventions were designed to complement and support the PIDSA Olive Project. Despite these constraints, several important outputs were delivered. In addition to extensive training-of-trainers programs and technical assistance activities, key achievements included the development of a comprehensive market study, "*Market Analysis for Value Chain and Olive Oil Consumption in Pakistan*," conducted by the Punjab Economic Research Institute, as well as the mapping of olive plantation areas.

g) Under the PIDSA-funded project "*Early Recovery of Agriculture and Livelihood Program for Conflicted Areas (Malakand)*," implemented by the Provincial Disaster Management Authority/Provincial Reconstruction and Rehabilitation Authority (PDMA/PaRRA) of Khyber Pakhtunkhwa between March 2010 and July 2012, with a total budget of Rs 713 million, olive cultivation initiatives were introduced in the Swat region with the technical support of PODB. As part of the project, approximately 24,000 imported olive plants were established over 71 hectares of rangeland under barani (rainfed) conditions. In addition, training sessions and follow-up support were provided to stakeholders. Grafting activities were also carried out on 247,878 wild olive plants. However, subsequent evaluations indicated a relatively low survival and growth rate of the plantations, mainly due to various constraints, which were later taken into consideration by PODB for future interventions.

h) Building on the positive outcomes and nationwide response to the PIDSA-funded olive initiatives, the Public Sector Development Programme (PSDP) launched a flagship mega-project titled *"Promotion of Olive Cultivation on Commercial Scale in Pakistan" (POCCSP)*, with a total allocation of PKR 2,444.545 million, implemented by PARC. The project was designed on the premise that large tracts of Pakistan's virgin land are suitable for olive cultivation, supported by research findings from adaptability trials of exotic cultivars and the widespread presence of wild olive populations across the country.

The primary objective of the project was to realize the full potential of olive cultivation across major regions, including Balochistan, Khyber Pakhtunkhwa (KP), Punjab, Azad Jammu and Kashmir (AJK), Gilgit-Baltistan (GB), and Southern Punjab. The first phase (2014–2021) has been completed, while Phase II, with an expanded budget of PKR 6,410.229 million, was initiated in 2021-2022 under the implementation of the Pakistan Oilseed Department (POD) of the Ministry of National Food Security and Research (MNFSR) and was scheduled for completion in 2024.

Over its implementation period, the project aims to establish olive plantations on approximately 75,000 acres by supplying both imported and locally produced olive plants. It also focuses on strengthening public and private sector capacity for large-scale production of certified, disease-free nursery plants, including the development of mother orchards for quality budwood. Drip irrigation systems are being installed over 16,000 hectares, supporting approximately 3.6 million olive trees. At present, 25 olive oil extraction units of varying capacities are operational across the country in both public and private sectors. The project also emphasizes capacity building, particularly targeting youth and women, and includes the provision of oil extraction units and value-addition equipment to enhance processing capabilities. Overall, the project comprises nine components implemented at federal and provincial levels, including Punjab, Balochistan, KP, GB, and AJK. A detailed assessment of its agronomic outcomes is presented in Section III.

The Barani Agriculture Research Institute (BARI) at Chakwal has been engaged in olive research since 1991, during which more than 50 olive varieties have been evaluated for adaptability. In 2012, with the support of the Punjab Agriculture and Meat Company (PAMCO), a project was initiated involving the import of 13,100 saplings for the establishment of mother blocks. Subsequently, PIDSA-funded initiatives significantly accelerated olive development in the region, contributing to the transformation of the Potohar plateau into what is now referred to as the "Olive Valley" of Pakistan. In parallel, BARI conducted an adaptation study (2010-2014), funded by the Punjab Agricultural Research Board (PARB), focusing on the evaluation

of new olive cultivars and the standardization of propagation techniques and value-addition processes under rainfed conditions in Punjab.

i) Complementing the federal POCCSP initiative, the Government of Punjab launched a provincial olive development project (2015-2020) with a budget of PKR 2,629.786 million. The project aimed to expand olive cultivation by over 15,100 acres through the distribution of approximately 2.04 million certified nursery plants. Key components included strengthening the private sector's capacity for plant acclimatization, providing technical support for orchard establishment and management, improving water resource development, and promoting efficient drip irrigation systems. The project received support from USAID, which played a significant role in strengthening institutional capacity, particularly in establishing BARI as a Centre of Excellence for olive research and development. As part of these efforts, the Centre of Excellence for Olive Research and Training (CEFORT) was established at BARI Chakwal with a total cost of PKR 283.121 million. CEFORT is tasked with advancing research and capacity building in olive cultivation, orchard management, post-harvest processing, and value addition. It also serves as a hub for technology development and dissemination, genetic resource conservation, and socio-economic research related to the olive sector.

j) The *"Programme for Poverty Reduction" (PPR)*, funded by the Italian Government and implemented by the Pakistan Poverty Alleviation Fund (PPAF), introduced olive cultivation as a livelihood diversification strategy for rural communities. Between 2016 and 2020, a total of 53,608 olive saplings were planted across approximately 560 acres, benefiting 692 households. In addition to plantation activities, the program facilitated the establishment of three olive oil extraction units, one in KP and two in Balochistan, managed by community-based associations in collaboration with PPAF and partner organizations. The facility in Lower Dir also includes a unit dedicated to table olive processing, contributing to local value addition and income generation.

k) The European Union is currently funding the project *"Growth for Rural Advancement and Sustainable Progress (GRASP)"*, implemented by the International Trade Centre (ITC) from 2019 to 2024 in selected districts of Balochistan and Sindh. The project aims to reduce poverty and promote sustainable and inclusive economic growth by supporting rural Small and Medium-sized Enterprises (SMEs). In Balochistan, olive cultivation has been identified as a priority crop, offering opportunities for synergy with ongoing national and provincial initiatives. Field-level implementation is supported by FAO (for agricultural development) and PPAF (for Small and Medium-sized Entreprises (SME) development). This initiative builds upon earlier European Union-funded programs, such as the *Programme for Economic Advancement and Community Empowerment (PEACE)*, implemented in Swat from 2012 to 2018, which supported olive oil production and community-based enterprise development. The GRASP project is expected to further strengthen these foundations, including the promotion of producer groups managing shared olive processing facilities.

l) Keeping in view the olive cultivation success story, but also the complexity for reaching a viable value chain, the Government of Pakistan through Economic Affairs Division requested to Italian Agency for Development Cooperation (AICS) to further support the process of olive development. Positively, the Italian Government has financed the Project *"OliveCulture - Holistic and multi-professional Mechanism for a Pakistani Olive Value Chain"* which has been designed to strengthen the Pakistani olive oil value chain on several levels in a holistic,

participatory, and multifunctional way, involving institutions, businesses, farmers, youth, women and consumers, to improve productive, economic, and qualitative performances. The Project is funded by the Italian Ministry of Foreign Affairs and AICS and jointly implemented by CIHEAM – Bari and the Ministry of National Food Security and Research, through POD. The POD and its national project "Promotion of Olive cultivation on commercial scale in Pakistan - Phase II" are the main partners, encouraging herewith a holistic and multi-professional mechanism for strengthening the Pakistani quality olive value chain. The Project started on the 17th of January 2022 and ended in March 2024.

Table 1 provides a chronological overview of the major national and international projects implemented for the development of the olive sector in Pakistan.

Table 1. National and international projects executed for the promotion of olive cultivation and development of its value chain.

N°	Title of the project	Project time span	Executing organization/Sponsor	Project domain	Project cost PKR (Million)
1	Grafting wild olives into bearing species	1986	Pakistan Oilseed Development Board PODB	Pakistan Oilseed Development Board	-
2	Fruit, Vegetable and Olive Project	1986 to 1989	AGROTEC & Pakistan Agriculture Research Council (PARC)/Italian Government	Punjab, KPK, Baluchistan, FATA	-
3	Accelerated promotion of olive cultivation	2000 to 2004	Pakistan Oilseed Development Board (PODB)	KPK and Potohar	24.055
4	Rapid conversion of wild olive into oil bearing species	2004 to 2008	Pakistan Oilseed Development Board (PODB)	Punjab, KPK, Baluchistan	186.379
5	Development of olive model farms for R&D activities	NA	Pakistan Oilseed Development Board (PODB)	NA	-
6	Development of olive production and processing in Baluchistan	NA	PODB - M/o Food and Agriculture and Livestock (MINFAL	Baluchistan	190.00
7	Promotion of the production and marketing of olive oil in Pakistan.	2007 to 2008	Istituto Agronomico per l'Oltremare (IAO) & Pakistan Oilseed Development Board (PODB)/ Italian Government	KPK, Baluchistan	0.8 M. Euro
8	Adaptation study of new cultivars of olive and standardization of its propagation and value addition techniques	2010 to 2014	PARB, Punjab and Barani Agriculture Research Institute (BARI), Chakwal	Barani Areas of Punjab	21.97
9	Technical assistance and support to line ministries in the agricultural sector with emphasis on olive production (AFNEPAK)	2012-2016	Istituto Agronomico per l'Oltremare (IAO) & Pakistan Agriculture Research Council PARC)/Italian Government	Afghanistan, Nepal and Pakistan	2.4 M € (0.8 M for Pakistan)
10	Promotion of olive cultivation for economic development and poverty alleviation	2012 to 2015	Pakistan Italian Debt Swap Agreement (PIDSA) and PARC /Italian Government	Punjab, KPK, Baluchistan, FATA	382.15
11	Developing Potohar into an olive valley	2015 to 2020	Punjab Agriculture Development Program, BARI Chakwal	Punjab Barani regions	2629.79

12	Plantation of Five million of olive saplings in KPK and maintenance of model farm at Sangbhatti	2013 to 2019	Agriculture Development Program. Agriculture Research Institute, Peshawar	KPK and FATA	1154.17
13	Development of olive production and processing in Baluchistan	2016 to 2019	Baluchistan Agriculture Development Program. Agriculture Research Institute, Quetta	Baluchistan	190.00
14	Promotion of Olive Cultivation on commercial scale in Pakistan. Phase-1 (POCCSP)	2014 to 2022	M/o National Food Security and Research (MNFSR) - PARC	Punjab, KPK, Baluchistan, FATA and AJK	2320.27
15	Promotion of Olive cultivation on commercial scale in Pakistan. Phase-2 (POCCSP)	2021 to 2024	PSDP MFSR Pakistan Oilseed Department (POD)	Punjab, KPK, Baluchistan, AJK, GB, and Southern Punjab	6.41 billion
16	Project OliveCulture "Holistic and multi-professional mechanism for a Pakistani Olive Value Chain"	2022 to 2024	CIHEAM Bari & Pakistan Oilseed Department (POD)/ Italian Government	Baluchistan, Khyber Pakhtunkhwa, Punjab, Sindh, Gilgit-Baltistan and Islamabad Capital Territory	€ 1,500,000

III – Assessment of the agronomic studies done with the PSDP project from 2014

To effectively evaluate agronomic activities and olive crop production under the national project "*Promotion of Olive Cultivation on Commercial Scale in Pakistan (POCCSP, 2021),*" it is essential to first provide a clear overview of the initiative. The project, briefly introduced in the previous section, was approved in 2014 with a total allocation of Rs. 2,320.27 million, aiming to harness the country's potential for olive cultivation. The Ministry of National Food Security & Research entrusted to PARC its implementation. The initiative was structured in two phases and covered multiple regions, including Baluchistan, KP, Punjab, AJK, and GB. Phase I was successfully completed in 2019.

Subsequently, the second phase, titled "*Promotion of Olive Cultivation on Commercial Scale in Pakistan (Phase II): National Program on Olive Deepening*", was approved during the Executive Committee of the National Economic Council (ECNEC) meeting held on 1st of June 2021 by the Ministry of Planning Development & Special Initiatives. The MNFSR assigned its implementation to POD. Phase II targets the expansion of olive cultivation to 75,000 acres, alongside the grafting of 5 million wild olive plants across public and private lands, including forest areas. In addition, the program includes support for the establishment of six olive oil extraction units, ten table olive processing units, and ten nursery tunnels, all provided to the private sector on a 50% matching

grant basis. This phase was initiated during 2021-2022 and is scheduled for completion by 2024 (POCCSP, 2022).

Overall, the PSDP-funded project (Phases I and II combined) is designed to strengthen the olive value chain across diverse agro-ecological zones by providing essential services, infrastructure, equipment, and inputs. The key objectives defined for Phase I include:

- Establishment of olive plantations over 50,000 acres;
- Development of infrastructure and capacity in both public and private sectors for large-scale production of true-to-type, disease-free nursery plants;
- Provision of both exotic and locally produced olive plants to farmers;
- Human resource development through training programs, with emphasis on youth and gender inclusion;
- Installation of oil extraction units and value-addition equipment to support processing;
- Development of mother orchards for the supply of high-quality budwood.

These interventions were designed to incorporate state-of-the-art technological support, aiming to enhance the capabilities of stakeholders across the entire olive value chain, from production to processing. The project interventions and their follow-up progress and achievements for the period 2014-2021 (POCCSP, 2022) are summarized in Table 2.

In addition to the progress mentioned in Table 2, it may be mentioned: (i) 20% - 30% of the olive fruits are used in preparing value-added products, pickles, jams, sweets, and syrups which have increased demand, (ii) joint research, development, and training of olive value chain stakeholders have being conducted through specialized dedicated institutions such as CEFORT established by the Government of Punjab at BARI Chakwal with technical and financial support of USAID Pakistan, and (iii) the intellectual property rights for marketing olive oil and value-added products, a trade mark and logo as "*Pak Olive*" has been approved by the intellectual property organization, Government of Pakistan.

The project assigned an "Impact Assessment Study", released in April 2022 and conducted by Khaity.Pk. The study was based on a structured, questionnaire-based survey of approximately 670 olive growers representing the project's operational regions across the country. It provided a comprehensive evaluation of the project's interventions and their outcomes. Overall, the findings indicate that the implemented activities have generated tangible results and positive impacts, highlighting Pakistan's strong potential to further develop a sustainable olive value chain. It is important to note that the assessment covers the period from 2014 to 2021, during which only about 20% of the plantations had begun fruiting.

Table 2. Summary of key interventions and progress under POCCSP.

Intervention	Description	Progress
Provision of certified, true-to-type olive plants	Distribution of imported certified olive saplings	13,354 acres planted (1.719 million saplings): Baluchistan 56%, KP 24%, Punjab 15%, AJK 3%, GB 2%; ~3,884 farmers benefited; >17% plantations fruiting
Installation of drip irrigation systems	Deployment of High-Efficiency Irrigation Systems (HEIS) at farm level	Installed on 1,686 acres for 124 farmers (75% of target): Baluchistan 35%, KP 45%, Punjab 20%
Specialized olive nurseries	Establishment of double-shaded nurseries for propagation	12 nurseries established: 6 in Baluchistan, 3 in KP, 2 in Punjab, 1 in ICT; equipped with irrigation, heating, cooling, and temperature control systems
Olive oil extraction units	Installation of olive processing mills	9 mills installed: MORI TEM Oliomio Gold (100 kg/hr) at multiple sites; PIERALISI (600 kg/hr) at BARI Attock, ARI Loralai, BARDC Quetta
Adaptability trials support	Support to provinces for testing exotic olive varieties	25 trials completed; data collection ongoing for variety registration and certification
Establishment of olive mother blocks (GPUs)	Development of germplasm units in public institutions	GPUs established across all project regions, including GB and AJK
Local plant propagation	Production of olive plants through cuttings	1.856 million cuttings planted across project components
Training of stakeholders	Capacity building across the olive value chain	63 training sessions conducted (out of 91); >4,370 farmers trained in best practices, processing, and marketing
Installation of weather stations	Deployment of agro-meteorological monitoring systems	5 stations installed: BARI Attock, NTHRI Shinkiyari, ARI Quetta, UET Khuzdar, Loralai
Upgradation of value-addition labs	Enhancement of research and processing laboratories	Labs upgraded at BARI Chakwal, ARI Tarnab, ARI Quetta; improved infrastructure, equipment, and standardization capacity

As olive trees typically reach full productivity after nearly 10 years, the long-term outcomes are expected to be significantly greater. The key findings of the study are summarized below:

- Approximately 45% of irrigated land and 35% of rainfed land have been allocated to olive cultivation.
- The average survival rate of olive plantations on farmers' fields ranges between 80-90%, although mortality rates of up to 50% were reported in some cases, mainly due to drought and water scarcity.
- About 73% of farmers reported receiving guidance from the project on cultivar selection, with Arbequina and Arbosana being the most widely planted varieties.
- Around 37% of farmers reported the presence of wild olive trees on their land, typically covering areas between 1 to 10 acres.

- Approximately 59% of farmers use pesticides once or twice a year to manage pests and diseases, with costs ranging from Rs. 1,000 to 10,000 per acre.
- About 86% of farmers apply fertilizers, mostly once per season, at an average cost of Rs. 10,000 per acre. Among them, 90% rely on organic fertilizers, particularly animal manure (81%) and poultry waste (6%). Meanwhile, 13% of farmers reported not using any fertilizers.
- Of the 670 farms surveyed, only 19% had started production, and about 7% had reached 50% production capacity.
- Harvesting is predominantly manual, practiced by 99% of farmers, while only 1% use mechanical tools. The lack of appropriate harvesting machinery remains a major constraint. Harvesting costs are typically around Rs. 10,000 per acre.
- Drip irrigation systems were installed on 1,686 acres under the project, whereas other farmers continue to rely on conventional irrigation methods.
- A large majority (91%) of farmers believe that olive cultivation has a positive impact on soil quality.
- Livestock manure is widely used as fertilizer, accounting for 77% of usage across provinces.
- In most cases, farms are located more than 5 km from markets, which increases transportation challenges.
- Around 35% of farmers produce value-added olive products at the farm level. Among these, producers are distributed as follows: Baluchistan (53%), KP (14%), Punjab (28%), and ICT/Federal (5%).
- Access to processing and storage infrastructure remains limited: 63% of farmers lack access to olive extraction units, 78% do not have access to government storage facilities, and 69% do not own storage facilities. Notably, 90% expressed interest in establishing such facilities with government support (80-100% subsidy).
- Regarding government-established value-addition laboratories, 48% of farmers reported no access, 35% did not respond, and 9% were unaware of their existence.
- Concerning weather stations, 74% of farmers reported no nearby access or awareness, while only 11% had access to such facilities.
- Farm maintenance costs were estimated at approximately Rs. 5,000 per acre by 21% of farmers, while 76% did not provide a response.
- Transportation costs vary depending on distance to market: 46% of farmers reported costs below Rs. 20,000, 9% between Rs. 20,000-50,000, and 43% between Rs. 50,000-100,000.
- Training programs were attended by 54% of farmers, while 11% were unaware of such opportunities. Participants generally reported positive impacts on their skills and knowledge, with strong demand for future training, particularly in agronomic practices and cost reduction.
- Overall, 58% of farmers stated that training improved their knowledge of olive cultivation, while 37% did not respond and 4% reported no noticeable benefit.
- 84% of farmers believe that olive cultivation has a positive impact on surrounding vegetation and wildlife.

IV – Synthesis of agronomic research on olive cultivation in Pakistan

Olive tree vegetative and reproductive growth are strongly influenced by environmental factors such as light availability, canopy architecture, and varietal characteristics (Schneider *et al.,* 2012; Cherbiy-Hoffmann *et al.,* 2013; Rousseaux *et al.,* 2020). Differences among cultivars in leaf area distribution, anatomical traits, and canopy structure play a crucial role in determining productivity. Under Mediterranean conditions, cultivars such as Arbequina, Coratina, and Frantoio have been identified as highly suitable due to their favorable agronomic and physiological traits (Tous, 2010; Neri *et al.,* 2020).

1. Adaptability and cultivar evaluation

To assess suitability under local conditions, extensive adaptability trials have been conducted across Pakistan. Trials at 93 locations across the country have assessed cultivar suitability for different ecological zones (Awan *et al.,* 2014; Pulido-Fernández *et al.,* 2019). According to the POCCSP project report (2014-2021), more than 100 olive cultivars were introduced and tested, particularly by BARI Chakwal and ARI Peshawar. These studies demonstrated that a large proportion of the tested cultivars are suitable for oil extraction, while some show better performance as table olives.

Despite this extensive work, a major limitation remains the absence of a centralized and structured database linking cultivar performance to specific environmental conditions. This gap makes it difficult for farmers to select appropriate varieties based on yield potential, oil quality, and adaptability. Historically, the availability of certified, true-to-type, disease-free planting material was also a constraint, although recent initiatives under POCCSP have improved access through nursery development and plant distribution.

Given that Pakistan's climate differs from the Mediterranean, often characterized by higher temperature extremes, lower and erratic rainfall, and variable soil conditions, cultivar performance varies widely across regions. For example, oil content analysis of different cultivars collected from Quetta, Loralai, and Zhob showed significant variation, with oil content ranging from 17.5% in Dolce Agogia to 65% in Gemlik (Khaliq *et al.,* 2020). Gemlik was identified as a superior cultivar in terms of oil recovery, while Arbequina and Frantoio also showed consistently high oil content.

Regional comparative studies further highlight environmental effects. In Chakwal, higher fruit set, number of fruits per tree, and oil content were recorded, whereas Sangbhatti conditions favored larger fruit size and higher overall fruit yield (Awan and Rab, 2014). Cultivar-specific responses were also evident: Leccino performed best in terms of fruit number, yield, and oil content, Pendolino exhibited higher fruit set percentage, and Coratina produced larger fruits but with comparatively lower oil content.

Similarly, under arid sub-tropical conditions of Quetta, significant differences among cultivars were observed in oil content and yield components. Kalamata (21%), Leccino (20%), and Arbequina (17%) showed the highest oil production, while Pendolino (16%) and Arbosana (10%)

performed less favorably (Asif *et al.,* 2022). These findings confirm that genotype × environment interactions play a decisive role in cultivar performance.

2. Yield, oil quality, and biochemical traits

Climatic conditions strongly influence olive oil composition and quality, particularly fatty acid profiles and phenolic content. Studies have shown that temperature, rainfall, and altitude significantly affect oil characteristics (Awan *et al.,* 2015). For instance, olives grown in Chakwal exhibited higher levels of palmitic, palmitoleic, stearic, and linoleic acids, whereas those grown in Sangbhatti had higher oleic and linolenic acid content. The wetter conditions in Sangbhatti were also associated with increased polyphenol concentration, which contributes to antioxidant activity and oil stability.

Oil quality parameters such as peroxide value (PV) and acidity generally remained within acceptable limits for virgin olive oil as defined by international standards, although variations were observed across locations (Ullah *et al.,* 2018; Awan *et al.,* 2020). In some cases, PV exceeded recommended limits, particularly in Chakwal, likely due to environmental stress and differences in enzymatic activity, such as lipoxygenase.

Morphological and biochemical characterization studies further revealed substantial diversity among olive genotypes. For example, Qureshi *et al.* (2020) reported significant variation in leaf morphology, fruit weight, and fatty acid composition among eight olive genotypes from the Potohar region. The genotype Mariana exhibited the highest fruit weight (5.41 g) and favorable fatty acid composition, indicating its suitability for semi-arid conditions. Similarly, Sumrah *et al.* (2021) found that table olive varieties such as Ascolana, Earlik, Gemlik, and Hamdi performed well under Pothwar conditions, producing high yields (up to 22.66 kg/tree), larger fruits (6.29 g), and higher oil recovery (24.66%).

3. Propagation, grafting, and plant establishment

Propagation techniques, particularly grafting, significantly influence plant establishment and early growth. Hussein *et al.* (2016) demonstrated that grafting time affects multiple growth parameters, including sprouting percentage, shoot length, and leaf development. Grafting in July resulted in higher sprouting rates and number of sprouts, while June grafting promoted longer shoots and greater leaf development. Among the cultivars tested, Frantoio showed superior overall performance, suggesting its suitability as a scion under local conditions.

4. Phenology, pollination, and fruit set

Phenological traits and reproductive biology are critical for determining olive productivity. Pollen viability and germination capacity, which directly affect fertilization success, vary among cultivars and are influenced by environmental conditions, particularly temperature (Iqbal *et al.,* 2020). Several cultivars, including Gemlik, Coratina, Frantoio, Nabali, and Moraiolo, showed promising pollen performance, while Ottobratica was identified as a suitable pollinizer due to its high pollen viability.

Fruit set and yield are closely linked to pollination dynamics. Studies conducted under Pothwar conditions revealed that cultivars such as Coratina, Frantoio, and Leccino exhibit partial self-incompatibility, whereas Ottobratica is fully self-incompatible (Iqbal *et al.,* 2020). Cross-pollination significantly improves fruit set and yield, emphasizing the importance of selecting compatible cultivar combinations in orchard design. In most cases, fruit set percentages remained relatively low, indicating the need for improved pollination management strategies under local conditions.

5. Environmental and nutritional influences

Nutrient availability and seasonal dynamics play an important role in olive growth and productivity. Farhat *et al.* (2021) reported that calcium levels peak during periods of active vegetative growth, while magnesium levels increase during fruit development and dormancy. Soil analysis from olive-growing regions indicated alkaline conditions with low organic matter and deficiencies in nitrogen and phosphorus, while potassium, calcium, and magnesium were generally adequate. These findings highlight the importance of targeted nutrient management to optimize yield and quality.

6. Local germplasm and future prospects

The evaluation of local and exotic germplasm has contributed to the identification of promising cultivars for different regions. Locally developed varieties such as Zaitoon-1 and Zaitoon-2 have shown good adaptability, with average yields of approximately 23 kg per plant and oil content around 19.34% (BARI, 2022). These cultivars have demonstrated successful performance across multiple districts in Punjab, indicating strong potential for expansion.

In addition, studies on wild olive species (*Olea ferruginea*) have explored their potential as an alternative oil source. Although current oil quality is relatively low and classified as lampante due to processing limitations, improvements in harvesting and processing practices could enhance its commercial value (Anwar *et al.,* 2013).

Despite the extensive research conducted, significant gaps remain, particularly in the systematic evaluation of cultivars across different agro-ecological zones such as Baluchistan (Palwasha *et al.,* 2022). Future research should focus on integrating morphological, biochemical, and molecular approaches to better characterize olive germplasm and develop region-specific recommendations for sustainable olive production.

V – Identification of the major olive varietal trials established in Pakistan

1. Varietal tests and performance

As outlined in the previous sections, thousands of olive plants were imported from countries where olive cultivation is well established as a commercial crop. The primary objective was to promote olive cultivation in Pakistan by introducing these exotic cultivars and evaluating their performance under local conditions. These varieties were planted across diverse agro-ecological zones to identify both the most promising cultivars and the areas best suited for olive production. In parallel, the multiplication of selected varieties was initiated through the establishment of

mother blocks in suitable regions. However, the development of nursery systems remained inadequate, limiting the large-scale availability of planting material.

The varieties recommended for dissemination were predominantly exotic, sourced mainly from Mediterranean countries such as Italy and Spain, as well as from North Africa. Nevertheless, it is important to recognize that olive cultivars do not perform uniformly across different environments, and their adaptability is highly dependent on local climatic and edaphic conditions.

From a research perspective, a well-structured evaluation and selection system based on adaptability trials is essential to identify cultivars that are best suited to specific agro-climatic zones. Evidence suggests that olive varieties performing well under sub-mountainous agro-climatic conditions offer strong potential for the successful establishment of commercial olive cultivation and the development of a sustainable olive industry in such regions, provided that other agronomic and infrastructural requirements are met.

Although a substantial number of varietal trials were established under the PIDSA project with the aim of generating reliable data in a timely manner, the lack of consistent follow-up and systematic monitoring limited their effectiveness and the overall utility of the results.

2. Olive varieties genetic characterization studies

In Pakistan, limited information is available on the genetic diversity and divergence of both cultivated and indigenous wild olive populations, despite its importance for crop improvement and germplasm utilization (Naz *et al.,* 2019). Several molecular studies have therefore been conducted to characterize olive genetic resources using different marker systems.

A. Genetic diversity and differentiation between wild and cultivated olives

Initial studies using Randomly Amplified Polymorphic DNA (RAPD) markers revealed substantial genetic diversity among olive genotypes collected from regions such as Buner, Bajaur, Malakand, and Upper Dir (Naz *et al.,* 2019). A total of 36 loci were amplified across 30 genotypes, all of which were polymorphic, indicating high genetic variability. Gene diversity values ranged from 0.067 to 0.515, confirming the presence of both low and highly variable loci.

Multivariate analyses clearly distinguished wild and cultivated genotypes, demonstrating significant divergence between them. Wild olive populations from Malakand, Buner, and Bajaur were genetically closer to each other, while those from Upper Dir were more distinct. These findings highlight the potential of wild germplasm as a valuable genetic resource for breeding and cultivar development. However, the study also emphasized the need for broader sampling and the use of more advanced genotyping tools to better understand population structure.

Similarly, Amplified Fragment Length Polymorphism (AFLP) analysis confirmed clear genetic separation between *Olea europaea* (cultivated) and *Olea cuspidata* (wild) populations in Azad Jammu and Kashmir (Hussain *et al.,* 2017). The results suggested that cultivated olives were likely introduced from abroad and subsequently propagated through grafting onto local wild rootstocks. This distinction is important for maintaining genetic diversity and guiding grafting strategies to avoid genetic erosion.

1.1 DNA fingerprinting and varietal identification

Molecular tools have also been widely applied for varietal identification and authentication. Chloroplast DNA (cpDNA) markers have proven effective in distinguishing olive cultivars through phylogenetic analysis (Noman *et al.,* 2015). Using concatenated chloroplast gene sequences, more than 100 unknown samples were analyzed, resulting in the identification of 49 plants belonging to 10 known varieties, including Arbosana, Frantoio, Koroneiki, Leccino, and Coratina. However, approximately 51% of samples could not be assigned to known varieties, indicating the presence of uncharacterized germplasm or the lack of reference sequences.

Phylogenetic reconstruction and SNP analysis further confirmed clear clustering of major cultivars, while sequence similarity was higher within cultivars (>98.7%) than between cultivars (~96-97%). These findings demonstrate the utility of chloroplast markers for reliable and cost-effective varietal identification and highlight their potential for germplasm conservation and nursery certification.

A large-scale study by Ramazan and Ali (2014) further supported the effectiveness of DNA-based identification. Out of 965 unknown olive plants analyzed, 515 were successfully classified into 27 varieties using chloroplast DNA markers and genome sequence analysis. However, a substantial proportion (47%) remained unidentified due to the absence of reference genome sequences. The study emphasized the importance of expanding reference databases and using multiple marker regions (concatenated sequences) to improve identification accuracy. It also contributed to the development of a valuable DNA sequence repository for indigenous olive germplasm.

B. SSR and RAPD marker-based genetic analysis

Simple Sequence Repeat (SSR) markers have been extensively used to assess genetic diversity and population structure. In one study, 63 SSR markers amplified 618 alleles across 13 olive varieties, of which 582 were polymorphic, indicating high allelic diversity (Iqbal *et al.,* 2021). Cluster analysis grouped the genotypes into two major clusters: one including varieties such as Manzanilla, Arbequina, and Koroneiki, and the other comprising Bari Zaitoon, Coratina, Gemlik, Frantoio, Pendolino, and Ottobratica. Certain markers, such as UDO-24, demonstrated high discriminatory power by identifying multiple varieties individually.

RAPD marker systems have also been used for DNA fingerprinting and varietal differentiation (Iqbal *et al.,* 2019). In this study, 59 out of 62 markers were polymorphic, generating 583 alleles, of which 498 were polymorphic. Genetic similarity among varieties ranged from 0.548 to 0.728, indicating moderate genetic divergence. Specific primer combinations were able to distinguish all studied varieties, demonstrating the effectiveness of RAPD markers for varietal identification and nursery certification, although some cultivars such as Bulkasar selection and Arbequina lacked unique alleles.

C. Implications for breeding and germplasm management

Overall, these studies consistently demonstrate a high level of genetic diversity among both wild and cultivated olive populations in Pakistan. The clear genetic distinction between indigenous wild olives and introduced cultivars provides opportunities for their use in breeding programs, particularly for improving adaptability to local environmental conditions. At the same time, the

presence of a large proportion of unidentified genotypes highlights the need for more comprehensive reference databases and advanced molecular tools. The integration of different marker systems (RAPD, SSR, AFLP, and cpDNA sequencing) can significantly enhance the accuracy of varietal identification, support germplasm conservation, and ensure the propagation of true-to-type planting material. These findings are particularly relevant for the development of a sustainable olive industry, as they provide a scientific basis for cultivar selection, breeding strategies, and the establishment of certified nurseries in Pakistan.

VI – Strategic considerations and policy gaps in the development of the olive sector in Pakistan

The promotion of olive cultivation as an alternative oilseed crop for edible oil production represents a promising opportunity for Pakistan. Large areas of the country, particularly marginal lands and regions not currently utilized for major cash crops, are well suited for olive production. However, to fully realize this potential, strong policy support and widespread awareness are required to encourage both consumers and industry stakeholders to adopt olive oil as a viable and healthier alternative to conventional vegetable oils.

The review of the olive sector indicated that numerous initiatives have been undertaken at federal and provincial levels, along with contributions from international donors, particularly Italy, as well as local NGOs and community organizations. Despite significant financial investments and research support, these efforts have not yet translated into a substantial breakthrough in olive cultivation or domestic olive oil production. This suggests that existing interventions, although extensive, lack coherence, coordination, and long-term strategic alignment.

One of the major gaps identified is the lack of standardization and coordination in research activities. Multiple institutions are engaged in varietal evaluation through adaptability trials and genetic characterization using molecular tools such as DNA markers, polymorphism analysis, and Simple Sequence Repeats (SSR). However, there is no unified system for data collection, evaluation protocols, or reporting standards aligned with international practices. This limits the comparability and practical application of research findings. Similarly, certification systems for olive planting material and nurseries, whether imported or locally developed, are either weak or absent, and are not governed by accredited bodies in accordance with international standards.

Furthermore, legislative and policy frameworks for genetic improvement of olive crops remain underdeveloped. Issues such as varietal registration, plant certification, disease resistance breeding, and quality assurance require formal regulation at both national and provincial levels to ensure sustainable sector growth.

Institutional coordination between federal and provincial stakeholders is also weak, often leading to duplication of efforts and inefficient resource utilization. Moreover, collaboration among technical experts, including breeders, pathologists, agronomists, data analysts, and market specialists, is insufficient. There is a clear need for an integrated support system that connects all stakeholders across the olive value chain, including growers, researchers, extension services, processors, commercial actors, and policymakers. Establishing a dedicated body, such as a Pakistan Olive Oil Council, could play a critical role in coordinating sectoral activities, monitoring progress, and facilitating policy reforms related to production, processing, marketing, and trade.

Several structural and economic constraints further hinder sector development. These include competition with established cash crops due to the absence of crop zoning policies, price volatility, underdeveloped market infrastructure, weak industrial linkages, and limited adoption of recommended agronomic practices by farmers. Additionally, the lack of a comprehensive and consistent olive development policy has restricted long-term planning and investment.

To address these challenges, a cluster-based approach to olive cultivation is recommended. Identifying and developing agro-ecological clusters dedicated to olive production can enhance productivity and efficiency. These clusters should be supported through targeted subsidies, improved market linkages, public-private partnerships, and access to specialized agronomic technologies. Organizing smallholder farmers into cooperatives at village and regional levels would further strengthen production systems, facilitate processing, and improve market access.

At the policy level, Pakistan currently lacks a comprehensive legal and regulatory framework governing the olive value chain, from production to processing and marketing, aligned with international standards. While the National Food Security Policy (2018) highlights the importance of promoting oilseed crops for import substitution, a dedicated and coherent olive policy is still missing. Such a policy should clearly define the roles and responsibilities of federal and provincial governments, particularly in the context of the 18th Constitutional Amendment, and establish a coordinated roadmap for sector development.

Finally, integrated policy interventions are required across the entire value chain. These should include financial incentives, infrastructure development, support for cooperative systems, and strengthened linkages between producers and processing industries. A sustainable olive sector strategy should focus on expanding cultivation, promoting high-yielding and stress-tolerant cultivars, improving processing technologies, and enhancing value addition. Aligning these efforts within a unified national framework will be essential to reduce dependence on imported edible oils and to unlock the full potential of the olive industry in Pakistan.

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