Policy View point: NO.**77: 2026**

Responsible and Scalable Agricultural Drone Adoption in Pakistan: A CPEC 2.0 Pilot-to-Scale Pathway

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Executive Summary

While agricultural drones have the potential to be useful in areas such as crop scouting, pesticide application, seeding, and field mapping, they cannot solve the fundamental problems of low productivity in agriculture in Pakistan. Although, agriculture accounts for 23.4 percent of GDP and employs a substantial share of Pakistan's labour force, productivity outcomes are influenced by a broader range of factors, such as water management, seed quality, extension services, market incentives, climate risks, and access to finance, to name a few. Despite these factors, agricultural drones have increasingly been discussed in Pakistan in the context of modernizing agriculture, especially due to their potential to automate tasks that require a lot of time, reduce exposure of farmers to agricultural chemicals, and provide more precise and targeted farm management. In line with this, there is a need for a sound drone policy that focuses only on certain tasks on the farm where there is a clear business case, rather than on structural constraints such as water management, seed quality, extension services, market access, climate risks, and access to finance, which drones cannot directly address. The experience in China suggests that in some cases, such as pesticide spraying and crop management increased revenues and labor savings are possible, while other research identifies significant trade-offs, including increased spraying frequency and the need for stricter operational controls. All this evidence suggests a service-based and well-regulated approach, not based on broad assumptions or blanket subsidies, is the more effective and sustainable solution. This policy view is a 24-month, independently assessed course of action embedded within the current framework of agriculture cooperation under CPEC, but which deliberately avoids making any immediate and massive deployment recommendations. The proposed pathway would start with a single-window agricultural UAS protocol, including pilot projects that are competitive, with drone-as-a-service for small farmers and with clear operational, safety, and data-governance standards. Scale-up would only happen once predetermined thresholds that cover economic viability, compliance, safety, environmental impact and inclusion are achieved. In such a design, CPEC 2.0 can provide technology partnership, testing, training, maintenance, research collaboration, and private sector involvement, while the federal and provincial governments will remain responsible for regulation and implementation.

1. Introduction

Pakistan's agricultural productivity is constrained by poor water management, weak extension services, poor quality of inputs, climate vulnerability, and value chain development, which are further limiting the country's agricultural productivity. Concurrently, agricultural drones are becoming part of the broader policy and technology discussion on agricultural development, especially as countries pursue precision agriculture, automation, and digital farm services. In this context, drones are important not only for their ability to solve structural problems in agriculture, but also because they can reinforce specific operations, such as crop monitoring, mapping, and targeted application of agricultural inputs. The real question is therefore not why Pakistan should embrace agricultural drones per se, but where they can create a tangible impact, within what regulatory framework, and via what business model can they be scaled up on a sustainable basis.

The lessons learned from other nations like China are useful to consider both the possibilities and challenges of agricultural drones. In some cases, impact and empirical studies have shown improvements in farm revenues, labour savings, operating efficiency, and decreased exposure to pesticides. However, the results are not consistently favourable: spending on pesticides does not always drop and the frequency of pesticide use does not always decline; in some situations, spraying can actually increase; and the effects vary according to the type of crop, the nature of the farm, the quality of services provided, the timing of the spray, and the local conditions under which the service is delivered. Combined, these results indicate that the argument for adoption must be evaluated on a task-by-task basis and cannot be taken for granted in the absence of local experience. In this context, CPEC 2.0 can be used for purpose of technology transfer, collaborative research, technical training, demonstration projects, standards and selected industry partnerships. The goal should not be to purchase big equipment but to test commercially viable applications in Pakistan, put in place safeguards, and create markets of competitive services. Scale should hence, be based on evidence, and not technology goals.

2. Policy Problem and Analytical Scope

Pakistan's agricultural performance is held back by a set of interlocking failures rather than any single technology gap. These consist of weak linkages to extension and research, poor water supply, inadequately targeted and inefficient support, poor availability of quality inputs, fragmented service markets, increased climate exposure, and underdeveloped value chains. There are also constraints on the demand side: farmers may have limited or no awareness of how digital and technology-based tools can be applied to agriculture, and thereby traditional farming practices will likely persist without awareness of benefits, risks, or operating conditions connected to new technologies. Practical awareness and extension support should thus be given special attention as a policy response, along with technical trainings, because the introduction of technology alone cannot ensure its effective adoption and sustained use by farmers. The World Bank notes that agriculture growth in Pakistan slowed from an average of over 4 percent per year between 1970 and 2000 to below 3 percent thereafter. It further notes that poorly functioning agricultural markets, significant policy interventions, and inefficient and poorly targeted agricultural subsidies have discouraged a shift towards more water-efficient and higher-value agriculture[1]. This is not an all-inclusive solution for using agricultural drones, but just one component of a precision farming system that enables multiple applications. Drones can be divided into two groups of uses. The sensing applications for instance imaging, crop scouting and field mapping are mostly related to the generation of information. Intervention applications like spraying, nutrient application and seeding take it one step further and add other aviation, chemical, environmental and liability risks along with it. In both cases, the information produced is only useful if it can be utilized to make farm management decisions.

The ultimate aim is to enable agricultural drone services that can be demonstrated to improve agricultural operations and/or outcomes. Imports, subsidies, and drone assembly should not be used as indicators of success, but rather as indicators of farmer and sector outcomes.

3. What the International Evidence Shows

China has a lot of small farms, fast-growing service industries, and a lot of plant protection drone use. But in any place, there is no single productivity measure. The results will vary depending on the size of the farm, type of crop, pest problems, quality of the services rendered, timing, terrain, weather, chemicals used, and the way things were done previously.

Quan et al. (2023) created a service model for local cost-benefit testing and aggregation. The authors analysed over 2,000 grain farmers from 11 provinces in China. Their findings revealed additional farm revenue of approximately US$ 434-488/hectare with labor savings of 14.4-15.8 hours/hectare when drones were used. There were no significant effects on pesticide cost or pesticide application frequency, and results were variable across farms. The results also demonstrated the potential for using drones as a service to increase efficiency. The study recommended that Pakistan should carry out a cost-benefit analysis and localize the grouping of services instead of blindly following the results of China.

1.https://www.worldbank.org/en/brief/2022/04/27/pakistan-agriculture-food-systems

In their study, Zhang et al. (2026) found that Chinese maize farmers incurred less than 29 percent of the non-pesticide operating costs when using drones for plant protection and spent 90 percent less time handling pesticides. But farmers were applying 33% more times, and there was no reduction in spending per application. Yield losses were also decreased by 4.6 percent. Overall, superior timing can mean better pest control and safety without necessarily reducing the amount of chemicals used.

Institutional factors also play an important role in adoption. Chen et al. (2020) found out that cooperatives and collective purchasing/service contracts are crucial. For example, farm size, cooperative membership, and information regarding the benefits positively impact the willingness to use drones in Jilin Province. Several farmers also chose to purchase drones as a group or via a farmer organization.

Finally, Food and Agriculture Organisation (FAO's) global review also says that automation needs a solid business case, good infrastructure, skills, and inclusive service models. It reminds to provide subsidies and use technology responsibly, particularly for small farmers, women, and youth (FAO, 2022).[2]

3.1. Environmental and Operational Evidence

Precision application in drone-based spraying refers to the targeted application of pesticides at the required location, dose, and timings, while minimising unnecessary applications to non-target areas. However, precision application does not automatically ensure uniform or effective spraying. Spray performance will vary according to nozzle type, droplet size, rotor airflow, altitude, speed, canopy structure and weather conditions. Consequently, inconsistent spray coverage, inappropriate operating parameters, and lack of application uniformity remain important operational challenges (Qin and Chen, 2023). Local no-spray rules and residue checks are important because field studies indicate that buffer zones, windbreaks, and approved products can help to minimize residues on nearby crops (Kim et al., 2023). Aerial pesticide applications should be done in accordance with the minimum standard set by FAO and World Health Organization (WHO). Moreover, benefits should be reported by crop, task, season, and comparison method. While adopting the national yield multiplier, Pakistan should wait until local trials are conducted to demonstrate its effectiveness.

4. Three Immediate Policy Priorities

4.1. Create a One-Stop Agricultural Unmanned Aircraft System (UAS) Framework

Create a single protocol for operating UASs across the agricultural sector, as the use of UASs in agriculture spans aviation, pesticide management, security, and provincial agriculture needs. A single-window framework would not supersede the requirements of these institutions but would give one consolidated approval and compliance interface to the applicants and leave it to each competent authority to take its own substantive decision. The protocol should clarify the difference between imaging and payload-release operations, include a common application checklist, identify which authority will approve each requirement, have clear service timelines, and establish pre-season approval procedures for validated, low-risk operations. This would eliminate unnecessary duplication and ambiguity in approvals and maintain sector-specific protections. This priority is not about the centralization of regulatory power, but about administrative coordination and regulatory clarity.

4.2. Develop a Competitive Drone-as-a-Service Market

Drone-as-a-service models have to be prioritized for smallholders as they would otherwise be responsible for acquiring the expensive equipment, operating, maintaining, and periodically upgrading it. If the service providers are of good quality, they are the ones who are competing for business, allowing farmers to access the technology when they need it and the provider is incentivized to make better use of it, maintain it and deliver better service. If affordability is truly an issue during pilot, service vouchers or co-financing may be used to help overcome the affordability barrier. Local assembly and equipment subsidies, on the other hand, should be deferred until there is clear evidence of utilization, demand, service quality, and commercial viability. The reasoning is very simple: before public funding is dedicated to owning and operating the drone, it needs to demonstrate that it is addresses a legitimate farm-service need.

4.3. Build Capability, Data Governance and Inclusive Access

Building modular capability, strong governance of data and technology, and accessible access is critical to ensure adoption is not hampered by a lack of skilled staff and farmers' apprehensions on data and technology utilization. The responsibilities of the pilots, agricultural applicators, technicians and data analysts should clearly be separated. Extension services and co-operatives should, in turn, fill the farmers with practical awar-

2.https://www.fao.org/americas/news/news-detail/FAO-report-analyses-how-automation-in-agriculture-is-helping-to-transform-agrifood-systems/es eness of what drones can and cannot do, how services can be acquired, what information the farmers should be provided, and what precautions should be taken for their safety. Likewise, it is important that there are clear standards for farmer consent, data security, access rights, retention, portability, and interoperable data management. Monitoring participation by smallholders, tenant farmers, women, youth, and other unserved populations should also be done to ensure the system reaches those who need it most. The basic premise is that no matter how technically sophisticated the drone system, if users are unaware, operators aren't skilled, or farmers cannot meaningfully control their own data, then the system cannot scale.

5. A CPEC 2.0 Delivery Model for Agricultural Drones

CPEC already has an institutional basis for agricultural cooperation. The dedicated Joint Working Group (JWG) identifies capacity building, agricultural technology extension, processing, market information, and broader agricultural development as priority areas. This architecture can be incorporated with agricultural drones, which can then be viewed as a means of cooperation that can be regulated, implemented, and evaluated by Pakistani institutions.

Therefore, the suggested approach is to establish a "CPEC Agricultural Drone Pilot and Standards Program (CPEC-ADPSP)" through the agricultural cooperation mechanism and competent institutions in Pakistan. The program aims to conduct trials to identify potential areas of agricultural drone services to increase productivity, safety, and service efficiency in the context of Pakistan-China cooperation. There should also be no policy restrictions on participation by qualified Chinese and Pakistani companies.

Figure 1: CPEC Agricultural Drone Pilot and Standards Program (CPEC-ADPSP)

1. INSTITUTIONAL BASIS

CPEC already has an institutional basis for agriculture cooperation. The dedicated Joint Working Group identifies capacity building, agricultural technology extension, processing, market information and broader agricultural development as priority areas.

2. ROLE OF CPEC – ENABLING, NOT OPERATIONAL

Agricultural drones can be proposed within this architecture, but CPEC should not be represented as the operational regulator or the direct manager of field services.

The recommended mechanism is a CPEC Agricultural Drone Demonstration and Standards Programme, endorsed through the agriculture cooperation structure and delivered by competent Pakistani institutions.

3. RECOMMENDED MECHANISM

- CPEC Agricultural Drone Demonstration and Standards Programme
- Endorsed through the agriculture cooperation structure
- Delivered by competent Pakistani institutions

4. CONTRIBUTIONS OF CHINA

- Technology providers
- Training and capacity building
- Comparative protocols and standards
- Maintenance know-how
- Joint research and development
- Investment and financing support

5. CONTRIBUTIONS OF PAKISTAN

- Local problem definition and prioritization
- Regulatory approval and policy facilitation
- Independent trials and impact evaluation
- Service-market development and promotion
- Data governance and security
- Transparent procurement and oversight

6. OPEN, COMPETITIVE AND INCLUSIVE PARTICIPATION

CPEC already has an institutional basis for agriculture cooperation. The dedicated Joint Working Group identifies capacity building, agricultural technology extension, processing, market information and broader agricultural development as priority areas.

Source: Author's Construction

5.1. Technology Transfer Ladder

The technology transfer ladder consists of four steps as described below. However, the transition from one stage to the next should depend on existing demand, the use of services, technical reliability, cost competitiveness, and local capacity.

Stage 1: Import, Test and Compare

Import and test different certified Chinese drone platforms and service models for importation and evaluation in Pakistan under different crops and operational conditions through CPEC-supported projects.

Stage 2: Local Service Capability

Under CPEC, train operators, build repair capacity, calibration facilities, build stocks of spare parts, and develop interoperable data workflow with Pakistan through technical training and industry collaboration.

Stage 3: Joint Adaptation

Implement Pakistan-China joint R&D on nozzles, payloads, batteries, route planning, crop models and safety features with universities, research institutions and companies within the framework of innovation cooperation under CPEC.

Stage 4: Selective Localization

Only consider Pakistan-China assembly/manufacturing of parts where demand, quality, cost, and export competitiveness are proven, based on the industrial cooperation and SEZs under CPEC.

5.2. Institutional Responsibilities

The following table outlines the potential institutional roles and responsibilities required to ensure coordinated, safe, and effective implementation of agricultural drone services in Pakistan.

Table 1: Institutional Coordination Framework for Agricultural Drone Services

Institution	Primary Role
Ministry of Planning / CPEC Secretariat	Policy coordination, CPEC engagement, program dashboard and escalation; not routine flight or farm service management.
MNFSR / Department of Plant Protection[3]	Approved products and use patterns, application-equipment standards, residue and drift safeguards, and operator competency for pesticide application.
Pakistan Civil Aviation Authority[4] / Competent Aviation Authority[5]	Aircraft registration, remote-pilot requirements, airspace permissions, track-and-trace, and accident and incident procedures.
Provincial Agriculture Departments	Site selection, extension linkage, beneficiary aggregation, field supervision, and enforcement of provincial requirements.
PARC, universities and independent evaluators	Trial protocols, baseline and comparison groups, agronomic validation, cost-benefit analysis, and publication of results.
Private service providers and insurers	Operations, maintenance, farmer contracts, record-keeping, liability cover, and compliance with service-level standards.

Source: Author's Creation

3.https://plantprotection.gov.pk/services/pesticide-registration/pesticides-laws-and-rules/
4.https://pakistancode.gov.pk
5.https://caapakistan.com.pk

6. Regulatory, Environmental and Data Safeguards

The CPEC-ADPSP should establish two regulatory tracks:

- Track A would be for imaging, mapping and scouting with no payload release. Since these activities will not require aerial release of agricultural chemicals, the primary focus of the pilot approval process should be on aircraft registration, remote-pilot competency, airspace and site approvals, geofencing or restricted-area controls (where applicable), privacy and data-governance considerations, and basic operational safety. These requirements could be managed within the single-window system, by means of a standard checklist, and time-bound approval for pre-approved pilot districts and standard operating conditions. This track should be the easier one to participate in to test crop scouting, field mapping, crop health assessment, and irrigation diagnostics.
- Track B would cover spraying, dispersal, or other payload-release operations and would require both aviation authorization and agricultural-application approval. The single-window system should ensure the coordination of these clearances without amalgamating their substantive requirements. Prior to approval, the operator must have certified personnel, approved agricultural product and application pattern, calibrated equipment, defined weather and buffer conditions, operational plan, digital record keeping, liability coverage, and incident-response arrangements. The provincial agriculture authorities should verify the requirements for the crops and sites, and the competent aviation authority should check the requirements of the flights. The higher control track is required due to the chemical, environmental, public-safety, and liability hazards associated with the release of payload.

6.1. Minimum requirements for Each Track

Technical cooperation, training, and knowledge exchange might be made easier through CPEC 2.0, but all the operational requirements must be specified and implemented by the competent Pakistani authorities.

- Technical inspection and seasonal calibration of aircraft and application systems should be performed, and recalibration should be done after extensive repairs.
- Agricultural applicators and remote pilots should be certified, be medically fit to fly, and receive documented recurrent training, as and when required. Weather limits for wind, temperature, humidity and rainfall, and flight height and speed should be met during operations and should be in accordance with defined weather thresholds. Operators should also have approved emergency-landing and battery-fire procedures.
- Buffer areas should be identified around livestock, water bodies, roads, protected areas and sensitive crops, as well as around homes. Where appropriate, windbreaks or other drift-mitigation should be used. Operators should be able to document everything in a digital operation log, including the operator, aircraft, field site, date and time, weather, product and dose, flight path, treated area, and operational deviation or incident. Records must be kept in an interoperable and audit-trail manner.
- Operators need to follow Personal Protective Equipment (PPE), safe chemical mixing and loading, container handling and disposal, bystander exclusion and post-application re-entry requirements.
- Residue, spray drift and environmental monitoring should be carried out at a representative statistical sample of pilot sites. It is also important for service providers to have third-party liability insurance and follow established protocols in handling complaints, reporting and investigating incidents.
- Pakistan's operating protocol should follow the internationally recognized reference of FAO/WHO guidelines for aerial pesticide application with local adaptation as per local climatic conditions, pesticide-registration rules, and settlement pattern with local crops.
- Security safeguards, such as geofencing and track and trace (where applicable), should commensurate with operational risk and be part of the approval process.
- Approval mechanisms should be clear, coordinated and have a time limit. Slow and repetitive approvals can be ineffective for time-sensitive agricultural activities, and inadequate oversight can lead to safety, residue, and public-trust issues.

7. Pilot Design, Financing & Results Framework

A 24-month pilot should cover at least two crop seasons and a limited number of representative crop-task combinations. The purpose is to produce decision-quality evidence, not demonstration photographs. Sites should be selected with provincial governments, using the Integrated Agricultural Census[6] crop-reporting data and transparent criteria. Each treatment site should have a credible comparison using the best available local conventional practice.

7.1. Proposed Pilot Portfolio

The following table presents illustrative pilot cases across Pakistan to evaluate the operational, agronomic, and economic performance of agricultural drone services under different cropping systems.

Table 2: Proposed Provincial Pilot Cases and Evaluation Focus for Agricultural Drone Services

Pilot Case	Evaluation focus
Punjab **Rice/Wheat belt**	Compare regulated drone spraying with calibrated ground application across timeliness, coverage, labor exposure, cost, and yield/quality. Avoid assuming an effect before measuring.
Sindh **Cotton**	Combine scouting with targeted treatment for pest and water-stress management; examine whether improved timing reduces crop loss and total active ingredient per hectare.
Khyber Pakhtunkhwa **Orchards**	Test imaging and selective application in difficult terrain, with attention to canopy penetration, drift, and service routing across small orchards.
Balochistan **Date Orchards and Water Mapping**	Begin with mapping, crop health, and irrigation diagnostics; add chemical application only after an approved, crop-specific case is established.

Source: Author's Creation

7.2. Core Indicators and Decision Gates

Agricultural drone programs must be assessed by crop, operation, season, farm size, and service provider to generate consistent and comparable evidence. Monitoring must be done in three groups of indicators.

- Economic indicators should include cost per hectare, farmer willingness to pay, service provider profitability, and viability of drone services versus traditional services. They should also establish if services can gradually be accessed via farmer payments, commercial revenues, or targeted co-financing instead of ongoing blanket subsidies.
- Operational and agronomic indicators should include the number of acres covered per hour, the number of hours the aircraft is in operation, reliability and up-time of the aircraft, maintenance performance, and the use of appropriate inputs, including pesticides, fertilizer, seeds, and water. They should also evaluate spray quality, timeliness of operations, crop yield and quality, and performance compared to the optimum conventional practice.
- Safety and inclusion indicators should include labour and pesticide exposure, safety incidents, operational deviations, spray drift, pesticide residues, and other environmental factors. Monitoring should also evaluate the participation of smallholders, tenant farmers, women and other under-represented groups, as well as compliance with the certification, operational and data-governance requirements.

An integrated monitoring and evaluation system should present the outcomes clearly and as needed, with confidence intervals. Considerations for evaluation should include weather, pest pressure, crop characteristics and comparator quality. Scale-up should only occur if independent evaluation shows acceptable safety performance, environmental performance, maintenance and service delivery, and positive economic returns for at least two production seasons.

Moreover, crop-task combinations which do not achieve the necessary economic, operational, agronomic, safety, environmental, and/or inclusion levels should be redesigned, retested, or eliminated. If a newer generation of equipment or service model becomes available for the pilot, results should also be interpreted in the context of technological change: the introduction of a new generation of equipment(s) and/or service model during the pilot should be documented and assessed if the original results are applicable. This would ensure that the agricultural drone deployment is evidence-based and not target-based, and scale-up decisions are based on impact and technology readiness.

6.https://www.pbs.gov.pk/agriculture-census/

7.3. Financing approach

A focus on public finance needs to be on learning, inclusion, and public protection rather than focus on equipment volume. In pilots, the government can co-finance independent evaluation, training and calibration facilities, service vouchers for eligible smallholders, and temporary risk-sharing for qualified service providers. Providers should invest capital, provide effort, have an honest fee, carry insurance, and provide utilization and maintenance information. Future tax or localization incentives must be tied to verified value addition, interoperability, quality certification, after-sales service and employment, and not just final assembly.

8. Implementation Roadmap

Pakistan needs to implement the agricultural drone services in a phased manner: regulate–test–scale. The aim is to be regulatory-ready first and then develop credible evidence by means of controlled pilots. Scale-up should be undertaken for only those crop-task combinations that demonstrate clear economic, operational, safety, and inclusion benefits.

Phase 1: Regulate and Prepare: 0-6 Months

The initial phase should establish the enabling framework to ensure safe and coordinated deployment. Finalization of the agricultural UAS operating protocol, defining approval procedures, identifying pilot locations, prequalifying service providers, establishing baseline data, and preparation of certification, training, and monitoring arrangements are the key actions.

Phase 2: Test and Evaluate: 6-24 Months

At least two production seasons and representative crop-task combinations should be used for selected drone applications. Pilots should produce evidence verified independently that proves economic viability, operational performance, agronomic outcomes, safety, environmental effects, and farmer inclusion. The results must be compared to the best conventional practices.

Phase 3: Scale Conditionally: Years 3-5

Wider deployment of only validated crop-task-service combinations be undertaken. The scale-up should enable competitive service markets, maintenance and repair networks, trained operators and technicians, interoperable data systems, and sustainable financing models. If the demand, quality, cost, and commercial viability are established, selective localization or joint manufacturing may be considered.

Long-Term Direction: Integrated Precision Agriculture

Integrated Precision Agriculture is a long-term direction. After the initial scale-up phase, verified drone services should increasingly be integrated with other precision-agriculture solutions, such as satellite and remote-sensing data, weather information, irrigation management, extension services, crop analytics, and digital farm advisory platforms.

The roadmap thus adheres to a straightforward mantra: regulate before deployment, test before scaling, and scale only what independent evidence proves to be effective, safe and commercially viable.

8.1. Pilot-District Regulatory Mechanism

For the 24-month pilot, the regulation should be coordinated at the district level, not on a case-by-case basis, through a flight permit. A standard compliance checklist and clear institutional responsibilities are needed before a common agricultural UAS operating protocol is agreed to by federal and provincial authorities. The district implementation cell, attached to the provincial Agriculture Department, would be the operational point in the district for site verification, farmer aggregation, and reporting, without replacing statutory regulators. A pre-season operating plan should be developed for each pilot district including approved sites, crop-task combinations, service providers, buffer zones, and weather and pesticide conditions. Track A (sensing) activities could be approved based on time, provided that safeguards are demonstrated; repeated, validated activities may be approved as standing activities with monitoring instead of re-approval, and if serious incidents or material changes occur, they should be re-approved.

Track B (spraying/dispersal) activities may be approved based on time, subject to additional crop/product-specific clearance. Repeated, validated activities may be approved as standing activities with monitoring instead of re-approval. If a serious incident or material change occurs, re-approval should be considered. This requires streamlining procedures and processes – harmonized forms, fixed timelines, recognized certifications, and common protocols should be used for the reporting and sharing of incidents – without the need for institutional change, with the regulatory authority held by Pakistani institutions, and with a focus on cooperation and learning through CPEC.

This district-based organization also facilitates credible evaluation. Treatment districts should be closely matched with similar control districts geographically, in soil type, cropping pattern, and farm structure; controls should not be included in the treatment during the evaluation period; and spillover from treatment through service providers and farmer networks should be recorded separately. Ideally, baseline data should be gathered prior to deployment, and outcomes should be compared across at least two seasons. However, a well-designed natural experiment, utilizing matched districts, may provide a more feasible counterfactual, as spillover makes a randomized controlled trial difficult. The assessment must also document farmer adaptation to new drone technology and service models to guide the development of next-generation services and not to dictate the technology to be bought by farmers during the pilot.

9. Key Risks & Policy Responses

Three risks are particularly likely to undermine the program at an early stage: premature procurement before market validation, unsafe or noncompliant spraying, and regulatory delays that cause agricultural operations to miss their time-sensitive application windows. Table 3 shows the key implementation risks, their associated failure modes, and mitigation measures.

Table 3: Key Implementation Risks and Mitigation Measures for Agricultural Drone Services

Risk	Failure Mode	Required Response
Premature procurement	Large equipment purchases occur before a viable service market is established.	Use competitive pilots and utilization thresholds; prohibit bulk procurement or assembly commitments until after independent evaluation.
Spray drift and residues	Off-target deposition harms neighboring crops, water, people, or market compliance.	Require approved products, calibration, weather limits, buffers, digital logs, sampling, and immediate suspension after a serious incident.
Regulatory delay	Seasonal operations lose value because approvals arrive after the agronomic window.	Create a single-window workflow with standard rural operating conditions and time-bound, pre-season approvals for validated operations.
Vendor and data lock-in	Publicly funded systems become dependent on proprietary software, parts, or inaccessible farm data.	Mandate data portability, open export formats, transparent APIs where feasible, local repair capability, and competitive re-tendering.
Exclusion of smallholders	Providers focus on large, contiguous farms and bypass tenants, women, and remote plots.	Aggregate demand through cooperatives and extension; use targeted service vouchers and publish beneficiary and pricing data.
Weak maintenance and skills	Aircraft downtime, poor calibration, or unqualified operators undermine safety and economics.	Certify pilots, applicators, and technicians separately; require spare parts plans, recurrent training, service-level standards, and insurance.

Source: Author's Creation

10. Conclusion

Pakistan's agriculture sector faces persistent challenges including difficult terrain, fragmented and dispersed farmland, labor constraints, and limited access to timely agriculture services. These conditions can make conventional methods of crop monitoring and input application costly and difficult to deliver efficiently, particularly in remote and smallholder farming areas. Agricultural drones could help address these service-delivery constraints by enabling more timely and targeted crop monitoring, spraying, and other field operations. However, the goal should not be for the nation to pursue a national yield goal or to fly more drones. Instead, Pakistan should follow a sequenced strategy: Regulation first, service-based pilots second, and then scale-up based on independent evidence of economic value, safety and inclusion.

CPEC 2.0 can play a role in this process through technology partnerships, joint trials, training, research, and engaging the private sector. However, the roles and powers of the regulatory, procurement, farmer protection, data governance and independent evaluation should remain with Pakistan institutions. In the end, a pilot-first approach will help Pakistan scale the good, re-design the bad, and build its own capacity without falling into technological hype, rushing to purchase, and ensuring permanent subsidy.

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