Republic of Kazakhstan



TECHNOLOGY NEEDS ASSESSMENT FOR ADAPTATION TO CLIMATE CHANGE

Sector: Agriculture (water focus)

BARRIER ANALYSIS AND ENABLING FRAMEWORK (BAEF) REPORT

May 2026

UN environment programme | copenhagen climate centre | TNA TECHNOLOGY NEEDS ASSESSMENT | AIIB ASIAN INFRASTRUCTURE INVESTMENT BANK | IGTIC

Abbreviations and acronyms

Acronym	Definition
ADB	Asian Development Bank
AIIB	Asian Infrastructure Investment Bank
BAEF	Barrier Analysis and Enabling Framework
CA	Conservation Agriculture
CAPEX	Capital Expenditure
CBAM	Carbon Border Adjustment Mechanism (EU)
CIMMYT	International Maize and Wheat Improvement Center
CSSM	Climate-Smart Soil Management
EBRD	European Bank for Reconstruction and Development
EU	European Union
FFS	Farmer Field School
GCF	Green Climate Fund
GEF	Global Environment Facility
GHG	Greenhouse Gas
IFC	International Finance Corporation
IFOAM	International Federation of Organic Agriculture Movements
IsDB	Islamic Development Bank
IWMI	International Water Management Institute
KAZ ETS	Kazakhstan Emissions Trading Scheme
KazAgroFinance	Kazakhstani agricultural development bank (lessor)
KazNIIVKh	Kazakh Research Institute of Water Management
KazNIIZiR	Kazakh Research Institute of Agriculture and Plant Growing
KazNIIZP	Kazakh Research Institute of Soil Science and Agrochemistry
KVR	Committee for Water Resources (under MoENR)
MoENR	Ministry of Ecology and Natural Resources of Kazakhstan
MoA	Ministry of Agriculture of Kazakhstan
MRV	Measurement, Reporting and Verification
NbS	Nature-based Solutions
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organisation
PES	Payments for Ecosystem Services
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SOC	Soil Organic Carbon
TAP	Technology Action Plan
TNA	Technology Needs Assessment
UDP	UNEP DTU Partnership (now UNEP-CCC)
UNEP-CCC	UNEP Copenhagen Climate Centre
UNFCCC	United Nations Framework Convention on Climate Change
VCS	Verified Carbon Standard (Verra)
WB	World Bank

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Executive summary

This Barrier Analysis and Enabling Framework (BAEF) Report is the second deliverable of Kazakhstan's Technology Needs Assessment (TNA) for adaptation supported by the Asian Infrastructure Investment Bank (AIIB) and the UNEP Copenhagen Climate Centre. It builds on the technologies prioritised in the TNA Report for the Agriculture (water focus) sector and applies the methodology of the BAEF Guidebook (UDP, 2015) and the TNA Step-by-Step Guidebook (UNEP-CCC, 2024). For each technology, the report identifies the barriers obstructing transfer and diffusion, screens them with the Sectoral Working Group, translates the retained barriers into enabling measures, groups the measures into strategic programmes and assesses those programmes for inclusion in the forthcoming Technology Action Plan (TAP).

Four adaptation technologies are covered: Conservation Agriculture (no-till and crop rotation), Agroforestry for erosion control and Soil Protection, Climate-Smart Soil Management (CSSM) and Drip Irrigation. They are complementary applications of a single water-focused strategy: the first three conserve green water — the soil moisture on which the rain-fed grain belt of Akmola, Kostanay, North Kazakhstan and Pavlodar depends — while drip irrigation economises blue water in the irrigated south (Turkestan, Almaty, Zhambyl and Kyzylorda). The preliminary deployment targets are: at least 4 million hectares of full Conservation Agriculture by 2035; at least 100,000 hectares of restored shelterbelts by 2035; 2 million hectares under verified CSSM by 2030; and the expansion of drip irrigation from approximately 250,000 to 600,000 hectares by 2030, in line with the Water Resources Management Concept 2024–2030.

For each technology the core problem was decomposed through problem-tree analysis, inverted into an objective (solution) tree and complemented by a market map locating the weakest links in the supply or service-delivery chain (Annex 1). The long lists of barriers, each paired with its proposed countermeasure, were scored by the Agriculture Sectoral Working Group through a structured online questionnaire: twelve members completed the assessment for the first three

technologies and eight for drip irrigation, rating 39 barriers on a five-point severity scale and 39 measures on a three-point priority scale — 78 items in total, reproduced in full in Annex 3.

Identification of barriers was followed by screening process. For Conservation Agriculture no barrier is blocking: farmer knowledge gaps and the entrenched ploughing culture lead at 3.75, and two barriers — fragmented services (2.58) and gender inequality (1.67) — fell below the 3.0 retention threshold, leaving eight for the enabling framework. For agroforestry, the long-term financing gap (4.00) and insecure land-use rights with the absence of MRV/REDD+ (3.92) head a list. For CSSM, nine of the ten barriers are high-severity, led by the absence of market incentives and carbon-market access (4.00) and two economic barriers at 3.92 — a reinforcing economic-and-market trap in which no revenue pathway rewards soil-carbon gains, finance is incompatible with the payback horizon and the subsidy system rewards the degrading practice. Drip irrigation produced the strongest stakeholder signal of all: the degradation of KazVodKhoz canals with absent meltwater storage (4.75) and transboundary water dependence with poor water quality (4.62) were rated critical or key by every respondent, no barrier fell below the threshold, and the working group treats water security as a precondition without which farm-level investment loses meaning.

For every retained barrier a corresponding enabling measure was proposed. The highest-rated include subsidies for soil-health inputs (2.83), the agroforestry adaptation finance fund and the NbS/EbA support window in KazAgroFinance (2.75 each), blended drip finance with long-term leasing (2.75) and — rated high unanimously by the eight drip respondents — bilateral water agreements with national water-quality and filtration standards (3.00). The measures are grouped into fifteen strategic programmes across the four technologies (three for Conservation Agriculture and four for each of the others), and each programme is assessed against impact, societal benefits, cost and feasibility and recommended for the TAP as a core financial, regulatory, infrastructure, enabling institutional or support action.

Cross-technology analysis (Section 1.5) identifies six structural constraints recurring across the sector: finance misaligned with adaptation payback horizons; a subsidy architecture that finances the status quo; land tenure too short to capture long-horizon returns; unpriced water and soil benefits with no measurement, market or reward; fragmented institutions without a monitoring backbone; and a knowledge, demonstration and behavioural deficit — together with gender inequality as a cross-cutting design requirement rather than a standalone barrier. The corresponding sector-wide enabling framework rests on six common measures: a sector-wide adaptation finance architecture; reorientation of the subsidy envelope towards results-based adaptation payments; tenure reform conditional on adaptation; national measurement and market infrastructure for water and soil outcomes — MRV methodologies, certification, payments for ecosystem services, carbon aggregation and a volumetric water tariff with universal metering; coordination bodies with a shared monitoring backbone; and a national extension, demonstration and behavioural-change system.

The framework is sequenced by dependency. The measurement and coordination backbone and the reorientation of existing subsidies come first; the finance, tenure and market instruments follow; and the long-horizon deployments build on these foundations. Together these steps convert adaptation from a subsidised cost into an investable activity and provide the analytical foundation for the Technology Action Plan that follows.

Chapter 1 — Barrier Analysis and Enabling Framework for Agriculture (water focus)

Technology prioritisation for the agriculture (water focus) sector was completed during the first stage of Kazakhstan's TNA project and is documented in the TNA Report on Technology Prioritisation. A desk review drawing on international adaptation databases, the experience of the first national TNA (2014–2017) and current strategic documents produced an extended inventory of 28 candidate technologies spanning water resources and on-farm irrigation, soil and land management, climate-resilient crops, livestock systems, and agroforestry and ecosystem management. The Agriculture Sectoral Working Group then screened this inventory against two criteria — climate adaptation potential and economic viability — narrowing it to a long list of 12 technologies, each documented in a dedicated Technology Fact Sheet (TFS).

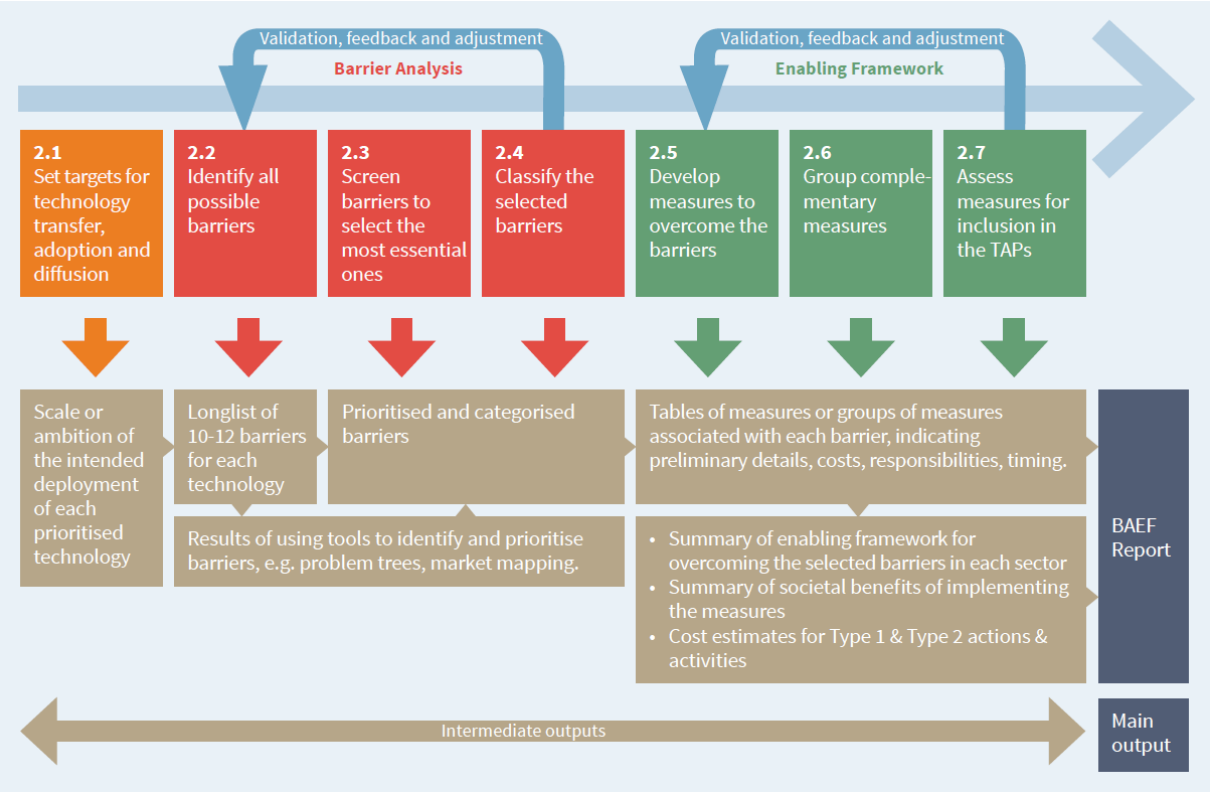


Figure 1.1 Seven steps in the BAEF process: from barriers to enabling frameworks (UNEP-CCC, 2024).

The long list was then evaluated through a Multi-Criteria Analysis built on nine sub-criteria grouped into six dimensions: capital and operating costs, economic benefits (job creation and growth in farm income), gender equality and social inclusion, preservation of soil fertility, reduction of vulnerability to climate change, and institutional feasibility together with alignment to national adaptation priorities. Working group members took part both in selecting the criteria and in setting their weights. The stability of the resulting ranking was tested under three alternative weighting scenarios — economy-oriented, environment- and climate-oriented, and equal weights — and the ordering of the leading technologies remained unchanged. Conservation Agriculture, Agroforestry and Climate-Smart Soil Management emerged as the three top-ranked options. Given the water focus assigned to the sector and its first place in the initial screening round, Drip Irrigation was added as the fourth priority technology. The barrier analysis therefore covers the following four technologies:

- Conservation Agriculture (no-till and crop rotation)
- Agroforestry for erosion control
- Climate-Smart Soil Management (CSSM)
- Drip Irrigation

The barrier analysis and enabling framework set out in this chapter were prepared for these four technologies in accordance with the TNA Step-by-Step Guidebook (UNEP-CCC, 2024) and the BAEF Guidebook (UDP, 2015). For each technology, the core problem constraining diffusion was decomposed through problem-tree analysis and inverted into an objective (solution) tree, while a market map was drawn to locate the weakest links in the relevant supply or service-delivery chain; all figures are collected in Annex 1. The seven analytical steps shown in Figure 1.1 were followed, with one adjustment to the standard sequence: enabling measures were formulated in parallel with barrier identification rather than after screening. Members of the sectoral working group accordingly received a working document in which every barrier was paired with its proposed countermeasure before completing the online screening questionnaire. Twelve substantive responses were received, covering 78 rated items — 39 barriers scored on a five-point severity scale and 39 measures on a three-point priority scale — and the full numerical results are reproduced in Annex 3. Carrying out the two steps together shortened the assessment timeline and gave respondents a complete picture of each constraint and its possible remedy before ranking.

1.1 Technology 1: Conservation Agriculture (No-Till and Crop Rotation)

1.1.1 General description and target for Conservation Agriculture

Conservation Agriculture (CA) is a crop-production system based on three linked principles defined by the FAO: minimal mechanical soil disturbance through direct seeding or no-till; maintenance of a permanent organic soil cover from crop residues or cover crops; and diversification of crop species through rotations. In the rainfed grain belt of northern Kazakhstan the system functions principally as a climate-adaptation technology. Abandoning the plough and retaining residues conserves soil moisture, captures snow, moderates soil-surface temperatures and reduces wind and water erosion, while diversified rotations interrupt pest and disease cycles and progressively improve soil structure (FAO Kazakhstan case study).

The adaptive value of the technology is demonstrated most clearly under drought. During the 2012 drought, which more than halved the national wheat harvest, fields under zero tillage yielded up to three times more grain than conventionally tilled fields and are credited with helping the country avoid severe wheat shortages (CIMMYT, 2013; World Bank, 2013). Field experience in northern Kazakhstan attributes to the practice an increase in plant-available soil moisture of roughly a quarter, a reduction in erosion of 75–100 per cent, and an approximate doubling of average wheat yields, from about 1.4 to 2.6 t/ha (CIMMYT, 2013). These effects matter increasingly as mean temperatures rise and droughts become more frequent, and as arable soils continue to lose humus at approximately 1 per cent per year under conventional tillage (BTR, 2024).

Kazakhstan is one of the world's leading adopters of CA and ranks among the top ten countries by area under the system. The most recent peer-reviewed assessment estimates that, by 2015/16, about 10.5 million hectares were under reduced tillage, of which some 2.5 million hectares —

around 15.6 per cent of the cropped area — qualified as full CA with permanent no-till and crop rotation (Kassam, Friedrich and Derpsch, 2019). Adoption is concentrated in the four northern grain oblasts — Akmola, Kostanay, North Kazakhstan and Pavlodar — which together account for roughly 70 per cent of the country's arable land (UNDP, 2024). The technology is endorsed by FAO, ICARDA and CIMMYT and is supported domestically by the Barayev Research Institute and by the national agricultural development policy (TNA Report, 2025).

Although CA has been promoted in Kazakhstan for two decades, adoption has plateaued at roughly 2.5 million hectares — about one-tenth of arable land — and is concentrated on large enterprises in the northern grain belt. Medium and small farms, which face the steepest financing and knowledge constraints, remain largely outside the transition, and the quality of practice (rotation design, residue management) is uneven. With drought frequency and severity rising, completing and deepening CA adoption across these under-served segments is the adaptation gap this assessment addresses, which is why CA is re-examined under the current TNA.

Preliminary deployment target: *Expand full Conservation Agriculture (permanent no-till with diversified crop rotation) from about 2.5 million hectares to at least 4 million hectares across the northern rainfed grain belt (Akmola, Kostanay, North Kazakhstan and Pavlodar) by 2035*.

1.1.2 Identification of barriers for Conservation Agriculture technology

Following the BAEF Guidebook (UDP, 2015), Conservation Agriculture was categorised as a market good of the Capital Goods type: its physical carrier — the direct-drill seeder and supporting equipment — diffuses through commercial supply chains, and the adoption decision rests with individual farm enterprises. The barrier analysis for the technology was carried out using market mapping, problem-tree and solution-tree analysis (Figures A1.1–A1.3, Annex 1). The diagrams were prepared by the national consultant with the support of the TNA team, and the long-list of barriers was developed on the basis of this analysis.

The problem tree identifies the starter problem as the limited adoption and scaling of Conservation Agriculture in Kazakhstan and traces it to five groups of causes. Economic and financial barriers dominate: an upfront machinery investment of USD 80,000–150,000, a National Bank base rate of 18 per cent translating into commercial lending at 20–24 per cent — incompatible with the long payback period of CA investments — and the absence of dedicated, climate-aligned state finance. Technology and market barriers stem from near-total dependence on imported machinery, restricted farmer access to CA-specific inputs and limited grain-storage infrastructure — licensed elevator capacity of about 13 million tonnes against gross harvests of 22–26 million tonnes in recent seasons (AZRK, 2025; Grain Union of Kazakhstan, 2023) — with the underdeveloped national innovation and extension system identified as a structural root cause. Institutional and regulatory barriers arise from subsidy schemes that favour conventional practices such as mineral fertiliser use and from weak coordination between research, policy and farmers. Capacity and awareness barriers comprise limited farmer awareness of CA benefits, weak dissemination of knowledge and ineffective extension and university training. Finally, behavioural and external barriers — risk-averse farmer behaviour reinforced by limited demonstration of CA economics, yield variability and unpredictable grain-export restrictions — suppress the multi-year reinvestment on which conversion depends. The effect chains above the starter problem show the cost of inaction: continued soil-moisture loss, accelerating erosion and land degradation, declining and more variable yields, falling farm profitability, and rising fuel consumption and greenhouse-gas emissions.

The barriers were further developed into a long list prepared by the national consultant with the support of the TNA team. The long list comprises ten barriers across nine categories; each barrier

carries a short description of its adaptation context and is paired with a corresponding enabling measure (Section 1.1.5). In this form the list was submitted to the Agriculture Sectoral Working Group for assessment, the results of which are presented in Section 1.1.3. Following the structure of the BAEF template, the barriers divide into economic and financial barriers and non-financial barriers.

Economic and financial barriers

Access to machinery and finance. Direct-drill seeders are the principal moisture-conservation instrument in Kazakhstan's drought-prone grain zone. Imported units (CLAAS, HORSCH) cost USD 80,000–250,000, and even locally assembled CT Assembly LLP machinery is unaffordable for most farms below 500 ha without concessional finance. High commercial lending rates and limited access to KazAgroFinance and Damu programmes compound the barrier.

Transition-period risk and subsidy instability. During the 3–5-year soil-restoration period of conversion to CA, yields may decline by 10–20 per cent, placing reserve-constrained farms in conditions of maximum climate vulnerability precisely at the moment of transition to a more drought-resilient system. State subsidy programmes are exposed to budget cuts capable of abruptly collapsing adoption incentives.

Non-financial barriers

Market conditions — absence of market incentives and price volatility. No certification or price-premium mechanism differentiates grain produced under CA. Most farms market their output through informal intermediaries without any CA-related price advantage, while grain-export quotas and state interventions create unpredictable price signals that destroy the multi-year investment horizon required for conversion to CA.

Legal and regulatory — insecure land-use rights and absence of results-based payments. Short-term or uncertain land-use rights make CA investments with a 3–5-year horizon economically unjustifiable: no farmer will invest in restoring soil health without long-term tenure guarantees. There is also no mechanism rewarding farms for verified adaptation results — reduced erosion, improved moisture retention and yield stabilisation under drought.

Institutional capacity — fragmented services, R&D and supply chains. Agricultural advisory services cover only a small fraction of the rural districts of the northern oblasts where CA adoption is most needed. CIMMYT and Barayev Institute demonstration sites cover limited territory, R&D results are not systematically translated into farm practice, and the supply of agrochemicals and CA-suitable seed is unevenly distributed across the northern districts.

Human capacity — farmer knowledge gaps and equipment-service deficit. Incorrect application of CA principles nullifies the adaptation benefits. Many small and medium farmers lack basic knowledge of CA agronomy, and Kazakhstan's vocational education system offers limited programmes in direct-drill seeder maintenance, creating equipment-downtime risk within the critical sowing windows.

Social, cultural and behavioural — entrenched culture of traditional ploughing. Soviet-era agronomic norms prioritising deep ploughing remain embedded in the farming culture. Farm managers trained under these conventions are sceptical of no-till and resistant to radical practice change, perpetuating practices that aggravate wind erosion and reduce soil-moisture retention.

Information and awareness — low awareness and lack of local data. Farmers lack access to evidence-based data on the adaptation returns of CA — fuel savings of 30–50 per cent, yield stabilisation and per-hectare erosion reduction. Advisory materials operate with national averages

that mask local precipitation variability, and the use of digital platforms (e-Qazagro, GeoPard) among small farms remains very low.

Technical — absence of monitoring and zonal variability. Kazakhstan's agro-climatic zones require zone-specific CA packages, which a single national template cannot provide; this generates unstable field results that undermine adoption incentives. Dependence on imported seeders creates price and logistical vulnerability capable of interrupting the investment process, especially in dry years.

Gender equality — gender inequality in access to CA and training. Women farm managers face multi-level barriers in accessing CA. Collateral requirements in machinery leasing disproportionately restrict women land users, Farmer Field Schools and CA events are predominantly attended by men, and vocational training in CA agronomy has almost no entry points for women.

1.1.3 Screening of barriers for Conservation Agriculture

The long list of ten barriers presented in Section 1.1.2 was screened by the Agriculture Sectoral Working Group through a structured online questionnaire. Twelve members of the working group completed the assessment, rating the impact of each barrier on the adoption of Conservation Agriculture on a five-tier scale derived from the BAEF Guidebook: critical (blocking), key, important, less important and insignificant. For analysis, the ratings were converted into ordinal scores from 5 (critical) to 1 (insignificant) and averaged across respondents; the full score distributions are presented in Annex 3.

For the interpretation of the results, three screening bands were applied: barriers with a mean score of 3.5 or higher are classified as high-severity (crucial) barriers; barriers scoring between 3.0 and 3.49 as important; and barriers scoring below 3.0 as lower-priority barriers. The results are summarised in Table 1.1.

Table 1.1. Stakeholder screening of barriers for Conservation Agriculture

Rank	Barrier (category)	Mean score (1–5)	Rated critical or key, %	Screening band
1–2	Farmer knowledge gaps and equipment-service deficit (human capacity)	3.75	67%	High severity (crucial)
1–2	Entrenched culture of traditional ploughing (social, cultural and behavioural)	3.75	50%	High severity (crucial)
3–5	Absence of market incentives and price volatility (market conditions)	3.58	58%	High severity (crucial)
3–5	Access to machinery and finance (economic and financial)	3.58	50%	High severity (crucial)
3–5	Low awareness and lack of local data (information and awareness)	3.58	50%	High severity (crucial)
6	Transition-period risk and subsidy instability (economic and financial)	3.50	58%	High severity (crucial)

Rank	Barrier (category)	Mean score (1–5)	Rated critical or key, %	Screening band
7	Absence of monitoring infrastructure and zonal variability (technical)	3.33	33%	Important
8	Insecure land-use rights and absence of results-based payments (legal and regulatory)	3.00	33%	Important
9	Fragmented services, R&D and supply chains (institutional capacity)	2.58	17%	Lower priority
10	Gender inequality in access to CA and training (gender equality)	1.67	0%	Lower priority

No barrier was assessed by the working group as an outright blocking (killer) constraint: the highest mean score is 3.75 and no barrier was rated critical by a majority of respondents. Six barriers form the high-severity group. Farmer knowledge gaps and the equipment-service deficit, together with the entrenched culture of traditional ploughing, head the ranking at 3.75 — the former with the highest share of critical or key ratings (67 per cent). They are followed by the absence of market incentives, access to machinery and finance, and low awareness, each at 3.58, and by transition-period risk and subsidy instability at exactly the 3.50 threshold. The assessment thus indicates that the working group judges knowledge, behavioural and market constraints to be at least as severe as the capital-cost barrier itself. The absence of monitoring infrastructure and zonal variability (3.33) and insecure land-use rights (3.00) form the middle, important band.

Two barriers fell below the importance threshold. Fragmented services, R&D and supply chains scored 2.58, with only two of twelve respondents rating it critical or key, and gender inequality in access to CA and training scored 1.67, receiving no critical or key ratings and seven insignificant ratings. Both are accordingly classified as lower-priority barriers.

1.1.4 Classification of barriers for Conservation Agriculture

The long list of barriers was screened to isolate the most critical constraints obstructing the adoption and diffusion of Conservation Agriculture in Kazakhstan. Barriers with a mean score below 3.0 — the “important” rating on the five-tier scale (Section 1.1.3, Table 1.1) — were classified as minor obstacles that do not fundamentally constrain national deployment and were excluded from the further analysis. Two barriers were screened out on this basis: fragmented services, R&D and supply chains (2.58) and gender inequality in access to CA and training (1.67); the gender dimension is nevertheless retained as a cross-cutting consideration in the design of enabling measures. The remaining high-scoring barriers are listed below under two categories.

Economic and financial barriers

Economic and financial constraints form the structural core of the adoption problem: the cost of the technology’s capital carrier and the financing conditions available to farms are misaligned with the multi-year payback profile of the conversion.

- **Access to Machinery and Finance (Score: 3.58):** Direct-drill seeders — the principal moisture-conservation instrument of the technology — cost USD 80,000–250,000 for imported units, while commercial lending at 20–24 per cent and limited access to KazAgroFinance and

Damu programmes place them beyond the reach of most farms below 500 ha without concessional finance.

- **Transition-Period Risk and Subsidy Instability (3.50):** Yields may decline by 10–20 per cent during the 3–5-year soil-restoration period, exposing reserve-constrained farms to maximum climate vulnerability precisely at the moment of conversion, while state subsidy programmes remain subject to annual budget cycles capable of abruptly withdrawing adoption incentives.

Non-financial barriers

The non-financial barriers represent an interconnected web of knowledge, behavioural, market, technical and regulatory constraints — rated by the working group as at least as severe as the capital-cost barrier itself.

- **Farmer Knowledge Gaps and Equipment-Service Deficit (3.75):** Incorrect application of CA principles nullifies the adaptation benefits; many small and medium farmers lack basic CA agronomy, and the scarcity of direct-drill seeder maintenance programmes creates equipment-downtime risk within the critical sowing windows.
- **Entrenched Culture of Traditional Ploughing (3.75):** Soviet-era agronomic norms prioritising deep ploughing remain embedded in the farming culture; managers trained under these conventions are sceptical of no-till and resist radical practice change, perpetuating practices that aggravate wind erosion and reduce soil-moisture retention.
- **Absence of Market Incentives and Price Volatility (3.58):** No certification or price-premium mechanism differentiates CA-produced grain, while grain-export quotas and state interventions generate unpredictable price signals that destroy the multi-year investment horizon on which conversion depends.
- **Low Awareness and Lack of Local Data (3.58):** Farmers lack evidence-based data on the adaptation returns of CA under local conditions; advisory materials operate with national averages that mask precipitation variability, and uptake of digital platforms (e-Qazagro, GeoPard) among small farms remains very low.
- **Absence of Monitoring Infrastructure and Zonal Variability (3.33):** Kazakhstan's agro-climatic zones require zone-specific CA packages that a single national template cannot provide, generating unstable field results, while dependence on imported seeders creates price and logistical vulnerability, especially in dry years.
- **Insecure Land-Use Rights and Absence of Results-Based Payments (3.00):** Short or uncertain land-use rights make investments with a 3–5-year horizon economically unjustifiable, and no mechanism rewards farms for verified adaptation results such as reduced erosion, improved moisture retention or yield stabilisation under drought.

Table 1.2. Classification of barriers by BAEF category: Conservation Agriculture

Barrier type	Category	Specific Barrier	Description of the Barrier	Score
Economic and financial	Economic and financial	Access to Machinery and Finance	Direct-drill seeders (USD 80,000–250,000) and credit at 20–24% place CA beyond medium and small farms.	3.58
	Economic and financial	Transition-Period Risk and Subsidy Instability	A 10–20% yield dip during the 3–5-year transition is unsupported by transitional payments.	3.50

Barrier type	Category	Specific Barrier	Description of the Barrier	Score
Non-financial	Human skills	Farmer Knowledge Gaps and Equipment-Service Deficit	Misapplication of CA negates benefits; CA agronomy and machinery service are scarce.	3.75
	Social and cultural	Entrenched Culture of Traditional Ploughing	Soviet-era deep-ploughing norms and scepticism toward no-till persist.	3.75
	Market conditions	Absence of Market Incentives and Price Volatility	No certification or premium differentiates CA grain; export-quota volatility deters investment.	3.58
	Information	Low Awareness and Lack of Local Data	Farmers lack local evidence on the adaptation returns of CA.	3.58
	Technical	Absence of Monitoring Infrastructure and Zonal Variability	Zone-specific CA packages and monitoring are lacking.	3.33
	Legal and regulatory	Insecure Land-Use Rights and Absence of Results-Based Payments	Short tenure makes 3–5-year-horizon investment irrational.	3.00

1.1.5 Measures for Conservation Agriculture

For each barrier of the long list, a corresponding enabling measure was developed by the national consultant with the support of the TNA team and submitted to the Agriculture Sectoral Working Group in the same structured questionnaire. The working group assessed the priority of each measure on a three-tier scale — high, medium and low — converted for analysis into scores from 3 (high) to 1 (low) and averaged across the twelve respondents; the full distributions are presented in Annex 3. The eight measures addressing the eight retained barriers are described below under two categories, with their mean priority scores. One refinement proposed through the open feedback field of the questionnaire has been incorporated into the economic measures.

Economic and financial measures

- **Preferential Leasing and Machinery Cooperatives (Score: 2.67):** Expand concessional leasing through KazAgroFinance on terms designed specifically for CA (5–7 years, preferential rates), targeting medium farms and cooperatives of small farms; establish group cooperatives for the shared use of direct-drill seeders (3–5 neighbouring farms per unit) with reduced collateral requirements; and open a dedicated CA machinery co-financing window under the Green Economy framework, positioned explicitly as climate adaptation finance.
- **Transition Payments and Subsidy Reform (2.58):** Introduce three-year direct per-hectare payments for new CA adopters, positioned explicitly as insurance for the climate-transition period; extend state crop-insurance coverage (GKFU) to transition-period yield-decline risk; and reorient the subsidy architecture from input subsidies towards results-based payments tied to verified CA application. Following stakeholder feedback, state support should be differentiated with explicit priority for adaptation technologies, including separate subsidy groups and dedicated credit products for minimum-tillage machinery.

Non-financial measures

- **Improved Training Programmes and Technical Support Service (2.67):** Integrate CA agronomy into agrarian college curricula — soil-health management, herbicide-resistance protocols, precision seeding, drought-resilient rotation design and mulch management for moisture retention; establish a certification system for CA advisers; and build partnerships with CT Assembly LLP, CLAAS and HORSCH dealer networks to create regional technical service centres with certified technicians.

- **CA Adaptation Calculator (2.58):** Develop a Kazakhstani CA adaptation-return calculator allowing farms of any size to model projected fuel savings (30–50 per cent), drought-year yield stabilisation, moisture-retention improvement and per-hectare wind-erosion reduction; commission district-level climate projections under the RCP 4.5/8.5 scenarios for 2030–2050 and integrate them into CA agronomic packages and Farmer Field School curricula.
- **Marketing Campaign and Improved Communication (2.50):** Conduct multi-year, evidence-based communication campaigns built on peer learning, presenting Kazakhstani data on fuel savings, soil health, drought-year yield stability and long-term economic performance; engage respected managers of large farms as change agents; and position no-till explicitly as drought-resilient farming for northern Kazakhstan.
- **Land Reform and Payments for Ecosystem Services (2.25):** Reform the Land Code to establish a guaranteed minimum lease term of 15–25 years for farms committed to CA conversion; develop a national agri-environmental payment scheme rewarding verified adaptation results — reduced erosion, improved moisture retention and drought-year yield stabilisation — piloted in Akmola and Kostanay oblasts; and develop a soil-carbon MRV methodology compatible with the KAZ ETS and voluntary carbon markets (Verra VCS).
- **Zonal Practice Packages (2.17):** Develop and publish regionally differentiated CA adaptation packages for each main agro-climatic zone of northern Kazakhstan — crop recommendations, sowing windows, herbicide programmes and mulch-management protocols — validated through multi-year field trials of CIMMYT and the Barayev Institute and calibrated to the RCP 4.5/8.5 scenarios for 2030/2050; support the expansion of local direct-drill seeder production capacity.
- **CA Grain Certification (2.00):** Develop a national CA grain certification standard aligned with GlobalG.A.P., creating price differentiation on domestic and export markets; support CA farmer cooperatives to aggregate volumes and strengthen bargaining positions; and establish multi-year exemptions from grain-export quotas for CA producers to secure the investment horizon.

The gender-inclusion measure received the lowest priority from the working group (1.25, with nine of twelve low ratings), consistent with the screening of the corresponding barrier. It is therefore not advanced as a standalone measure; instead, its elements — alternative collateral guarantees in machinery leasing, a target of at least 30 per cent women's participation in Farmer Field Schools and advisory events, women-led demonstration farms, and promotion of the CA adaptation calculator and e-Qazagro through women's farmer networks — are mainstreamed as cross-cutting requirements of the measures described above.

Table 1.3. Measures mapped to the barriers they address: Conservation Agriculture

Barrier addressed	Corresponding measure	Priority
Access to Machinery and Finance	Preferential Leasing and Machinery Cooperatives	2.67
Transition-Period Risk and Subsidy Instability	Transition Payments and Subsidy Reform	2.58
Farmer Knowledge Gaps and Equipment-Service Deficit	Improved Training Programmes and Technical Support Services	2.67
Entrenched Culture of Traditional Ploughing	Marketing Campaign and Improved Communication	2.50
Absence of Market Incentives and Price Volatility	CA Grain Certification	2.00
Low Awareness and Lack of Local Data	CA Adaptation Calculator	2.58
Absence of Monitoring Infrastructure and Zonal Variability	Zonal Practice Packages	2.17

Barrier addressed	Corresponding measure	Priority
Insecure Land-Use Rights and Absence of Results-Based Payments	Land Reform and Payments for Ecosystem Services	2.25

1.1.6 Grouping complementary measures for Conservation Agriculture

The eight prioritised complex measures have been organised into three interactive, cross-cutting strategic packages that together form the enabling framework for Conservation Agriculture. The grouping ensures that financial instruments, regulatory rewards and knowledge systems advance in parallel, preventing the risk of isolated measures — such as financing machinery for farms that lack the agronomic skills to use it, or training farmers who cannot finance the equipment.

- **Programme 1.) CA Transition Finance and Incentive Framework (Economic & Financial Package):** This package directly pairs *Preferential Leasing and Machinery Cooperatives (Score: 2.67)* with *Transition Payments and Subsidy Reform (2.58)*. Concessional 5–7-year leasing through KazAgroFinance and shared-use machinery cooperatives lower the entry threshold for the USD 80,000–250,000 capital carrier, while three-year per-hectare transition payments and extended state crop-insurance coverage de-risk the 3–5-year conversion period in which yields may temporarily decline by 10–20 per cent. Reorienting the subsidy architecture towards results-based payments — with separate subsidy groups and credit products for minimum-tillage machinery, as proposed through stakeholder feedback — stabilises the incentive system against annual budget cycles. The package thereby addresses both retained economic and financial barriers across the full investment cycle: entry capital and transition cash-flow risk.
- **Programme 2.) Tenure Security and Market Reward Framework (Regulatory & Market Package):** This package combines *Land Reform and Payments for Ecosystem Services (2.25)* with *CA Grain Certification (2.00)*. Guaranteed minimum lease terms of 15–25 years for farms committed to CA conversion allow producers to capture the long-term soil-health returns they finance, while the agri-environmental payment scheme and a soil-carbon MRV methodology compatible with the KAZ ETS and voluntary markets convert verified adaptation results — reduced erosion, improved moisture retention, drought-year yield stabilisation — into income streams. Create a national certification standard for CA-grown grain, backed by producer cooperatives and time-limited exemptions from grain-export quotas, so that sustainably produced grain earns a price premium. The package thus removes the legal-regulatory and market-conditions barriers by making adaptation performance bankable.
- **Programme 3.) Knowledge, Evidence and Outreach Framework (Capacity & Information Package):** This human-centric package integrates *Improved Training Programmes and Equipment Service (2.67)*, *CA Adaptation Calculator (2.58)*, *Marketing Campaign and Improved Communication (2.50)* and *Zonal Practice Packages (2.17)*. It targets the two highest-rated barriers of the entire screening — farmer knowledge gaps and the entrenched culture of traditional ploughing (both 3.75) — together with low awareness (3.58) and zonal variability (3.33). The measures operate as a chain: zonal packages define what to do in each agro-climatic zone; college curricula, adviser certification and regional service centres build the capacity to do it; the adaptation calculator quantifies what conversion returns for each individual farm; and the multi-year communication campaign, fronted by respected managers of large farms, converts that evidence into a change of agronomic norms. Gender-inclusion requirements — alternative collateral guarantees, a minimum 30 per cent women's participation target and women-led demonstration farms — run across the package as cross-cutting conditions.

1.1.7 Assessment of measures for inclusion in the TAP

The three programmes formed in Section 1.1.6 have been assessed to determine their viability for inclusion in the Technology Action Plan (TAP) against the four criteria of the BAEF template — impact, societal benefits, cost and feasibility — and are described below (Table 1.4).

Programme 1: CA Transition Finance and Incentive Framework

- **Impact:** Directly removes both retained economic and financial barriers (scored 3.58 and 3.50) at the critical diffusion frontier identified in Section 1.1.1 — the more than 5,000 medium farms of 500–5,000 ha and some 15,000 small farms. Concessional leasing and machinery cooperatives lower the entry threshold for the USD 80,000–250,000 capital carrier, while transition payments and extended insurance coverage neutralise the cash-flow trough of the 3–5-year conversion, enabling progress towards the deployment target of at least 4 million hectares of full CA by 2035.
- **Societal benefits:** Stabilises grain yields in drought years, strengthening national food security; reduces fuel and machinery costs by 30–50 per cent; and protects rural incomes in the farm segments most exposed to climate variability.
- **Cost:** Moderate to high fiscal outlay for concessional leasing margins and three-year per-hectare transition payments, partially offset by reorienting existing input subsidies towards results-based payments rather than creating new budget lines; the extension of crop-insurance coverage adds marginal administrative cost.
- **Feasibility:** High. The programme builds on the existing KazAgroFinance leasing and state subsidy machinery, integrates the two measures assigned the highest priority by the working group (2.67 and 2.58), and is explicitly supported by stakeholder feedback calling for separate subsidy groups and credit products for minimum-tillage machinery.

Programme 2: Tenure Security and Market Reward Framework

- **Impact:** Converts the long-horizon returns of CA into bankable assets: guaranteed 15–25-year lease terms allow farmers to capture the soil-health gains they finance; agri-environmental payments and a soil-carbon MRV methodology compatible with the KAZ ETS and voluntary markets monetise verified adaptation results; and certification with multi-year export-quota exemptions establishes the market premium whose absence the screening identified.
- **Societal benefits:** Secure land tenure stimulates rural investment beyond CA itself; verified erosion reduction protects settlements and infrastructure from wind erosion and dust; and carbon-market participation opens an income stream aligned with the 2025 amendments to the Environmental Code establishing the legal basis for Article 6 of the Paris Agreement and a domestic voluntary carbon market.
- **Cost:** Low to moderate, predominantly legislative and administrative — amendment of the Land Code, development of the certification standard and the MRV methodology — with budget requirements concentrated in the agri-environmental payment scheme, which is piloted in Akmola and Kostanay oblasts before national scaling.
- **Feasibility:** Moderate. Land Code reform requires a legislative process and coordination between the Ministry of Agriculture and the Ministry of Ecology and Natural Resources, and the lower priority scores of the constituent measures (2.25 and 2.00) signal stakeholder caution on timing. The legal basis for carbon-market participation already exists, and the certification standard is a conventional regulatory task.

Programme 3: Knowledge, Evidence and Outreach Framework

- **Impact:** Targets the two highest-rated barriers of the entire screening (both 3.75). Zonal practice packages, college curricula, adviser certification and regional service centres raise the quality of CA practice — reducing the failed conversions that discredit the technology — while the adaptation calculator and the peer-led communication campaign convert locally credible evidence into a change of agronomic norms.
- **Societal benefits:** Builds rural human capital through vocational education and the employment of certified technicians and advisers; mainstreams gender-inclusion requirements, including alternative collateral guarantees, a minimum 30 per cent women's participation target and women-led demonstration farms; and improves the information base available to farms of all sizes.
- **Cost:** Low to moderate — curricula development, calculator software with commissioned district-level climate projections, and multi-year communication campaigns — largely delivered through existing institutions: CIMMYT, the Barayev Institute, agrarian colleges and Farmer Field Schools.
- **Feasibility:** High. The constituent training measure received the joint-highest priority score (2.67); the institutional partners already operate in the northern grain oblasts; and the peer-learning model reproduces the demonstration-driven approach that underpinned Kazakhstan's earlier no-till expansion (CIMMYT, 2013).

Table 1.4. Summary Assessment Matrix for TAP Inclusion: Conservation Agriculture

Programme Title	Strategic Focus	Estimated Cost (indicative, 10 yr)	Implementation Feasibility	Recommended TAP Action
Programme 1: Transition Finance and Incentives	Capital access and transition de-risking	Moderate–high — ~USD 100–180M: 3-yr per-ha transition payments (~USD 45–90M), interest-rate subsidy on the concessional seeder-leasing portfolio (~USD 40–70M), crop-insurance extension and administration (~USD 10–20M); partly offset by reorienting existing input subsidies rather than new budget lines	High (existing KazAgroFinance and subsidy machinery; top-priority measures, 2.67 and 2.58)	Include as Core Financial Action
Programme 2: Tenure Security and Market Reward	Long-term return capture and market pull	Low–moderate — ~USD 15–30M: Land Code amendment and certification standard largely administrative; budget concentrated in the soil-carbon MRV methodology (~USD 3–5M) and the agri-environmental PES pilot in Akmola and Kostanay (~USD 10–20M) before national scaling	Moderate (legislative reform; cross-ministerial coordination)	Include as Core Regulatory Action
Programme 3: Knowledge,	Capacity, evidence	Low–moderate — ~USD 20–40M: college curricula and adviser certification, adaptation calculator with commissioned district-level climate	High (existing institutions; top-scored	Include as Immediate

Evidence and Outreach	and norm change	projections, zonal practice packages, multi-year peer-led campaigns; delivered through existing institutions (CIMMYT, Barayev Institute, agrarian colleges), so cost is programme funding, not new infrastructure	training measure, 2.67)	Support Action

1.2 Technology 2: Agroforestry for Erosion Control and Soil Protection

1.2.1 General description and target for Agroforestry for Erosion Control

Shelterbelt agroforestry consists of linear or mosaic plantings of trees and shrubs on and around agricultural land, established primarily for wind-erosion control, soil-moisture retention and the stabilisation of crop yields. In the northern grain belt of Kazakhstan it is deployed as a nature-based, ecosystem-based adaptation (NbS/EbA) technology: by reducing wind speed over the fields it protects the soil surface, conserves moisture, moderates the field microclimate and stabilises wheat yields, with carbon sequestration and biodiversity corridors as secondary co-benefits.

The protective mechanism is well established. Internationally, shelterbelts occupying as little as 5 per cent of farmland reduce wind speed by 30–50 per cent and soil loss by up to 80 per cent, lower lee-side evapotranspiration by 10–30 per cent and, unlike most field practices, remain effective during drought, with percentage yield gains generally greater in drier regions (Brandle, Hodges and Zhou, 2004). On this basis the present assessment adopts a conservative wheat-yield gain of 4–15 per cent near functioning shelterbelts and an erosion reduction of the order of 5–15 t/ha per year on wind-exposed land.

The principal deployment zone is the steppe and dry-steppe oblasts of the northern grain belt — Akmola, Kostanay, North Kazakhstan and Pavlodar — where the Soviet-era shelterbelt network has substantially degraded, by roughly 70 per cent since 1991; a recent field assessment of belts in the Akmola region found up to 80 per cent tree mortality and a widespread loss of protective function (SilvaWorld, 2025). The critical diffusion frontier is the grain farms of 500–5,000 hectares that carry the heaviest wind-erosion load and hold the greatest combined restoration potential. Agroforestry supports Kazakhstan's NDC 3.0 (2025) and the national afforestation effort under the Zhasyl El programme and the Concept for Conservation and Sustainable Use of Biodiversity to 2030, which targets the planting of 10,000 hectares of shelterbelts, more than two billion trees and 114 new forest nurseries over 2021–2025 (UNECE; Astana Times, 2025).

Preliminary deployment target: *Restore and newly establish at least 100,000 hectares of functional shelterbelt and field-protective tree lines on degraded cropland across the northern grain belt (Akmola, Kostanay, North Kazakhstan and Pavlodar oblasts) by 2035.*

The target is ambitious relative to the 10,000 hectares of shelterbelts in the current national plan, but is justified by the extent of the degraded Soviet-era network and the wind-erosion exposure of the northern cropland, and it assumes that the enabling measures set out below are in place.

Technology constraints: trees on agricultural land remain legally ambiguous under the land-category system of the Land Code; the 10–20-year establishment horizon for full protective function exceeds most current lease terms; the nursery and seedling supply of climate-adapted native species is well below the level the target requires; and zone-specific species-selection guidance is not yet available through advisory services.

1.2.2 Identification of barriers for Agroforestry

Following the BAEF Guidebook (UDP, 2015), shelterbelt agroforestry was categorised as a publicly provided good with significant market elements: the supply of planting material operates as a capital-good market, while the ecosystem services that shelterbelts deliver are externalities not captured by any current payment mechanism. Barriers were diagnosed through problem-tree analysis and market mapping (Figures A1.5 and A1.4, Annex 1). The diagrams were prepared by the national consultant with the support of the TNA team, and the long list of barriers was

developed on the basis of this analysis; the mirrored objective tree (Figure A1.6) is taken up with the measures in Section 1.2.5.

The problem tree identifies the starter problem as the limited adoption of agroforestry (shelterbelts and windbreaks) by wheat farms in Kazakhstan and traces it to five groups of causes. Economic and financial barriers are central: shelterbelts yield their adaptation benefits only after 5–10 years, whereas agricultural finance is built around the annual wheat cycle, and with a National Bank base rate of 18 per cent feeding commercial lending of 20–24 per cent, the absence of dedicated long-tenor instruments and farm-level carbon pre-financing makes multi-decade investment unviable — a systemic financial and policy root cause. Technology and market barriers stem from the lack of reliable seedling supply (insufficient state nurseries and embryonic private capacity), the roughly 70 per cent of the Soviet-era shelterbelt network now degraded with no restoration programme, and the absence of remote-sensing monitoring — a structural technology root cause. Institutional and regulatory barriers arise from a mandate split between the Ministry of Agriculture and the Ministry of Ecology with no NbS/EbA coordination body, subsidies that favour wheat inputs, and no framework linking shelterbelt carbon to the KAZ ETS or Article 6. Capacity and awareness barriers comprise limited farmer awareness of shelterbelt benefits, the absence of a demonstration base and the lack of advisory and remote-sensing training. Finally, behavioural and external barriers — a wheat-monoculture preference that treats shelterbelts as forgone cropping area, the 10–20-year income gap before returns, and land-tenure uncertainty compounded by grain-price volatility — keep non-adoption economically rational for most farmers. The effect chains above the starter problem show the cost of inaction: accelerating erosion and biodiversity loss, declining and more variable yields, intensifying dust storms and desertification risk, lost water retention, and rising emissions with the REDD+ opportunity foregone. The barriers are detailed in Section 1.2.2 and screened in Section 1.2.3.

Based on the analysis above, the barriers were developed into a long list prepared by the national consultant with the support of the TNA team. The long list comprises ten barriers across nine categories; each barrier carries a short description of its adaptation context and is paired with a corresponding enabling measure (Section 1.2.5). In this form the list was submitted to the Agriculture Sectoral Working Group for assessment, the results of which are presented in Section 1.2.3. Following the structure of the BAEF template, the barriers divide into economic and financial barriers and non-financial barriers.

Economic and financial barriers

- **Long-term financing gap.** Shelterbelts deliver their adaptation benefits — yield stabilisation and erosion protection — only after 5–10 years, whereas Kazakhstan's agricultural finance is built around the annual wheat cycle. Neither KazAgroFinance nor Damu offers long-tenor products for shelterbelt establishment, and commercial lending at 20–24 per cent makes investment in multi-decade adaptation infrastructure economically unviable; the high upfront costs are beyond medium and small farms without targeted support.
- **Subsidy mismatch and market volatility.** The subsidy system concentrates support on wheat inputs (fertiliser, fuel, machinery) and provides no comparable incentive for shelterbelt establishment, effectively penalising adaptation investment, while grain-export restrictions and world-price volatility reduce farm income and the capital available for multi-decade programmes.

Non-financial barriers

- **Market conditions — no market infrastructure for ecosystem services.** No market intermediaries exist to monetise shelterbelt outputs: there are no carbon aggregators,

ecosystem-service brokers or PES mechanism rewarding verified adaptation results (erosion reduction, water retention, biocorridors), and non-timber products such as sea buckthorn and medicinal plants lack national aggregation and marketing infrastructure.

- **Legal and regulatory — insecure land-use rights and absence of MRV/REDD+.** The 10–20-year establishment period makes secure lease rights a precondition for rational investment, yet no approved MRV protocol exists for carbon accumulation in agroforestry shelterbelts under the KAZ ETS or Article 6, and the REDD+ policy base is not linked to farm-level agroforestry.
- **Institutional capacity — institutional fragmentation and absence of monitoring.** Agroforestry sits between the Ministry of Agriculture and the Ministry of Ecology with no designated coordinating body, NbS/EbA mandate or unified budget; there is no national system monitoring primary adaptation indicators, and without localised wind-erosion maps and drought projections, shelterbelt placement relies on historical patterns rather than forward-looking climate projections.
- **Human capacity — advisory and nursery gaps.** Advisory services do not cover shelterbelt management, NbS/EbA approaches or remote-sensing tools, and mass establishment requires climate-adapted native species (saxaul, elm, birch, willow, sea buckthorn) in volumes far exceeding current nursery capacity; state nurseries are insufficient in coverage and do not plan species selection for projected 2030–2050 conditions.
- **Social, cultural and behavioural — wheat-monoculture mindset and rational risk-aversion.** Shelterbelt establishment temporarily removes productive land from wheat and yields tangible returns only after a decade; absent visible financial incentives, the decision not to plant remains economically rational for most farmers, given the structural absence of insurance mechanisms and the invisibility of long-term adaptation costs.
- **Information and awareness — low awareness and absence of a demonstration base.** Most grain farmers are unaware of agroforestry's primary adaptation value — the documented 4–15 per cent wheat-yield gain near shelterbelts, reduced dust-storm damage and improved microclimate — and no demonstration sites combine practical shelterbelt management with documented yield, erosion and remote-sensing data.
- **Technical — absence of remote-sensing infrastructure.** Remote sensing is a precondition for measuring all shelterbelt adaptation outcomes — erosion trends, shelterbelt condition and cover, biocorridor status and wind–moisture field data; without it, adaptation results cannot be verified, an evidence base for public investment cannot be built and carbon accumulation cannot be quantified. Copernicus, Landsat and GeoPard exist globally but are not integrated into Kazakhstani monitoring systems.
- **Gender equality — gender inequality in access to agroforestry programmes.** Women farm managers and rural women land users face layered barriers: collateral requirements for long-term finance disproportionately restrict women, NbS/EbA and Farmer Field School events are predominantly attended by men, and nursery vocational training offers few entry points for women.

1.2.3 Screening of barriers for Agroforestry

The long list of ten barriers presented in Section 1.2.2 was screened by the Agriculture Sectoral Working Group through a structured online questionnaire. Twelve members of the working group completed the assessment, rating the impact of each barrier on the adoption of agroforestry on a

five-tier scale derived from the BAEF Guidebook: critical (blocking), key, important, less important and insignificant. For analysis, the ratings were converted into ordinal scores from 5 (critical) to 1 (insignificant) and averaged across respondents; the full score distributions are presented in Annex 3.

For the interpretation of the results, three screening bands were applied: barriers with a mean score of 3.5 or higher are classified as high-severity (crucial) barriers; barriers scoring between 3.0 and 3.49 as important; and barriers scoring below 3.0 as lower-priority barriers. The results are summarised in Table 1.5.

Table 1.5. Stakeholder screening of barriers for Agroforestry

Rank	Barrier (category)	Mean score (1–5)	Rated critical or key, %	Screening band
1	Long-term financing gap (economic and financial)	4.00	67%	High severity (crucial)
2	Insecure land-use rights and absence of MRV/REDD+ (legal and regulatory)	3.92	67%	High severity (crucial)
3–5	Subsidy mismatch and market volatility (economic and financial)	3.75	58%	High severity (crucial)
3–5	No market infrastructure for ecosystem services (market conditions)	3.75	58%	High severity (crucial)
3–5	Advisory and nursery gaps (human capacity)	3.75	58%	High severity (crucial)
6	Low awareness and absence of a demonstration base (information and awareness)	3.50	50%	High severity (crucial)
7–8	Institutional fragmentation and absence of monitoring (institutional capacity)	3.42	50%	Important
7–8	Wheat-monoculture mindset and rational risk-aversion (social, cultural and behavioural)	3.42	50%	Important
9	Absence of remote-sensing infrastructure (technical)	3.33	42%	Important
10	Gender inequality in access to agroforestry programmes (gender equality)	1.92	8%	Lower priority

The working group rated the barriers to agroforestry markedly more severe than those to Conservation Agriculture: six of the ten reach the high-severity band. The long-term financing gap is assessed as a near-blocking constraint, with a mean of 4.00 and two-thirds of respondents rating it critical or key, reflecting the mismatch between the multi-decade payback of shelterbelts and an agricultural finance system built around the annual wheat cycle. It is followed by insecure land-use rights and the absence of MRV/REDD+ (3.92) and by a cluster at 3.75 — subsidy

mismatch, the absence of an ecosystem-service market, and advisory and nursery gaps — with low awareness at 3.50. The binding constraints are therefore the long investment horizon, the absence of a market or payment mechanism rewarding shelterbelt benefits, and the shortage of seedling supply and advisory capacity.

Institutional fragmentation and the wheat-monoculture mindset (both 3.42) and the absence of remote-sensing infrastructure (3.33) form the important band. Only gender inequality in access to agroforestry programmes fell below the importance threshold, with a mean of 1.92, no critical ratings and a single key rating.

1.2.4 Classification of barriers for Agroforestry

The long list of barriers was screened to isolate the most critical constraints obstructing the adoption and diffusion of agroforestry in Kazakhstan. Barriers with a mean score below 3.0 — the "important" rating on the five-tier scale (Section 1.2.3, Table 1.5) — were classified as minor obstacles that do not fundamentally constrain national deployment and were excluded from the further analysis. Only one barrier was screened out on this basis: gender inequality in access to agroforestry programmes (1.92); the gender dimension is nevertheless retained as a cross-cutting consideration in the design of enabling measures. The remaining nine high-scoring barriers are listed below under two categories.

Economic and financial barriers

Economic and financial constraints form the core of the adoption problem: the long payback of shelterbelts is fundamentally misaligned with the financing instruments and incentive structures available to farms.

- **Long-Term Financing Gap (Score: 4.00):** Shelterbelts deliver adaptation benefits only after 5–10 years, yet neither KazAgroFinance nor Damu offers long-tenor products for their establishment; commercial lending at 20–24 per cent renders multi-decade adaptation investment unviable and the high upfront costs are beyond medium and small farms without targeted support.
- **Subsidy Mismatch and Market Volatility (3.75):** The subsidy system concentrates on wheat inputs and offers no comparable incentive for shelterbelt establishment, effectively penalising adaptation investment, while grain-export restrictions and price volatility erode the capital available for multi-decade programmes.

Non-financial barriers

The non-financial barriers form an interconnected web of regulatory, market, institutional, capacity, behavioural and technical constraints, several of which the working group rated as severe as the financing gap itself.

- **Insecure Land-Use Rights and Absence of MRV/REDD+ (3.92):** The 10–20-year establishment period makes secure tenure a precondition for rational investment, yet no approved MRV protocol exists for shelterbelt carbon under the KAZ ETS or Article 6, and the REDD+ policy base is not linked to farm-level agroforestry.
- **No Market Infrastructure for Ecosystem Services (3.75):** No carbon aggregators, ecosystem-service brokers or PES mechanism exist to reward verified adaptation results, and non-timber products such as sea buckthorn and medicinal plants lack national aggregation and marketing infrastructure.

- **Advisory and Nursery Gaps (3.75):** Advisory services do not cover shelterbelt management or remote-sensing tools, and mass establishment requires climate-adapted native species in volumes far exceeding current nursery capacity, which does not plan species selection for projected 2030–2050 conditions.
- **Low Awareness and Absence of a Demonstration Base (3.50):** Most grain farmers are unaware of the documented 4–15 per cent wheat-yield gain near shelterbelts and the reduction in dust-storm damage, and no demonstration sites combine practical management with documented yield, erosion and remote-sensing data.
- **Institutional Fragmentation and Absence of Monitoring (3.42):** Agroforestry sits between the Ministry of Agriculture and the Ministry of Ecology with no coordinating body, NbS/EbA mandate or unified budget, and there is no national system monitoring erosion, shelterbelt condition or biocorridors.
- **Wheat-Monoculture Mindset and Rational Risk-Aversion (3.42):** Shelterbelt establishment temporarily removes land from wheat and returns value only after a decade; absent visible incentives, non-adoption remains economically rational given the structural absence of insurance and the invisibility of long-term adaptation costs.
- **Absence of Remote-Sensing Infrastructure (3.33):** Remote sensing is a precondition for measuring all shelterbelt adaptation outcomes; without integrating platforms such as Copernicus, Landsat and GeoPard into national monitoring, results cannot be verified, an evidence base cannot be built and carbon accumulation cannot be quantified.

Table 1.6. Classification of barriers by BAEF category: Agroforestry for Erosion Control

Barrier type	Category	Specific Barrier	Description of the Barrier	Score
Economic and financial	Economic and financial	Long-Term Financing Gap	Benefits accrue after 5–10 years; no long-tenor product exists; lending at 20–24% is unviable.	4.00
	Economic and financial	Subsidy Mismatch and Market Volatility	Subsidies favour wheat inputs, not shelterbelts; price volatility erodes capital.	3.75
Non-financial	Legal and regulatory	Insecure Land-Use Rights and Absence of MRV/REDD+	The 10–20-year establishment needs secure tenure; no MRV for shelterbelt carbon.	3.92
	Market conditions	No Market Infrastructure for Ecosystem Services	No carbon aggregators, ES brokers or PES reward verified results.	3.75
	Human skills	Advisory and Nursery Gaps	Advisory services omit shelterbelts; nursery capacity is below requirement.	3.75
	Information	Low Awareness and Absence of a Demonstration Base	Farmers unaware of 4–15% yield gains; no demonstration sites.	3.50
	Institutional capacity	Institutional Fragmentation and Absence of Monitoring	Split MoA/MoENR mandate; no coordination body or monitoring.	3.42
	Social and cultural	Wheat-Monoculture Mindset and Rational Risk-Aversion	Shelterbelts remove land from wheat; returns appear only after a decade.	3.42
	Technical	Absence of Remote-Sensing Infrastructure	No integration of Copernicus/Landsat/GeoPard for monitoring.	3.33

1.2.5 Measures for Agroforestry

For each barrier of the long list, a corresponding enabling measure was developed by the national consultant with the support of the TNA team and submitted to the Agriculture Sectoral Working Group in the same structured questionnaire. The working group assessed the priority of each measure on a three-tier scale — high, medium and low — converted for analysis into scores from 3 (high) to 1 (low) and averaged across the twelve respondents; the full distributions are presented in Annex 3. The nine measures addressing the nine retained barriers are described below under two categories, with their mean priority scores.

Economic and financial measures

- **Adaptation Finance Fund (Score: 2.75):** Establish a dedicated agroforestry climate-adaptation finance fund (as for example, Baiterek Holding) offering long-term (15–20-year) concessional loans (channelling concessional resources through existing institutions such as KazAgroFinance and partner development finance institutions, rather than operating as a stand-alone bank)and grants for shelterbelt establishment, with repayment schedules tied to the timing of adaptation benefits (yield stabilisation at 5 years, full erosion protection at 10); partner with the Asian Infrastructure Investment Bank (AIIB), the EBRD, IFC and Auyl Amanaty; reallocate part of KazAgroFinance support from conventional inputs to shelterbelt-establishment grants; and introduce an interest-rate subsidy to 5–7 per cent for registered agroforestry projects. The fund may channel concessional resources through existing institutions (e.g. KazAgroFinance and partner development finance institutions) rather than operate as a stand-alone bank.
- **NbS/EbA Support Window in KazAgroFinance (2.75):** Create a dedicated climate-adaptation nature-based-solutions window in KazAgroFinance covering shelterbelt establishment, remote-sensing infrastructure and adaptation-result tracking; introduce multi-year income-stabilisation payments for farms committing to shelterbelt programmes; and develop carbon pre-financing as a complementary instrument once MRV infrastructure is in place.

Non-financial measures

- **PES Scheme and Carbon Platform (2.58):** Develop a payments-for-ecosystem-services scheme rewarding verified adaptation results — reduced erosion, improved water retention, biocorridor maintenance — measurable through simple satellite indicators; establish a national carbon-project aggregation centre to pool agroforestry projects under the KAZ ETS and voluntary markets (Verra VCS, REDD+); and support regional aggregation hubs for non-timber forest products.
- **Land Reform and MRV Methodology (2.33):** Reform the Land Code to guarantee a minimum 25-year lease for farms implementing registered shelterbelt programmes and introduce a shelterbelt protective-easement instrument; develop and adopt a national MRV methodology for shelterbelt carbon compatible with the KAZ ETS, Verra VCS and REDD+; and develop a REDD+ policy base for agricultural shelterbelt restoration, piloted in the northern grain belt.
- **NbS Training Modules and Nursery Expansion (2.25):** Integrate three new modules into advisory-service curricula — NbS/EbA technical advice on shelterbelt design and establishment, remote-sensing advice on shelterbelt health and erosion, and carbon advisory as a secondary priority — and accelerate the establishment state nurseries (the figure of 114 nurseries is the target set in the national Zhasyl El programme, not derived in this

assessment)under the Zhasyl El programme with defined capacity targets for climate-adapted native species suited to projected 2050 conditions.

- **Remote-Sensing Integration (2.25):** Integrate Copernicus (ESA), Landsat (USGS), GeoPard Agriculture and drones into Kazakhstan's agricultural and environmental monitoring architecture, with continuous monitoring of shelterbelt condition and biodiversity as the primary objective and quantification of carbon accumulation as the secondary; link the system to e-Qazagro, the KAZ ETS MRV registry and NDC adaptation reporting. This is the foundational action on which the PES, carbon and REDD+ instruments all depend.
- **Shelterbelt-Effect Research and Publications (2.25):** Build a Kazakhstani evidence base on the economic effectiveness of shelterbelts — documented 4–15 per cent wheat-yield gains, reduced dust-storm damage, water-saving data and potential non-timber income — communicate with primary emphasis on adaptation benefits, and engage large farms in the northern oblasts as demonstration partners.
- **NbS/EbA Coordination Body and Monitoring System (2.08):** Create an inter-agency NbS/EbA coordination body with a core mandate for climate-adaptation monitoring and shelterbelt restoration; deploy an integrated national shelterbelt monitoring system; launch a national remote-sensing shelterbelt inventory to map current condition and priority restoration zones; and commission localised wind-erosion maps and drought projections for the northern grain oblasts.
- **Agroforestry Adaptation Calculator and Demonstration Plots (2.08):** Develop an agroforestry adaptation calculator for the northern grain belt as a tool, allowing farms to model erosion reduction, wheat-yield gains, wind-damage reduction and microclimate effects; and establish three to five integrated demonstration sites in Akmola, Kostanay and North Kazakhstan combining practical shelterbelt management, documentation of adaptation outcomes and remote-sensing monitoring.

The gender-inclusion measure received the lowest priority from the working group (1.42), consistent with the screening of the corresponding barrier. It is therefore not advanced as a standalone measure; instead, its elements — alternative collateral guarantees in long-term finance, a target of at least 30 per cent women's participation in NbS/EbA Farmer Field Schools, women-led shelterbelt demonstration sites, outreach through women's farmer networks, and entry points for women in nursery vocational training — are mainstreamed as cross-cutting requirements of the measures above.

Table 1.7. Measures mapped to the barriers they address: Agroforestry for Erosion Control

Barrier addressed	Corresponding measure	Priority
Long-Term Financing Gap	Adaptation Finance Fund	2.75
Subsidy Mismatch and Market Volatility	NbS/EbA Support Window in KazAgroFinance	2.75
No Market Infrastructure for Ecosystem Services	PES Scheme and Carbon Platform	2.58
Insecure Land-Use Rights and Absence of MRV/REDD+	Land Reform and MRV Methodology	2.33
Advisory and Nursery Gaps	NbS Training Modules and Nursery Expansion	2.25
Absence of Remote-Sensing Infrastructure	Remote-Sensing Integration	2.25
Wheat-Monoculture Mindset and Rational Risk-Aversion	Shelterbelt-Effect Research and Publications	2.25
Institutional Fragmentation and Absence of Monitoring	NbS/EbA Coordination Body and Monitoring System	2.08

Barrier addressed	Corresponding measure	Priority
Low Awareness and Absence of a Demonstration Base	Agroforestry Adaptation Calculator and Demonstration Plots	2.08

1.2.6 Grouping complementary measures for Agroforestry

The nine prioritised measures have been organised into four interactive, cross-cutting strategic packages that together form the enabling framework for agroforestry. The grouping ensures that long-term finance, regulatory and market rewards, institutional coordination and monitoring, and knowledge systems advance in parallel, preventing the risk of isolated measures — such as financing shelterbelts that cannot be monitored, or creating a payment scheme with no verification system behind it.

- **Programme 1.) Long-Term Adaptation Finance Framework (Economic & Financial Package):** This package pairs *Adaptation Finance Fund (2.75)* with *NbS/EbA Support Window in KazAgroFinance (2.75)*. Together they supply the long-tenor concessional capital that the annual-cycle finance system lacks: 15–20-year loans and grants with repayment tied to the arrival of adaptation benefits, an interest-rate subsidy for registered projects, and a dedicated KazAgroFinance window that also covers monitoring and result tracking. The package directly removes the two retained economic and financial barriers.
- **Programme 2.) Tenure Security and Ecosystem-Service Market Framework (Regulatory & Market Package):** This package combines *Land Reform and MRV Methodology (2.33)* with *PES Scheme and Carbon Platform (2.58)*. A guaranteed 25-year lease and a shelterbelt protective easement secure the establishment horizon, while the national MRV methodology turns verified adaptation results into payments and tradable carbon under the KAZ ETS and voluntary markets. Tenure and MRV are interdependent: neither the payment scheme nor carbon revenue can operate without secure rights and an accepted measurement protocol.
- **Programme 3.) Institutional Coordination and Monitoring Framework (Institutional & Technical Package):** This package links *NbS/EbA Coordination Body and Monitoring System (2.08)* with *Remote-Sensing Integration (2.25)*. It establishes the coordinating authority that the split mandate currently lacks and the remote-sensing backbone (Copernicus, Landsat, GeoPard, drones) on which every adaptation metric depends. This programme is foundational: the payment and carbon mechanisms of Programme 2 cannot be verified without it.
- **Programme 4.) Capacity, Evidence and Outreach Framework (Capacity & Information Package):** This package integrates *NbS Training Modules and Nursery Expansion (2.25)*, *Shelterbelt-Effect Research and Publications (2.25)* and *Agroforestry Adaptation Calculator and Demonstration Plots (2.08)*. It builds the seedling supply and advisory skills required for delivery, generates the Kazakhstani evidence base on shelterbelt performance, and disseminates it through the calculator and demonstration sites. Gender-inclusion requirements run across the package as cross-cutting conditions.

1.2.7 Assessment of measures for inclusion in the TAP

The four programmes formed in Section 1.2.6 have been assessed to determine their viability for inclusion in the Technology Action Plan (TAP) against the four criteria of the BAEF template — impact, societal benefits, cost and feasibility — and are described below (Table 1.8).

Programme 1: Long-Term Adaptation Finance Framework

- **Impact:** Removes the highest-rated barrier of the entire screening — the long-term financing gap (4.00) — and the subsidy mismatch (3.75) by supplying long-tenor concessional capital matched to the 5–10-year benefit horizon, enabling shelterbelt establishment on the 500–5,000-hectare farms that carry the heaviest erosion load and progress towards the target of at least 100,000 hectares by 2035.
- **Societal benefits:** Protects grain production from wind erosion and dust storms, stabilises rural incomes over the establishment period and, by reallocating part of existing support, redirects public finance towards climate-adaptation infrastructure.
- **Cost:** High fiscal commitment for the concessional fund and interest-rate subsidy, mitigated by partnership with the EBRD, IFC and Auyl Amanaty and by reallocating part of existing KazAgroFinance support rather than creating wholly new budget lines.
- **Feasibility:** Moderate to high. The measures received the joint-highest priority scores (2.75) and build on existing KazAgroFinance structures, though the long-tenor product design and the reallocation of subsidies require political commitment.

Programme 2: Tenure Security and Ecosystem-Service Market Framework

- **Impact:** Addresses insecure tenure and the absence of MRV/REDD+ (3.92) and the missing ecosystem-service market (3.75) by guaranteeing a 25-year lease and converting verified adaptation results into PES payments and tradable carbon, making the long-horizon investment rational and bankable.
- **Societal benefits:** Secure tenure stimulates rural investment beyond agroforestry; verified erosion reduction protects settlements from dust storms; and carbon-market access aligns with the 2025 amendments to the Environmental Code establishing the legal basis for Article 6 of the Paris Agreement and a domestic voluntary carbon market.
- **Cost:** Low to moderate, predominantly legislative and methodological — Land Code amendment and MRV development — with the budget concentrated in the PES scheme, which can be piloted in the northern grain belt before national scaling.
- **Feasibility:** Moderate. Land Code reform and an accepted MRV protocol require a legislative process and coordination between the Ministry of Agriculture and the Ministry of Ecology, and they depend on the monitoring backbone delivered by Programme 3.

Programme 3: Institutional Coordination and Monitoring Framework

- **Impact:** Resolves institutional fragmentation (3.42) and the absence of remote-sensing infrastructure (3.33) by creating the coordinating authority the split mandate lacks and the monitoring system on which all adaptation measurement — and therefore the payment and carbon mechanisms of Programme 2 — depends.
- **Societal benefits:** Provides the public-good information base — wind-erosion maps, drought projections, shelterbelt and biocorridor monitoring — that supports evidence-based public investment and transparent reporting under the NDC.
- **Cost:** Low to moderate: the establishment of a coordination body and the integration of existing global remote-sensing platforms (Copernicus, Landsat, GeoPard) rather than the creation of new satellite infrastructure.
- **Feasibility:** Moderate to high technically, as the remote-sensing platforms already exist and need integration rather than development; the main requirement is the inter-ministerial mandate for the coordination body.

Programme 4: Capacity, Evidence and Outreach Framework

- **Impact:** Addresses advisory and nursery gaps (3.75), low awareness (3.50) and the wheat-monoculture mindset (3.42) by building seedling supply and advisory skills, generating Kazakhstani evidence on shelterbelt performance and disseminating it through the calculator and demonstration sites, raising the quality of establishment and shifting farmer behaviour.
- **Societal benefits:** Builds rural human capital and nursery employment, mainstreams gender-inclusion requirements, and improves the information available to farms of all sizes through demonstration plots and the adaptation calculator.
- **Cost:** Low to moderate — curricula development, nursery capacity, calculator software and demonstration sites — delivered largely through existing institutions and the Zhasyl El nursery programme.
- **Feasibility:** High. The measures build on the existing Zhasyl El nursery programme and advisory structures and require no legislative change, although nursery scale-up to climate-adapted native species takes several years to mature.

Table 1.8. Summary Assessment Matrix for TAP Inclusion: Agroforestry

Programme Title	Strategic Focus	Estimated Cost (indicative, 10 yr)	Implementation Feasibility	Recommended TAP Action
Programme 1: Long-Term Adaptation Finance	Long-tenor capital for establishment	High — ~USD 80–150M (concessional element ~30%): 15–20-yr concessional loans and establishment grants, interest-rate subsidy to 5–7%; blended with EBRD, IFC and Auyl Amanaty, and partly a reallocation of existing KazAgroFinance support rather than new expenditure	Moderate–high (top-scored measures, 2.75 and 2.75; political commitment needed)	Include as Core Financial Action
Programme 2: Tenure Security and ES Market	Long-term return capture and market pull	Low–moderate — ~USD 10–25M: Land Code amendment and conservation easement (administrative), national MRV methodology, PES pilot in the northern grain belt; at-scale PES payments financed from environmental charges and the Programme 1 envelope	Moderate (legislative reform; depends on Programme 3)	Include as Core Regulatory Action
Programme 3: Institutional Coordination and Monitoring	Coordination and the measurement backbone	Low–moderate — ~USD 5–15M: coordination-body operations, national remote-sensing shelterbelt inventory and monitoring system; integrates existing free platforms (Copernicus, Landsat, GeoPard, drones) rather than building new satellite infrastructure	Moderate–high (platforms exist; needs inter-ministerial mandate)	Include as Enabling Institutional Action
Programme 4: Capacity,	Capacity,	Moderate — ~USD 30–50M: nursery scale-up under the Zhasyl El	High (no legislative	Include as

Evidence and Outreach	evidence and norm change	programme is the dominant item (~USD 25–40M of largely committed state investment); advisory modules, shelterbelt-effect research, calculator and 3–5 demonstration sites add ~USD 5–10M	change; nursery scale-up takes time)	Support Action

1.3 Technology 3: Climate-Smart Soil Management (Mulch, Biochar, Compost)

1.3.1 General description and target for Climate-Smart Soil Management

Climate-Smart Soil Management (CSSM) is an integrated agronomic package that combines organic amendments (compost, biochar, biofertilisers), cover crops, conservation tillage and precision nutrient management to rebuild soil organic carbon, improve moisture retention and reduce dependency on chemical inputs. In Kazakhstan's context it functions as an adaptation technology, stabilising yields under drought and reversing the decline in soil humus — on the order of 1 per cent per annum — documented under conventional intensive tillage (BTR, 2024). By raising soil organic carbon, CSSM increases the water-holding capacity of the soil and buffers crops against the precipitation deficits that increasingly characterise the northern grain belt. The technology supports Kazakhstan's NDC 3.0 (2025), which identifies soil-health restoration as a priority adaptation measure, and the State Programme for the Development of the Agro-Industrial Complex.

In concrete terms, CSSM's distinctive toolkit comprises biochar and compost application, organic and biological amendments, active management of the soil microbiome, soil-carbon build-up and precision nutrient management — none of which is intrinsic to Conservation Agriculture's reduced-tillage and residue-retention approach.

Preliminary deployment target: *Implement verified Climate-Smart Soil Management practices on at least 2 million hectares of degraded arable land in the northern oblasts (Akmola, Kostanay, North Kazakhstan and Pavlodar) by 2030, raising soil organic carbon on enrolled farms by a minimum of 0.3 percentage points above the 2025 baseline and reducing wind erosion by 20 per cent, as verified through the national soil-health monitoring programme.*

The target is ambitious but anchored to the scale of soil degradation in the northern grain belt and to the soil-health restoration priority of NDC 3.0; it assumes that the enabling measures set out below — in particular the reorientation of subsidies and a functioning soil-carbon measurement system — are in place.

Technology constraints: input supply chains for organic amendments are underdeveloped, with biochar effectively absent from the domestic market and compost concentrated in a few urban centres; the 3–5-year horizon over which soil-organic-carbon benefits accumulate exceeds most current lease terms; precision soil-monitoring data and certified soil-health advisors are scarce; and the KAZ ETS currently excludes agriculture, closing the primary domestic compliance pathway for sequestration outcomes.

1.3.2 Identification of barriers for CSSM

Following the BAEF Guidebook (UDP, 2015), CSSM inputs were categorised as a combination of consumer goods (biochar, compost, biofertilisers) and capital goods (precision soil-monitoring equipment) that diffuse through market supply chains while generating significant public-good externalities (soil-organic-carbon sequestration and erosion reduction). Barriers were diagnosed through problem-tree analysis and market mapping (Figures A1.8 and A1.7, Annex 1). The diagrams were prepared by the national consultant with the support of the TNA team, and the long list of barriers was developed on the basis of this analysis; the mirrored objective tree (Figure A1.9) is taken up with the measures in Section 1.3.5.

The problem tree identifies the starter problem as the systemic failure of Kazakhstani grain farms to invest in soil-organic-carbon restoration despite its demonstrated role in drought resilience and long-term yield stability, and shows that the central bottleneck is not the absence of agronomic knowledge at the research level but the disconnection between research outputs and farm-level incentives. Economic and financial barriers are decisive: the transition is capital-intensive while soil-carbon benefits accumulate only over 3–5 years, commercial lending at 20–24 per cent is incompatible with that horizon, and the subsidy architecture actively finances maladaptation by rewarding mineral-fertiliser intensity. Market barriers comprise the absence of certification, a price premium or carbon-market pathway and the underdevelopment of supply chains for organic amendments. Legal and regulatory barriers form a four-fold gap — short tenure, no soil-carbon MRV, an unadopted Law on Soil Protection and the exclusion of agriculture from the KAZ ETS. Institutional barriers arise from the absence of any ministry owning soil adaptation and the failure to translate research into extension; capacity, social, information and technical barriers complete the picture through knowledge gaps, the inertia of input-intensive norms, low awareness and the absence of precision soil monitoring. The effect chains above the starter problem show the consequences: accelerating soil degradation and erosion, declining and more variable yields, rising input dependency and lost sequestration potential. The barriers are detailed in Section 1.3.2 and screened in Section 1.3.3.

Based on the analysis presented in Section 1.3.1, the barriers were developed into a long list prepared by the national consultant with the support of the TNA team. The long list comprises ten barriers across nine categories; each barrier carries a short description of its adaptation context and is paired with a corresponding enabling measure (Section 1.3.5). In this form the list was submitted to the Agriculture Sectoral Working Group for assessment, the results of which are presented in Section 1.3.3. Following the structure of the BAEF template, the barriers divide into economic and financial barriers and non-financial barriers.

Economic and financial barriers

- **Adaptation finance gap.** The transition to CSSM is capital-intensive — organic amendments, precision soil-monitoring equipment and certified seed — while the yield benefits of improved soil organic carbon accumulate only over 3–5 years; commercial lending rates of 20–24 per cent are structurally incompatible with this payback horizon, placing the transition beyond reserve-constrained farms without targeted support.
- **Subsidies actively finance soil degradation.** The subsidy architecture finances maladaptation: mineral-fertiliser subsidies reward the input-intensive regime that drives soil-humus loss, creating a path-dependency that makes the transition to CSSM economically irrational without explicit policy correction.

Non-financial barriers

- **Market conditions — no market incentives, carbon-market access or feedstock base.** The market does not differentiate CSSM grain: there is no national certification standard, premium-price mechanism or carbon-market pathway connecting CSSM practice to farm revenue, and the input supply chains for organic amendments are underdeveloped, with biochar effectively absent from the domestic market and compost concentrated in a few urban centres.
- **Legal and regulatory — legal and institutional vacuum.** A four-fold gap constrains adoption: short land-tenure terms render the 3–5-year payback irrational for lessees; no national soil-carbon MRV system exists; the draft Law on Soil Protection remains unadopted; and the KAZ ETS excludes agriculture entirely, closing the primary domestic compliance carbon mechanism.
- **Institutional capacity — fragmentation, absence of monitoring and payments.** No ministry holds full responsibility for soil adaptation — the Ministry of Agriculture subsidises mineral fertilisers, the Ministry of Ecology monitors degradation — and no inter-ministerial mechanism integrates soil health into adaptation planning; research outputs from KazNIIZP and the Barayev Institute are not systematically translated into farm-level extension.
- **Human capacity — farmer knowledge gaps and demonstration-base deficit.** Farmers who do not understand soil-organic-matter dynamics, biological activity and moisture-retention mechanisms cannot evaluate CSSM as a drought-resilience investment; agricultural college curricula lack modules on soil biology, organic-amendment application and precision soil monitoring, and certified soil-health advisors are scarce.
- **Social, cultural and behavioural — inertia of chemicalised farming.** Conventional intensive chemical farming produces known yield results even while progressively eroding the soil capital on which those results depend; managers trained in Soviet-era input-intensive norms resist a practice change involving 3–5 years of yield uncertainty and upfront cost before the adaptive benefits materialise.
- **Information and awareness — low awareness and absence of early warning.** Farmers are not aware that their soils are degrading at a rate that progressively undermines drought resilience, nor of the economic value of arresting that decline; a Soil Adaptation Returns Calculator linking soil-carbon improvement to drought-year yield stability, input-cost savings and long-term land value does not exist in a form accessible to farm managers.
- **Technical — absence of soil monitoring and zonal variability.** Precision soil monitoring is the foundational adaptation tool: without data on soil-carbon content, water retention, compaction and biological activity, CSSM cannot be targeted efficiently or verified for carbon markets, and the high zonal variability of northern soils is not captured by current practice.
- **Gender equality — gender inequality in access to CSSM and training.** Women farm managers and rural women land users face layered barriers: collateral requirements for finance disproportionately restrict women, soil-health training and demonstration events are predominantly attended by men, and soil-health advisory roles offer few entry points for women.

1.3.3 Screening of barriers for CSSM

The long list of ten barriers presented was screened by the Agriculture Sectoral Working Group through a structured online questionnaire. Twelve members of the working group completed the assessment, rating the impact of each barrier on the adoption of CSSM on a five-tier scale derived

from the BAEF Guidebook: critical (blocking), key, important, less important and insignificant. For analysis, the ratings were converted into ordinal scores from 5 (critical) to 1 (insignificant) and averaged across respondents; the full score distributions are presented in Annex 3.

For the interpretation of the results, three screening bands were applied: barriers with a mean score of 3.5 or higher are classified as high-severity (crucial) barriers; barriers scoring between 3.0 and 3.49 as important; and barriers scoring below 3.0 as lower-priority barriers. The results are summarised in Table 1.9.

Table 1.9. Stakeholder screening of barriers for CSSM

Rank	Barrier (category)	Mean score (1–5)	Rated critical or key, %	Screening band
1	No market incentives, carbon-market access or feedstock base (market conditions)	4.00	75%	High severity (crucial)
2–3	Adaptation finance gap (economic and financial)	3.92	75%	High severity (crucial)
2–3	Subsidies actively finance soil degradation (economic and financial)	3.92	75%	High severity (crucial)
4–5	Farmer knowledge gaps and demonstration-base deficit (human capacity)	3.83	50%	High severity (crucial)
4–5	Inertia of chemicalised farming (social, cultural and behavioural)	3.83	50%	High severity (crucial)
6–7	Low awareness and absence of early warning (information and awareness)	3.75	50%	High severity (crucial)
6–7	Absence of soil monitoring and zonal variability (technical)	3.75	50%	High severity (crucial)
8	Fragmentation, absence of monitoring and payments (institutional capacity)	3.58	42%	High severity (crucial)
9	Legal and institutional vacuum (legal and regulatory)	3.50	50%	High severity (crucial)
10	Gender inequality in access to CSSM and training (gender equality)	2.25	8%	Lower priority

The working group assessed the barriers to CSSM as uniformly severe: nine of the ten barriers fall in the high-severity band, and none in the intermediate “important” band. The absence of market incentives, carbon-market access and a feedstock base is rated the most critical constraint, with a mean of 4.00 and three-quarters of respondents rating it critical or key, followed immediately by the two economic and financial barriers — the adaptation finance gap and the subsidies that finance soil degradation — both at 3.92 and likewise rated critical or key by three-quarters of the group. This pattern confirms that the binding constraints form a reinforcing economic-and-market

trap: there is no revenue pathway rewarding soil-carbon gains, finance is incompatible with the payback horizon, and the subsidy system actively rewards the degrading practice.

Knowledge gaps and the inertia of chemicalised farming (both 3.83), low awareness and the absence of soil monitoring (both 3.75), institutional fragmentation (3.58) and the legal and institutional vacuum (3.50) complete the high-severity band, underlining that the non-financial constraints are assessed as nearly as binding as the economic ones. Only gender inequality in access to CSSM and training fell below the importance threshold, with a mean of 2.25 and no critical ratings.

1.3.4 Classification of barriers for CSSM

The long list of barriers was screened to isolate the most critical constraints obstructing the adoption and diffusion of CSSM in Kazakhstan. Barriers with a mean score below 3.0 — the "important" rating on the five-tier scale (Section 1.3.3, Table 1.9) — were classified as minor obstacles and excluded from the further analysis. Only one barrier was screened out on this basis: gender inequality in access to CSSM and training (2.25); the gender dimension is nevertheless retained as a cross-cutting consideration in the design of enabling measures. The remaining nine barriers — all of which fall in the high-severity band — are listed below under two categories.

Economic and financial barriers

Economic and financial constraints lie at the core of the adoption problem: the long payback of soil-carbon restoration is misaligned with available finance, and the subsidy system actively rewards the degrading practice.

- **Adaptation Finance Gap (Score: 3.92):** The capital-intensive transition — amendments, monitoring equipment and certified seed — delivers soil-carbon benefits only over 3–5 years, a horizon incompatible with commercial lending at 20–24 per cent and beyond reserve-constrained farms without targeted support.
- **Subsidies Actively Finance Soil Degradation (3.92):** Mineral-fertiliser subsidies reward the input-intensive regime that drives soil-humus loss, creating a path-dependency that makes the transition to CSSM economically irrational without explicit policy correction.

Non-financial barriers

The non-financial barriers form an interconnected web of market, capacity, social, information, institutional, technical and legal constraints; the working group rated several of them as severe as the financing barriers, and the market barrier as the single most critical of all.

- **No Market Incentives, Carbon-Market Access or Feedstock Base (4.00):** No certification standard, price premium or carbon-market pathway connects CSSM practice to farm revenue, and supply chains for organic amendments are underdeveloped, with biochar effectively absent from the domestic market and compost concentrated in a few urban centres.
- **Farmer Knowledge Gaps and Demonstration-Base Deficit (3.83):** Farmers who do not understand soil-organic-matter dynamics cannot evaluate CSSM as a drought-resilience investment; college curricula lack modules on soil biology, organic amendments and precision monitoring, and certified soil-health advisors are scarce.
- **Inertia of Chemicalised Farming (3.83):** Conventional chemical farming produces known results while eroding the soil capital they depend on; managers trained in input-intensive norms resist a change involving 3–5 years of yield uncertainty before adaptive benefits materialise.

- **Low Awareness and Absence of Early Warning (3.75):** Farmers are unaware that their soils are degrading in ways that undermine drought resilience, and a Soil Adaptation Returns Calculator linking soil-carbon gains to yield stability, input savings and land value does not exist in an accessible form.
- **Absence of Soil Monitoring and Zonal Variability (3.75):** Without precision data on soil-carbon content, water retention, compaction and biological activity, CSSM cannot be targeted efficiently or verified for carbon markets, and the high zonal variability of northern soils is not captured.
- **Fragmentation, Absence of Monitoring and Payments (3.58):** No ministry owns soil adaptation — the Ministry of Agriculture subsidises fertilisers while the Ministry of Ecology monitors degradation — no inter-ministerial mechanism integrates soil health into adaptation, and research is not translated into farm-level extension.
- **Legal and Institutional Vacuum (3.50):** A four-fold gap — short tenure, no soil-carbon MRV, the unadopted Law on Soil Protection and the exclusion of agriculture from the KAZ ETS — leaves the practice without legal foundation or a compliance carbon pathway.

Table 1.10. Classification of barriers by BAEF category: Climate-Smart Soil Management

Barrier type	Category	Specific Barrier	Description of the Barrier	Score
Economic and financial	Economic and financial	Adaptation Finance Gap	Capital-intensive transition with a 3–5-year payback; lending at 20–24% is incompatible.	3.92
	Economic and financial	Subsidies Actively Finance Soil Degradation	Mineral-fertiliser subsidies reward the input-intensive regime that drives humus loss.	3.92
Non-financial	Market conditions	No Market Incentives, Carbon-Market Access or Feedstock Base	No certification, premium or carbon pathway rewards soil-carbon gains; biochar/compost supply is underdeveloped.	4.00
	Human skills	Farmer Knowledge Gaps and Demonstration-Base Deficit	Soil-biology, organic-amendment and precision-monitoring skills and demonstrations are scarce.	3.83
	Social and cultural	Inertia of Chemicalised Farming	Input-intensive norms resist a 3–5-year transition with upfront cost.	3.83
	Information	Low Awareness and Absence of Early Warning	Farmers are unaware of soil degradation; no Soil Adaptation Returns Calculator exists.	3.75
	Technical	Absence of Soil Monitoring and Zonal Variability	No precision data on soil carbon, water retention, compaction or biology.	3.75
	Institutional capacity	Fragmentation, Absence of Monitoring and Payments	No ministry owns soil adaptation; research is not translated into extension.	3.58
	Legal and regulatory	Legal and Institutional Vacuum	Short tenure, no soil-carbon MRV, unadopted Law on Soil Protection, KAZ ETS excludes agriculture.	3.50

1.3.5 Measures for CSSM

Enabling measures were derived by reformulating each barrier into its corresponding objective, prepared by the national consultant with the support of the TNA team and submitted to the Agriculture Sectoral Working Group in the same structured questionnaire. The working group assessed the priority of each measure on a three-tier scale — high, medium and low — converted

for analysis into scores from 3 (high) to 1 (low) and averaged across the twelve respondents; the full distributions are presented in Annex 3. The nine measures addressing the nine retained barriers are described below under two categories, with their mean priority scores.

Economic and financial measures

- **Subsidies for Soil-Health Inputs (Score: 2.83):** Reorient agricultural subsidies to support soil-health inputs — organic amendments (compost, biochar, biofertilisers), cover-crop seed and precision-application equipment — replacing or complementing the mineral-fertiliser subsidies that currently reward soil degradation, with payments conditioned on verified practice adoption. This measure received the highest priority of all (83 per cent rated it high).
- **Transition Finance Fund (2.75):** Establish a dedicated transition finance fund offering concessional, longer-tenor credit and grants matched to the 3–5-year soil-carbon payback horizon, in partnership with the Asian Infrastructure Investment Bank (AIIB) and other development finance institutions, to cover the upfront cost of amendments, equipment and certified seed for medium and small farms. Consolidate the finance instruments of all four technologies into a single Agriculture Adaptation Finance Facility/Fund for a more coordinated, efficient and financially sustainable approach (see Section 1.5).

Non-financial measures

- **Land Reform and Soil-Protection Law (2.50):** Extend minimum lease terms to make the 3–5-year payback rational, adopt the draft Law on Soil Protection with a penalty for humus loss, develop a national soil-carbon MRV methodology, and open a compliance pathway for agricultural soil carbon within or alongside the KAZ ETS and voluntary markets.
- **Training and Demonstration Network (2.50):** Build a soil-health training and demonstration network — college curriculum modules on soil biology, organic amendments and precision monitoring, certification of soil-health advisors, and demonstration farms documenting soil-carbon, yield and input-cost outcomes across the northern oblasts.
- **Certification and Carbon Aggregation (2.42):** Establish a CSSM certification standard and premium-price mechanism, and a carbon-aggregation facility pooling farm-level soil-carbon gains for the KAZ ETS and voluntary markets (Verra, Gold Standard); develop domestic supply chains for biochar and compost.
- **Soil-Management Coordination Body (2.42):** Create an inter-ministerial soil-management coordination body with a clear mandate for soil adaptation, integrating the Ministry of Agriculture and the Ministry of Ecology under a unified budget line, with a mechanism translating KazNIIZP and Barayev Institute research into farm-level extension.This soil-management body operates as a single inter-ministerial coordination body across all four technologies rather than a separate body per technology (see Section 1.5).
- **Training Programme for Sustainable Land Use (2.42):** Deliver a behavioural-change training programme promoting sustainable land use, using peer-to-peer learning and locally credible demonstration results to overcome the inertia of input-intensive norms and make the 3–5-year transition visible and trusted.
- **Soil Monitoring and Zonal Packages (2.33):** Deploy a precision soil-monitoring system (soil-carbon content, water retention, compaction, biological activity) and develop zonal CSSM packages tailored to the soil and climate variability of the northern oblasts, linked to the national monitoring programme and the soil-carbon MRV methodology.

- **Soil Adaptation Returns Calculator and Early Warning (2.17):** Develop a Soil Adaptation Returns Calculator linking soil-carbon improvement to drought-year yield stability, input-cost savings and long-term land value, integrated with an early-warning system for soil-degradation and drought risk and accessible to farm managers.

The gender-inclusion measure received the lowest priority from the working group (1.42), consistent with the screening of the corresponding barrier. It is therefore not advanced as a standalone measure; instead, its elements — alternative collateral guarantees in finance, a target of at least 30 per cent women's participation in soil-health training and demonstration activities, women-led demonstration plots, outreach through women's farmer networks, and entry points for women in soil-health advisory training — are mainstreamed as cross-cutting requirements of the measures above.

Table 1.11. Measures mapped to the barriers they address: Climate-Smart Soil Management

Barrier addressed	Corresponding measure	Priority
Subsidies Actively Finance Soil Degradation	Subsidies for Soil-Health Inputs	2.83
Adaptation Finance Gap	Transition Finance Fund	2.75
Farmer Knowledge Gaps and Demonstration-Base Deficit	Training and Demonstration Network	2.50
Legal and Institutional Vacuum	Land Reform and Soil-Protection Law	2.50
No Market Incentives, Carbon-Market Access or Feedstock Base	Certification and Carbon Aggregation	2.42
Fragmentation, Absence of Monitoring and Payments	Soil-Management Coordination Body	2.42
Inertia of Chemicalised Farming	Training Programme for Sustainable Land Use	2.42
Absence of Soil Monitoring and Zonal Variability	Soil Monitoring and Zonal Packages	2.33
Low Awareness and Absence of Early Warning	Soil Adaptation Returns Calculator and Early Warning	2.17

1.3.6 Grouping complementary measures for CSSM

The nine prioritised measures have been organised into four interactive, cross-cutting strategic packages that together form the enabling framework for CSSM. The grouping ensures that finance and incentives, the legal and market pathway for soil carbon, institutional coordination and monitoring, and capacity and outreach advance in parallel, preventing the risk of isolated measures — such as subsidising soil-health inputs with no verification system, or building a certification scheme on land that farmers do not securely hold.

- **Programme 1.) Soil-Health Finance and Incentive Framework (Economic & Financial Package):** This package pairs *Subsidies for Soil-Health Inputs (2.83)* with *Transition Finance Fund (2.75)*, the two highest-rated measures of the set. Together they correct the two reinforcing economic barriers: reorienting subsidies away from soil-degrading inputs removes the perverse incentive, while concessional, longer-tenor finance bridges the 3–5-year payback that commercial credit cannot accommodate.
- **Programme 2.) Tenure, Soil-Protection Law and Carbon-Market Framework (Regulatory & Market Package):** This package combines *Land Reform and Soil-Protection Law (2.50)* with *Certification and Carbon Aggregation (2.42)*. Secure tenure, an adopted Law on Soil Protection and a soil-carbon MRV methodology create the legal foundation on which certification, a price premium and carbon revenue can operate. The two are interdependent: without secure rights

and an accepted measurement protocol, neither the premium market nor the carbon pathway can reward soil-carbon gains.

- **Programme 3.) Institutional Coordination and Soil-Monitoring Framework (Institutional & Technical Package):** This package links *Soil-Management Coordination Body (2.42)* with *Soil Monitoring and Zonal Packages (2.33)*. It establishes the inter-ministerial authority that the split mandate currently lacks and the precision soil-monitoring backbone on which efficient targeting of CSSM and verification of soil-carbon outcomes depend. This programme is foundational: the certification and carbon mechanisms of Programme 2 cannot be verified without it.
- **Programme 4.) Capacity, Evidence and Outreach Framework (Capacity, Social & Information Package):** This package integrates *Training and Demonstration Network (2.50)*, *Training Programme for Sustainable Land Use (2.42)* and *Soil Adaptation Returns Calculator and Early Warning (2.17)*. It builds the soil-health skills and advisory base required for delivery, uses peer-led demonstration to overcome the inertia of input-intensive norms, and disseminates the economic case through the calculator and early-warning system. Gender-inclusion requirements run across the package as cross-cutting conditions.

1.3.7 Assessment of measures for inclusion in the TAP

The four programmes formed in Section 1.3.6 have been assessed to determine their viability for inclusion in the Technology Action Plan (TAP) against the four criteria of the BAEF template — impact, societal benefits, cost and feasibility — and are described below (Table 1.12).

Programme 1: Soil-Health Finance and Incentive Framework

- **Impact:** Corrects the two reinforcing economic barriers rated 3.92 — the adaptation finance gap and the subsidies that finance soil degradation — by reorienting subsidies towards soil-health inputs and bridging the 3–5-year payback with concessional finance, the single most direct lever for moving the 2-million-hectare target from aspiration to adoption.
- **Societal benefits:** Redirects public expenditure from a soil-degrading regime towards drought resilience, stabilises yields and rural incomes, and over time reduces the fiscal and food-security cost of declining soil productivity.
- **Cost:** High fiscal commitment, but substantially a reallocation of the existing mineral-fertiliser subsidy envelope rather than wholly new expenditure, with the transition fund leveraging development-finance partnership.
- **Feasibility:** Moderate to high. The measures received the two highest priority scores (2.83 and 2.75), and subsidy reorientation uses existing budget channels, though it requires political commitment to redirect support away from established fertiliser subsidies.

Programme 2: Tenure, Soil-Protection Law and Carbon-Market Framework

- **Impact:** Addresses the most critical barrier of the screening — the absence of market incentives and a carbon pathway (4.00) — together with the legal and institutional vacuum (3.50), by securing tenure, adopting the Law on Soil Protection, building a soil-carbon MRV methodology and opening certification and carbon revenue for verified soil-carbon gains.
- **Societal benefits:** Establishes soil protection in law, creates a premium and carbon income stream for farmers, and aligns agricultural soil carbon with the 2025 amendments to the Environmental Code on Article 6 and the domestic voluntary carbon market.

- **Cost:** Low to moderate, predominantly legislative and methodological — Land Code amendment, adoption of the Law on Soil Protection and MRV development — with certification and aggregation set up on existing market and registry structures.
- **Feasibility:** Moderate. The legislative process, the adoption of a stalled draft law and the inclusion of agriculture in carbon mechanisms require sustained cross-ministerial commitment, and the measures depend on the monitoring backbone delivered by Programme 3.

Programme 3: Institutional Coordination and Soil-Monitoring Framework

- **Impact:** Resolves institutional fragmentation (3.58) and the absence of soil monitoring (3.75) by creating the inter-ministerial authority the system lacks and the precision-monitoring backbone on which efficient targeting of CSSM and verification of soil-carbon — and therefore the carbon mechanisms of Programme 2 — depend.
- **Societal benefits:** Provides the public-good soil-information base — soil-carbon, moisture, compaction and zonal data — that supports evidence-based public investment and transparent reporting under the NDC.
- **Cost:** Low to moderate: the establishment of a coordination body and the deployment of a soil-monitoring system building on existing research capacity (KazNIIZP, the Barayev Institute) rather than new institutions.
- **Feasibility:** Moderate to high. The scientific capacity already exists and needs integration and a mandate rather than creation, the principal requirement being the inter-ministerial coordination authority.

Programme 4: Capacity, Evidence and Outreach Framework

- **Impact:** Addresses farmer knowledge gaps (3.83), the inertia of chemicalised farming (3.83) and low awareness (3.75) by building soil-health skills and the advisory base, using peer-led demonstration to shift entrenched norms, and disseminating the economic case through the calculator and early-warning system.
- **Societal benefits:** Builds rural human capital and a corps of certified soil-health advisors, mainstreams gender-inclusion requirements, and improves the information available to farms of all sizes through demonstration and the returns calculator.
- **Cost:** Low to moderate — curriculum modules, advisor certification, demonstration farms and calculator software — delivered largely through existing agricultural-education and research institutions.
- **Feasibility:** High. The programme builds on existing colleges, research institutes and extension structures and requires no legislative change, although building a corps of certified advisors and a demonstration network matures over several seasons.

Table 1.12. Summary Assessment Matrix for TAP Inclusion: Climate-Smart Soil Management

Programme Title	Strategic Focus	Estimated Cost (indicative, 10 yr)	Implementation Feasibility	Recommended TAP Action
Programme 1: Soil-	Subsidy reorientation	High — ~USD 200–300M (concessional element ~40%): soil-health input subsidies and	Moderate–high (top-scored	Include as Core

Programme Title	Strategic Focus	Estimated Cost (indicative, 10 yr)	Implementation Feasibility	Recommended TAP Action
Health Finance and Incentives	and transition finance	the transition finance fund; substantially a reallocation of the existing mineral-fertiliser subsidy envelope rather than new expenditure, with the fund leveraging EBRD/IFC development-finance partnership	measures, 2.83 and 2.75; political commitment needed)	Financial Action
Programme 2: Tenure, Soil-Protection Law and Carbon Market	Legal foundation and market/carbon reward	Low–moderate — ~USD 30–60M: Land Code amendment and adoption of the Law on Soil Protection are legislative; the budget sits in the CSSM certification system and the soil-carbon aggregation platform (~USD 20–40M), built on existing market and registry structures	Moderate (legislative reform; depends on Programme 3)	Include as Core Regulatory Action
Programme 3: Institutional Coordination and Soil Monitoring	Coordination and the measurement backbone	Moderate — ~USD 60–90M: soil-sensor networks and satellite-data integration are the dominant item; coordination-body operations and zonal practice packages add administrative cost; builds on KazNIIZP and Barayev Institute capacity rather than new institutions	Moderate–high (capacity exists; needs inter-ministerial mandate)	Include as Enabling Institutional Action
Programme 4: Capacity, Evidence and Outreach	Skills, behaviour change and evidence	Moderate — ~USD 100–150M: extension and demonstration network (300+ farms) is the dominant item; advisor certification, curricula, the soil adaptation calculator, early-warning system and the gender programme; delivered through existing education and research institutions	High (no legislative change; matures over several seasons)	Include as Support Action

1.4 Technology 4: Drip Irrigation

1.4.1 General description and target for Drip Irrigation

Drip irrigation delivers water and nutrients directly to the crop root zone through a network of pipes and emitters, achieving an application efficiency of 85–95 per cent compared with 40–50 per cent for the furrow irrigation that dominates Kazakhstan's southern oblasts. As an adaptation technology it reduces the exposure of irrigated agriculture to an increasingly uncertain water supply — approximately 80 per cent of the country's irrigation water originates in transboundary rivers (the Syrdarya, Ile and Ural) — and protects high-value horticulture against the summer shortages that climate change is intensifying, while enabling precise fertigation and reducing field-level water losses.

The area under drip irrigation currently stands at approximately 250,000 hectares. The Water Resources Management Concept 2024–2030 sets a national target of 600,000 hectares under drip irrigation by 2030, and the 50 per cent capital-cost reimbursement under Order No. 385 of the Ministry of Agriculture is the principal support instrument for adoption. The critical diffusion frontier comprises the roughly 2,500 medium and more than 45,000 small farms of the southern irrigated oblasts — Turkestan, Almaty, Zhambyl and Kyzylorda — which hold the bulk of the deployment potential but face the steepest financing and capacity constraints.

Preliminary deployment target: *Expand the area under drip irrigation from approximately 250,000 hectares to 1,3 million hectares by 2030, in line with the Water Resources Management Concept 2024–2030, concentrated in the high-value irrigated zones of Turkestan, Almaty, Zhambyl and Kyzylorda oblasts.*

The target adopts the figure already set in the national concept and is therefore realistic in policy terms, but it is achievable only if the water-security, finance and subsidy-administration measures set out below are in place.

Technology constraints: the economics of drip irrigation are confined to high-value crops (vegetables, fruit, cotton, vineyards), while rain-fed wheat — the dominant national crop — is unsuited to the technology; the 5–6-month open-field irrigation season limits capital utilisation and stretches payback to 4–7 years; mandatory filtration under Kazakhstan's mineralised and sediment-laden water adds 15–25 per cent to capital cost; all equipment is currently imported; and upstream canal losses of 30–40 per cent together with the absence of meltwater storage limit the field-level return on any farm investment.

1.4.2 Identification of barriers for Drip Irrigation

Following the BAEF Guidebook (UDP, 2015), drip irrigation equipment was categorised as a capital good with significant publicly-provided-good preconditions: the equipment itself diffuses through commercial supply chains, but its field-level return depends on canal infrastructure, transboundary water security and water allocation that no individual farm can provide. Barriers were diagnosed through problem-tree analysis and market mapping (Figures A1.11 and A1.10, Annex 1). The diagrams were prepared by the national consultant with the support of the TNA team, and the long list of barriers was developed on the basis of this analysis; the mirrored objective tree (Figure A1.12) is taken up with the measures in Section 1.4.6.

The problem tree identifies the starter problem as the failure to scale drip irrigation despite Kazakhstan's well-documented water deficit and the technology's proven water-use superiority, and demonstrates that the central bottleneck is not farm-level demand but a set of publicly-provided preconditions. Technical and infrastructure barriers come first: Soviet-era canals designed for furrow irrigation lose 30–40 per cent of water in transit, and small and medium reservoirs for storing spring meltwater are absent. External and regulatory barriers follow from the transboundary dependence of about 80 per cent of irrigation water without long-term volumetric guarantees, and from the absence of national water-quality standards for drip systems. Market and supply-chain barriers arise from complete import dependence, the absence of domestic manufacturing, a thin service network and unmanaged plastic waste. Economic and financial barriers comprise capital costs beyond the reach of small and medium farms, commercial lending incompatible with the 4–7-year payback, subsidy payment delays of up to 18 months and the confinement of drip economics to high-value crops. Institutional barriers stem from fragmented water governance and an area-based tariff without water meters that eliminates the price signal for saving; capacity and social barriers complete the picture through weak extension, an entrenched furrow-irrigation culture and gender exclusion. The effect chains show the consequences: continuing water losses, acute summer shortages, rising vulnerability of southern agriculture and foregone water savings. The barriers are detailed in Section 1.4.2 and screened in Section 1.4.3.

Based on the analysis presented in Section 1.4.2, the barriers were developed into a long list prepared by the national consultant with the support of the TNA team. The long list comprises nine aggregated barriers; each barrier carries a short description of its adaptation context and is mirrored one-to-one by a corresponding enabling measure (Section 1.4.5). In this form the list was

submitted to the Agriculture Sectoral Working Group for assessment, the results of which are presented in Section 1.4.3. Following the structure of the BAEF template, the barriers divide into economic and financial barriers and non-financial barriers.

Economic and financial barriers

- **Mismatch between drip economics, cropping structure and misaligned subsidies.** Drip irrigation is economically viable only on high-value crops (vegetables, fruit, cotton, vineyards), whereas wheat — the dominant crop — is grown rain-fed in the north and is unsuited to the technology; cotton subsidies have historically been calibrated for furrow irrigation, and the short 5–6-month season reduces capital utilisation and stretches payback to 4–7 years.
- **High capital costs and expensive cost of capital.** Capital expenditure of KZT 2.5–4 million per hectare (approximately USD 5,000–8,000) is beyond the reach of small and medium farms, and the National Bank base rate of 18 per cent makes commercial loans at 20–24 per cent incompatible with the 4–7-year payback; without concessional finance the net present value of the investment is negative for most farms, with the more than 45,000 small farms — the most climate-vulnerable segment — particularly affected.
- **Subsidy payment delays of up to 18 months and non-coverage of filtration and fertigation.** The 50 per cent reimbursement under Order No. 385 of the Ministry of Agriculture is the main adoption driver, but payment delays of up to 18 months create acute cash-flow stress — farms must first pay suppliers in full — and filtration and fertigation, mandatory under Kazakhstan's mineralised-water conditions and adding 15–25 per cent to capital cost, are not always eligible for reimbursement, leading to systems installed without filtration that fail prematurely.

Non-financial barriers

- **Technical and infrastructure — degradation of KazVodKhoz canals and absence of spring meltwater storage.** Soviet-era main and distribution canals were designed for furrow irrigation and lose 30–40 per cent of water in transit, while small and medium reservoirs for accumulating spring meltwater are absent — producing spring floods and acute summer shortages in the same regions. Without canal modernisation and reservoir construction, farm-level investment in drip irrigation loses meaning, since the water either does not reach the field or is unavailable in peak season.
- **External and regulatory — transboundary dependence and poor irrigation water quality.** Approximately 80 per cent of irrigation water comes from transboundary rivers — the Syrdarya (Uzbekistan, Kyrgyzstan), the Ile (China) and the Ural (Russia) — with no long-term volumetric guarantees, while high mineralisation and suspended solids, especially in the Syrdarya, cause rapid emitter clogging without mandatory filtration; national water-quality standards for drip irrigation have not been adopted.
- **Market conditions and supply chain — complete import dependence, no domestic manufacturing, weak service network and plastic waste.** All drip equipment (tape, emitters, fittings, filters) is imported — from Netafim, Rivulis, Jain, Toro, Eurodrip and partly Dayu — so the 600,000-hectare programme would finance imports rather than domestic value added; certified service teams and spare-parts depots are concentrated in Almaty and Shymkent, leaving remote districts with repair times of weeks; and drip tape lasting one to five years has no collection or recycling infrastructure.
- **Human capacity — weak agricultural extension on drip-compatible models and water saving.** Kazakhstan lacks a specialised extension service for drip irrigation, high-value crop

diversification and water saving; the existing capacity — the Netafim Academy, Farmer Field Schools and the demonstration plots of KazNIIVKh and KazNIIZiR — is fragmented and concentrated in pilot regions, leaving small and medium farms without agronomic and project support.

- **Institutional and regulatory — fragmented water governance and an area-based tariff without water meters.** Mandates are split across the Water Resources Committee (policy), KazVodKhoz (canal operation) and oblast akimats (local distribution), with basin councils lacking operational authority; water is charged by area rather than volume, eliminating the price signal for saving, and more than 80 per cent of farms have no water meters, making volumetric tariffs and water-use enforcement operationally impossible.
- **Social, cultural and behavioural — cross-cutting barriers: furrow-irrigation culture and gender exclusion.** Soviet-era irrigation norms favouring abundant furrow watering remain entrenched in the southern oblasts, and farm managers are sceptical of drip irrigation; in parallel, collateral requirements under Order No. 385 disproportionately limit women landholders, and Farmer Field Schools and the Netafim Academy are attended predominantly by men.

1.4.3 Screening of barriers for Drip Irrigation

The long list of nine barriers presented in Section 1.4.3 was screened by the Agriculture Sectoral Working Group through a structured online questionnaire. Eight of the twelve members of the working group completed the assessment for this technology, rating the impact of each barrier on the deployment of drip irrigation on a five-tier scale derived from the BAEF Guidebook: critical (blocking), key, important, less important and insignificant. For analysis, the ratings were converted into ordinal scores from 5 (critical) to 1 (insignificant) and averaged across respondents; the full score distributions are presented in Annex 3.

For the interpretation of the results, three screening bands were applied: barriers with a mean score of 3.5 or higher are classified as high-severity (crucial) barriers; barriers scoring between 3.0 and 3.49 as important; and barriers scoring below 3.0 as lower-priority barriers. The results are summarised in Table 1.13.

Table 1.13. Stakeholder screening of barriers for Drip Irrigation

Rank	Barrier (category)	Mean score (1–5)	Rated critical or key, %	Screening band
1	Degradation of KazVodKhoz canals and absence of spring meltwater storage (technical and infrastructure)	4.75	100%	High severity (crucial)
2	Transboundary dependence and poor irrigation water quality (external and regulatory)	4.62	100%	High severity (crucial)
3	High capital costs and expensive cost of capital (economic and financial)	4.50	88%	High severity (crucial)
4–5	Complete import dependence, no domestic manufacturing, weak service network and plastic waste (market conditions and supply chain)	4.38	88%	High severity (crucial)
4–5	Subsidy payment delays of up to 18 months and non-coverage of filtration and fertigation (economic and financial)	4.38	75%	High severity (crucial)

Rank	Barrier (category)	Mean score (1–5)	Rated critical or key, %	Screening band
6	Mismatch between drip economics, cropping structure and misaligned subsidies (economic and financial)	4.12	88%	High severity (crucial)
7–8	Weak agricultural extension on drip-compatible models and water saving (human capacity)	3.88	50%	High severity (crucial)
7–8	Fragmented water governance and an area-based tariff without water meters (institutional and regulatory)	3.88	62%	High severity (crucial)
9	Cross-cutting barriers: furrow-irrigation culture and gender exclusion (social, cultural and behavioural)	3.12	50%	Important

The working group assessed the barriers to drip irrigation as the most severe of the four prioritised technologies: eight of the nine barriers fall in the high-severity band and every respondent rated the two water-security barriers as critical or key. The degradation of the canal network and the absence of meltwater storage received a mean of 4.75 — six of the eight respondents rated it critical (blocking) — followed by transboundary dependence and water quality at 4.62. This pattern confirms the central finding of the problem-tree analysis: the working group treats canal infrastructure and water security as preconditions without which farm-level investment in drip systems loses meaning.

The second tier of high-severity barriers is financial and market-related: high capital costs (4.50), import dependence and the weak service network (4.38), subsidy payment delays (4.38) and the confinement of drip economics to high-value crops (4.12). Weak extension and fragmented water governance (both 3.88) complete the high-severity band. The cross-cutting cultural and gender barrier (3.12) is the only one in the important band, and no barrier scored below the 3.0 threshold.

1.4.4 Classification of barriers for Drip Irrigation

The long list of barriers was screened to isolate the most critical constraints obstructing the deployment of drip irrigation in Kazakhstan, applying the threshold used throughout this chapter: barriers with a mean score below 3.0 (Section 1.4.3, Table 1.13) are classified as minor obstacles and excluded from the further analysis. For drip irrigation, no barrier fell below the threshold: all nine barriers are retained — eight in the high-severity band and one, the cross-cutting cultural and gender barrier, as important. They are listed below under two categories.

Economic and financial barriers

The financial constraints operate on top of the infrastructure preconditions: even where water is secure, the capital cost, the cost of credit and the administration of the subsidy mechanism keep the technology beyond the reach of the small and medium farms that hold most of the deployment potential.

- **High Capital Costs and Expensive Cost of Capital (Score: 4.50):** Capital expenditure of KZT 2.5–4 million per hectare is beyond small and medium farms, and commercial credit at 20–24 per cent is incompatible with the 4–7-year payback, leaving the net present value negative for most farms without concessional finance.

- **Subsidy Payment Delays and Non-Coverage of Filtration and Fertigation (4.38):** Reimbursement delays of up to 18 months under Order No. 385 create acute cash-flow stress, and the exclusion of filtration and fertigation — mandatory under mineralised-water conditions — leads to systems installed without filtration that fail prematurely.
- **Mismatch Between Drip Economics, Cropping Structure and Misaligned Subsidies (4.12):** Viability is confined to high-value crops while subsidies have historically been calibrated for furrow irrigation, and the short open-field season stretches payback to 4–7 years.

Non-financial barriers

The non-financial barriers are dominated by the publicly-provided-good preconditions — water infrastructure, transboundary security, supply chains and governance — that no individual farm can resolve and that the working group rated as the most critical constraints of all.

- **Degradation of KazVodKhoz Canals and Absence of Spring Meltwater Storage (4.75):** In-transit losses of 30–40 per cent and the absence of meltwater reservoirs turn spring floods and summer shortages into two faces of the same failure; without canal modernisation and storage, farm-level drip investment loses meaning.
- **Transboundary Dependence and Poor Irrigation Water Quality (4.62):** About 80 per cent of irrigation water arrives through transboundary rivers without long-term volumetric guarantees, and high mineralisation and sediment cause rapid emitter clogging in the absence of adopted water-quality standards and mandatory filtration.
- **Complete Import Dependence, No Domestic Manufacturing, Weak Service Network and Plastic Waste (4.38):** All equipment is imported, certified service is concentrated in Almaty and Shymkent, and used drip tape has no collection or recycling infrastructure — so the national programme would finance imports while fields wait weeks for repairs.
- **Weak Agricultural Extension on Drip-Compatible Models and Water Saving (3.88):** Specialised extension for drip irrigation, crop diversification and water saving does not exist at scale; existing capacity is fragmented and concentrated in pilot regions.
- **Fragmented Water Governance and an Area-Based Tariff Without Water Meters (3.88):** Split mandates, basin councils without authority and an area-based water charge — with more than 80 per cent of farms unmetered — eliminate both the institutional capacity and the price signal for water saving.
- **Cross-Cutting Barriers: Furrow-Irrigation Culture and Gender Exclusion (3.12):** Entrenched Soviet-era furrow norms sustain scepticism towards drip systems, while collateral requirements and male-dominated training channels limit the participation of women landholders.

Table 1.14. Classification of barriers by BAEF category: Drip Irrigation

Barrier type	Category	Specific Barrier	Description of the Barrier	Score
Economic and financial	Economic and financial	High Capital Costs and Expensive Cost of Capital	CAPEX KZT 2.5–4 mln/ha; credit at 20–24% incompatible with the 4–7-year payback.	4.50
	Economic and financial	Subsidy Payment Delays and Non-Coverage of Filtration and Fertigation	Reimbursement delays up to 18 months; filtration/fertigation often ineligible.	4.38
	Economic and financial	Mismatch Between Drip Economics, Cropping	Viability confined to high-value crops; subsidies calibrated for furrow irrigation.	4.12

Barrier type	Category	Specific Barrier	Description of the Barrier	Score
		Structure and Misaligned Subsidies		
Non-financial	Technical and infrastructure	Degradation of KazVodKhoz Canals and Absence of Spring Meltwater Storage	In-transit losses of 30–40% and no meltwater storage; spring floods and summer shortages.	4.75
	External and regulatory	Transboundary Dependence and Poor Irrigation Water Quality	~80% of water from transboundary rivers; high mineralisation clogs emitters; no quality standards.	4.62
	Market conditions	Complete Import Dependence, Weak Service Network and Plastic Waste	All equipment imported; service concentrated in two cities; no tape recycling.	4.38
	Human skills	Weak Agricultural Extension on Drip-Compatible Models and Water Saving	No specialised extension at scale; capacity fragmented and pilot-confined.	3.88
	Institutional and regulatory	Fragmented Water Governance and an Area-Based Tariff Without Water Meters	Split mandates; area-based charge and >80% unmetered farms remove the saving signal.	3.88
	Social and cultural	Cross-Cutting: Furrow-Irrigation Culture and Gender Exclusion	Entrenched furrow norms; collateral and male-dominated training limit women.	3.12

1.4.5 Measures for Drip Irrigation

For each barrier of the long list, a corresponding enabling measure was developed by the national consultant with the support of the TNA team, mirroring the barriers one-to-one, and submitted to the Agriculture Sectoral Working Group in the same structured questionnaire. The eight respondents assessed the priority of each measure on a three-tier scale — high, medium and low — converted for analysis into scores from 3 (high) to 1 (low) and averaged; the full distributions are presented in Annex 3. The nine measures are described below under two categories, with their mean priority scores.

Economic and financial measures

- **Blended Finance and Long-Term Leasing (Score: 2.75):** Mobilise blended finance through the Asian Infrastructure Investment Bank (AIIB), the Green Climate Fund, the EBRD, the ADB, the IsDB and the World Bank to provide concessional loans at 6–8 per cent aligned with drip economics, and extend KazAgroFinance leasing to 4–7 years with terms matched to system payback, prioritising medium farms and small-farm cooperatives in the southern oblasts.
- **Digital Subsidy-Payment Platform and Extension of Subsidies to Filtration and Fertigation (2.62):** Reduce subsidy disbursement under Order No. 385 to under three months through a digital platform integrated with e-Qazagro and KazAgroFinance, with automatic triggers on GPS-verified installation and a pre-financing window for accredited installers, and expand the eligible-component list to include filtration and fertigation as mandatory items.
- **Targeted Rollout in High-Value Zones, Cotton-Subsidy Reform and Greenhouse Clusters (2.38):** Concentrate deployment in the high-value zones of Turkestan, Almaty, Zhambyl and Kyzylorda where the technology is economically justified, reorient cotton subsidies from furrow to drip, and develop drip-irrigated vegetables, orchards, vineyards, and

other high-value irrigated crops. In parallel, promote the development of drip-irrigated greenhouse clusters and protected cultivation systems to extend production beyond the 5–6-month open-field growing season, improve capital utilization, increase water productivity, and enhance the climate resilience and competitiveness of irrigated agriculture. Non-financial measures

- **Bilateral Water Agreements and National Water-Quality and Filtration Standards (3.00):** Conclude long-term bilateral agreements with volumetric guarantees on the Syrdarya, Ile and Ural (with Uzbekistan and Kyrgyzstan, China and Russia, respectively), removing the investment risk of transboundary dependence, and adopt national water-quality standards for drip irrigation with mandatory testing as a condition of subsidy payment and mandatory filtration for saline and sediment-laden sources. The working group rated this measure high unanimously.
- **Rehabilitation of KazVodKhoz Canals and Construction of Small and Medium Meltwater Reservoirs (2.88):** Implement a national canal-modernisation programme targeting transit losses below 10 per cent by 2030 and, in parallel, construct small and medium reservoirs to accumulate spring meltwater — converting spring flood risk into summer irrigation supply and providing the baseline water security for drip investment.
- **Supply-Chain Localisation, Regional Service Hubs and a Tape-Collection Scheme (2.75):** Establish joint ventures and local assembly with leading manufacturers (Netafim, Rivulis, Jain, with Chinese partnerships) and at least one domestic tape line and one filtration line under EAEU localisation incentives; create regional service hubs with certified teams and parts depots in every irrigated oblast, with a peak-season response time within 72 hours; and introduce an extended-producer-responsibility scheme for the collection and recycling of used drip tape.
- **Integrated Water Governance, Volumetric Tariff and Universal Water Meters (2.62):** Separate the mandates of the Water Resources Committee (policy, tariffs, allocation) and KazVodKhoz (operation and modernisation), reform the Aral–Syrdarya and Balkhash–Alakol basin councils with the transfer of operational authority, and introduce a volumetric water tariff coupled with a national programme of universal water-meter installation, subsidised for small farms.
- **Peer-to-Peer Drip-Culture Campaigns and Explicit Gender Targets (2.50):** Run multi-year, evidence-based peer-to-peer campaigns engaging managers of large agro-holdings as change agents, with pilot demonstration sites in Turkestan, Almaty, Zhambyl and Kyzylorda as references; and apply explicit gender requirements across all drip programmes — a minimum 30 per cent share of women in Farmer Field Schools, the Netafim Academy and extension workshops, alternative guarantees in lieu of collateral for women landholders under Order No. 385, women-led demonstration farms and gender-disaggregated reporting.
- **National Extension Network for Drip Models, Water Saving and Crop Diversification (2.38):** Build a national drip and water-saving extension network combining KazNIIVKh, KazNIIZiR, KazNAU, IWMI Central Asia, ICARDA and oblast advisory hubs, with dedicated drip demonstration plots of 50–200 hectares in every irrigated oblast and crop-diversification programmes (vegetables, vineyards, berries, pomegranate) with agronomic packages optimised for drip systems.

Table 1.15. Measures mapped to the barriers they address: Drip Irrigation

Barrier addressed	Corresponding measure	Priority
Degradation of KazVodKhoz Canals and Absence of Spring Meltwater Storage	Rehabilitation of Canals and Construction of Meltwater Reservoirs	2.88
Transboundary Dependence and Poor Irrigation Water Quality	Bilateral Water Agreements and National Water-Quality/Filtration Standards	3.00
High Capital Costs and Expensive Cost of Capital	Blended Finance and Long-Term Leasing	2.75
Complete Import Dependence, Weak Service Network and Plastic Waste	Supply-Chain Localisation, Service Hubs and Tape-Collection Scheme	2.75
Subsidy Payment Delays and Non-Coverage of Filtration and Fertigation	Digital Subsidy-Payment Platform and Filtration/Fertigation Coverage	2.62
Mismatch Between Drip Economics, Cropping Structure and Misaligned Subsidies	Targeted Rollout, Cotton-Subsidy Reform and Greenhouse Clusters	2.38
Weak Agricultural Extension on Drip-Compatible Models and Water Saving	National Extension Network and Crop Diversification	2.38
Fragmented Water Governance and an Area-Based Tariff Without Water Meters	Integrated Water Governance, Volumetric Tariff and Universal Meters	2.62
Cross-Cutting: Furrow-Irrigation Culture and Gender Exclusion	Peer-to-Peer Campaigns and Explicit Gender Targets	2.50

1.4.6 Grouping complementary measures for Drip Irrigation

The nine prioritised measures have been organised into four interactive, cross-cutting strategic packages that together form the enabling framework for drip irrigation. The grouping follows the logic of the problem tree: water security and infrastructure are preconditions, finance and subsidy administration unlock farm-level investment, supply chains and governance make adoption sustainable, and extension and culture carry it to scale — preventing the central risk identified by the working group, namely financing farm-level systems for which the water either does not arrive or cannot be saved at a price signal.

- **Programme 1.) Water Security and Infrastructure Framework (Infrastructure & External Package):** This package pairs *Rehabilitation of KazVodKhoz Canals and Meltwater Reservoirs (2.88)* with *Bilateral Water Agreements and Water-Quality Standards (3.00)*, the two highest-rated measures, mirroring the two highest-rated barriers. Together they secure the physical delivery, the volumetric guarantees and the water quality on which every other measure depends; the unanimous high rating of the agreements-and-standards measure underlines the precondition status the working group assigns to water security.
- **Programme 2.) Drip Finance and Subsidy Reform Framework (Economic & Financial Package):** This package combines *Blended Finance and Long-Term Leasing (2.75)*, *Digital Subsidy-Payment Platform with Filtration Coverage (2.62)* and *Targeted Rollout, Cotton-Subsidy Reform and Greenhouse Clusters (2.38)*. Concessional capital at 6–8 per cent and 4–7-year leasing match the payback horizon, the digital platform removes the 18-month reimbursement bottleneck and extends coverage to filtration, and targeted deployment concentrates support where the economics are proven — jointly converting the subsidy programme from a cash-flow risk into a reliable adoption driver.
- **Programme 3.) Supply Chain and Water Governance Framework (Market & Institutional Package):** This package links *Supply-Chain Localisation, Service Hubs and Tape Collection (2.75)* with *Integrated Water Governance, Volumetric Tariff and Universal Meters (2.62)*. The volumetric tariff and metering create the demand signal for water saving, while localisation and regional service capacity supply and sustain the equipment that responds to it; the extended-

producer-responsibility scheme closes the material loop. Together they make adoption durable beyond the subsidy push.

- **Programme 4.) Extension, Culture and Inclusion Framework (Capacity & Social Package):** This package integrates *National Extension Network and Crop Diversification (2.38)* with *Peer-to-Peer Campaigns and Gender Targets (2.50)*. The extension network supplies the agronomic and project support that small and medium farms lack, while peer-led campaigns and explicit gender requirements shift the furrow-irrigation culture and open participation to women landholders — the cross-cutting conditions for the other three packages to reach the 45,000-plus small farms of the southern oblasts.

1.4.7 Assessment of measures for inclusion in the TAP

The four programmes formed in Section 1.4.6 have been assessed to determine their viability for inclusion in the Technology Action Plan (TAP) against the four criteria of the BAEF template — impact, societal benefits, cost and feasibility — and are described below (Table 1.16).

Programme 1: Water Security and Infrastructure Framework

- **Impact:** Removes the two most critical barriers of the entire agriculture screening — canal degradation with absent meltwater storage (4.75) and transboundary dependence with poor water quality (4.62) — and is the precondition on which the field-level return of every drip investment, and therefore the 600,000-hectare national target, depends.
- **Societal benefits:** Converts spring flood risk into summer irrigation supply, reduces in-transit water losses across all irrigation methods, strengthens the water security of the southern oblasts and lowers the exposure of national food production to upstream decisions of neighbouring states.
- **Cost:** Very high — a national infrastructure programme of canal rehabilitation and reservoir construction — requiring state-budget commitment supported by international financial institutions; the bilateral agreements and quality standards themselves are low-cost diplomatic and regulatory instruments.
- **Feasibility:** Moderate. The engineering capacity and the institutional owner (KazVodKhoz) exist, and the measures received the two highest priority scores (3.00 and 2.88), but the scale of investment and the dependence of volumetric guarantees on negotiations with four neighbouring states make this the longest-horizon programme.

Programme 2: Drip Finance and Subsidy Reform Framework

- **Impact:** Addresses the three economic and financial barriers (4.50, 4.38 and 4.12) by aligning the cost and tenor of capital with the 4–7-year payback, removing the 18-month reimbursement bottleneck, extending coverage to mandatory filtration and concentrating support where drip economics are proven — the direct lever for adoption on the medium and small farms of the diffusion frontier.
- **Societal benefits:** Opens the technology to the more than 45,000 small farms that are the most climate-vulnerable segment, stabilises horticultural incomes, reduces premature system failures and improves the transparency and speed of public support through the digital platform.
- **Cost:** Moderate for the state — the concessional element is carried largely by blended finance from the GCF, EBRD, ADB, IsDB and the World Bank, while the digital platform and the reform of existing subsidy lines are administrative rather than new expenditure.

- **Feasibility:** High. The measures build on the existing Order No. 385 mechanism, KazAgroFinance leasing and e-Qazagro infrastructure, and international climate-finance interest in water-saving agriculture is well established.

Programme 3: Supply Chain and Water Governance Framework

- **Impact:** Resolves the import-dependence and service barrier (4.38) and the governance and tariff barrier (3.88), retaining value added domestically, cutting repair times in remote districts and — through the volumetric tariff and universal metering — creating the permanent price signal for water saving that the current area-based charge eliminates.
- **Societal benefits:** Creates manufacturing and service employment in the irrigated oblasts, manages the plastic-waste stream of drip tape through producer responsibility, and establishes transparent, accountable water allocation through empowered basin councils.
- **Cost:** Moderate — localisation rests primarily on private and joint-venture investment under EAEU incentives, while the public cost is concentrated in the metering programme, subsidised for small farms, and in institutional reform.
- **Feasibility:** Moderate. Joint-venture interest from established manufacturers and EAEU localisation incentives support the market component, but the volumetric tariff and the redistribution of mandates between the Water Resources Committee, KazVodKhoz and the basin councils require sustained political commitment.

Programme 4: Extension, Culture and Inclusion Framework

- **Impact:** Addresses weak extension (3.88) and the cross-cutting cultural and gender barrier (3.12), supplying the agronomic and project support without which financed systems underperform, shifting entrenched furrow norms through credible peers, and opening participation to women landholders.
- **Societal benefits:** Builds rural advisory capacity on water saving and high-value cropping, raises the share of women in training and finance through explicit 30 per cent targets and alternative guarantees, and spreads verified field evidence through demonstration plots in every irrigated oblast.
- **Cost:** Low to moderate — the network combines existing institutions (KazNIIVKh, KazNIIZiR, KazNAU, IWMI, ICARDA) with oblast advisory hubs and demonstration plots, and the campaigns are communication rather than capital expenditure.
- **Feasibility:** High. The institutional partners already operate in the southern oblasts, the demonstration-plot model is proven, and no legislative change is required.

Table 1.16. Summary Assessment Matrix for TAP Inclusion: Drip Irrigation

Programme Title	Strategic Focus	Estimated Cost (indicative, 10 yr)	Implementation Feasibility	Recommended TAP Action
Programme 1: Water Security and Infrastructure	Canal rehabilitation, storage, transboundary guarantees,	Very high — ~USD 1.5–2.5B: canal rehabilitation and meltwater reservoirs, state-budget commitment with EBRD, World Bank and ADB co-financing; the bilateral agreements and water-quality	Moderate (capacity and owner exist; top-priority measures, 3.00 and 2.88; scale and	Include as Core Infrastructure Action

	quality standards	standards themselves are low-cost diplomatic and regulatory instruments	diplomacy define the horizon)	
Programme 2: Drip Finance and Subsidy Reform	Concessional capital, fast digital subsidies, targeted rollout	High — ~USD 0.85–1.3B mobilised: concessional element carried largely by GCF/EBRD/ADB/IsDB/World Bank blended finance at 6–8% with 4–7-yr leasing; the digital subsidy platform and Order No. 385 reform are administrative, so the net state share is moderate	High (builds on Order No. 385, KazAgroFinance and e-Qazagro)	Include as Core Financial Action
Programme 3: Supply Chain and Water Governance	Localisation, service hubs, volumetric tariff, metering	Moderate — ~USD 150–350M: localisation rests primarily on private and joint-venture capital under EAEU incentives; public cost concentrated in small-farm metering subsidies and institutional reform; the volumetric tariff is revenue-neutral or positive for water utilities	Moderate (JV interest exists; tariff and mandate reform need political commitment)	Include as Enabling Market and Governance Action
Programme 4: Extension, Culture and Inclusion	Extension network, peer campaigns, gender targets	Low–moderate — ~USD 10–30M: extension network combines existing institutions (KazNIIVKh, KazNIIZiR, KazNAU, IWMI, ICARDA) with oblast advisory hubs and demonstration plots; campaigns are communication, not capital expenditure	High (partners operate in the south; no legislative change)	Include as Support Action

1.5 Common barriers and measures in the Agriculture (water focus) sector

1.5.1 Identification of common barriers in the Agriculture (water focus) sector

The barrier analyses of the four prioritised technologies — Conservation Agriculture, Agroforestry for Erosion Control, Climate-Smart Soil Management and Drip Irrigation — reveal six primary constraints that cross-cut the sector. All four technologies manage the same scarce resource under a changing climate: water, conserved as soil moisture on the rain-fed cropland of the north and economised as irrigation supply in the south. The common barriers reflect a single underlying failure: the water and soil benefits that these technologies create are not measured, not priced and not financeable under current arrangements.

- **Finance Misaligned with Adaptation Payback Horizons:** Every technology requires upfront investment that pays back over multiple years — 3–5 years for Conservation Agriculture and soil-carbon restoration, 4–7 years for drip systems and 10–20 years for shelterbelts — while agricultural credit is built around the annual production cycle, with a National Bank base rate of 18 per cent feeding commercial lending of 20–24 per cent. The corresponding barriers were rated severe for all four technologies (means of 3.50–3.58 for Conservation Agriculture, 4.00 for agroforestry, 3.92 for CSSM and 4.50 for drip irrigation), and no long-tenor concessional instrument currently bridges the gap.

- **A Subsidy Architecture that Finances the Status Quo:** Across the sector, state support is calibrated to conventional input-intensive practice — mineral-fertiliser and wheat-input subsidies in the north, furrow-calibrated cotton support in the south — rewarding the practices that degrade soil and waste water while leaving adaptation investment unsupported; in drip irrigation, reimbursement delays of up to 18 months convert the main support instrument into a cash-flow risk. The working group rated these barriers between 3.50 and 4.38 across the technologies, including 3.92 for subsidies that actively finance soil degradation.
- **Land Tenure too Short to Capture Long-Horizon Returns:** Adaptation investments are fixed to the land, but current lease arrangements do not guarantee that the investor captures the returns: the constraint was rated 3.92 for agroforestry, is embedded in the four-fold legal vacuum for CSSM (3.50) and scored 3.00 for Conservation Agriculture. Insecure tenure makes it rational for farmers to decline investments whose benefits mature over a decade.
- **Unpriced Water and Soil Benefits — No Measurement, No Market, No Reward:** This is the central water-focused failure of the sector: retained soil moisture, reduced erosion, accumulated soil carbon and saved irrigation water are public goods without a price. There is no certification or premium for adaptation-produced output (3.58 for Conservation Agriculture; 4.00 for CSSM), no payment mechanism or carbon pathway for ecosystem services (3.75 for agroforestry, with the KAZ ETS excluding agriculture), no approved MRV methodology for soil or shelterbelt carbon (within the barriers rated 3.92 for agroforestry and 3.50 for CSSM), and — in irrigation — an area-based water charge without meters that removes the price of water itself (3.88). Until these outcomes are measured and rewarded, adaptation remains a cost rather than an asset.
- **Fragmented Institutions and an Absent Monitoring Backbone:** No single body owns agricultural adaptation: mandates are split between the Ministry of Agriculture, the Ministry of Ecology and — in irrigation — the Water Resources Committee, KazVodKhoz and oblast akimats, with no coordination mechanisms, while national monitoring of soil condition, shelterbelt cover and water use does not exist. The institutional barrier was rated 3.42–3.88 for agroforestry, CSSM and drip irrigation (and screened out only for Conservation Agriculture, at 2.58), while the monitoring and measurement dimension was rated 3.33–3.75 in every technology. Without measurement infrastructure, neither targeting nor verification nor payment is possible.
- **A Knowledge, Demonstration and Behavioural Deficit:** In every technology the working group rated farmer knowledge gaps, the absence of specialised extension and demonstration sites, and the inertia of Soviet-era practice norms — deep ploughing, input-intensive farming, wheat monoculture, abundant furrow watering — as binding constraints: high-severity means of 3.42–3.83 in the three technologies, 3.88 for the drip extension gap, with the furrow-irrigation culture in the important band (3.12). Where no local evidence shows the alternative working, non-adoption remains the rational choice — which is why demonstration sites and peer-to-peer knowledge transfer rank among the highest-priority enabling measures across all four technologies
- In addition, gender inequality in access to finance, training and demonstration activities was identified for every technology and consistently rated low as a standalone barrier (means of 1.67–2.25 where assessed separately, and 3.12 where combined with cultural barriers for drip irrigation), validating the approach taken throughout this chapter: gender inclusion is treated as a cross-cutting design requirement of every measure rather than as a separate workstream. The low scores reflect how stakeholders interpreted the barrier, not the importance of gender. The predominantly technical respondents scored each barrier by its direct effect on technology

adoption and judged the binding constraints to be structural and financial; they treated women's lower access to land, finance and training as a consequence of those same structural barriers rather than a separate adoption barrier. Gender is therefore mainstreamed into every measure (alternative collateral, a minimum 30% participation target, women-led demonstration sites) rather than run as a stand-alone workstream. In line with the TNA Step-by-Step and Gender guidelines, gender is therefore treated as a cross-cutting design requirement built into every measure — alternative collateral and credit-guarantee options for women, a minimum 30 per cent women's-participation target in training and demonstration activities, women-led demonstration sites, and gender-disaggregated monitoring — rather than as a single standalone action.

1.5.2 Common measures in the Agriculture (water focus) sector

To dismantle these bottlenecks, the following cross-cutting measures form a sector-wide enabling framework supporting the deployment of all four technologies. Each measure corresponds to one of the common barriers and consolidates the highest-rated technology-level measures identified in Sections 1.1–1.4.

- **A Sector-Wide Adaptation Finance Architecture:** This architecture takes the concrete form of a single Agriculture Adaptation Finance Facility/Fund serving all four technologies.
- **Reorientation of the Subsidy Envelope towards Results-Based Adaptation Payments:** Convert the existing subsidy budget from input-intensive support into the sector's largest source of adaptation finance: subsidies for soil-health inputs (rated 2.83, the highest of any measure in the northern technologies), multi-year transition payments, reformed and drip-aligned crop support, and digital disbursement platforms cutting payment times to under three months with filtration and fertigation included.
- **Tenure Reform Conditional on Adaptation:** Amend the Land Code to guarantee 15–25-year lease terms for farms implementing registered adaptation programmes — conservation practice, shelterbelt establishment, soil restoration — supported by the adoption of the Law on Soil Protection, converting long-horizon investments from irrational to bankable.
- **National Measurement and Market Infrastructure for Water and Soil Outcomes:** Build the systems that price what the technologies produce: national MRV methodologies for soil and shelterbelt carbon compatible with the KAZ ETS, Article 6 and voluntary markets; certification standards and premium markets for adaptation-produced output; payments for verified ecosystem services; carbon-aggregation facilities pooling farm-level gains; and, in irrigation, the volumetric water tariff with universal metering that restores the price signal for saving water. This is the water-focused core of the framework: once retained moisture, restored soil carbon and saved irrigation water carry value, the finance and subsidy instruments above acquire a revenue stream to lend against.
- **Coordination Bodies and a Shared Monitoring Backbone:** Create the inter-agency coordination the sector lacks — an NbS/EbA coordination body, a soil-management coordination body and empowered basin councils These functions are consolidated into a single inter-ministerial coordination body across the sector rather than separate bodies per technology.
- **A National Extension, Demonstration and Behavioural-Change System:** Consolidate the technology-level training, demonstration and outreach measures into one national system: specialised advisory networks and college curricula, demonstration plots in every relevant oblast, adaptation calculators and early-warning tools, and multi-year peer-to-peer campaigns

using credible local farmers as change agents — with gender requirements (a minimum 30 per cent share of women in training, alternative collateral guarantees and women-led demonstration farms) mainstreamed across every programme.

Together these measures form a single enabling framework for the water-focused adaptation of Kazakhstani agriculture, within which the four technologies are complementary applications of one strategy: conserving green water — the soil moisture on which the rain-fed grain belt of Akmola, Kostanay, North Kazakhstan and Pavlodar depends — through Conservation Agriculture, shelterbelts and Climate-Smart Soil Management, and economising blue water in the irrigated south of Turkestan, Almaty, Zhambyl and Kyzylorda through drip irrigation. The sequencing follows the dependency structure revealed by the analysis. The measurement and coordination backbone and the reorientation of existing subsidies come first, since they rest on existing budgets and institutions and everything else depends on them. The finance architecture, tenure reform and market instruments follow, unlocking the 2030 targets of 2 million hectares under Climate-Smart Soil Management and 600,000 hectares under drip irrigation. The long-horizon deployments — at least 4 million hectares of full Conservation Agriculture and 100,000 hectares of restored shelterbelts by 2035 — build on these foundations as the rewards for verified adaptation outcomes mature. Implemented together, the framework converts adaptation from a subsidised cost into an investable activity, and the four technology programmes into a coherent national response to the central climate risk facing Kazakhstani agriculture: water.

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Annex 1: Market maps, problem trees and objective trees

This Annex contains the analytical figures developed for each of the four prioritised technologies. The market maps follow the Albu and Griffith (2006) framework adapted to the BAEF Guidebook (Section 4.4): the central market chain shows the actors who own and transact the product as it moves from primary input to end user; the upper section shows the enabling business environment; and the lower section shows input and service providers. By convention, income flows from left to right and material/equipment flows in the opposite direction. The problem trees and objective trees follow the Logical Problem Analysis methodology described in Annex A of the BAEF Guidebook.

A1.1 Conservation Agriculture (No-Till and Crop Rotation)

Figure A1.1 — Market map for Conservation Agriculture in Kazakhstan

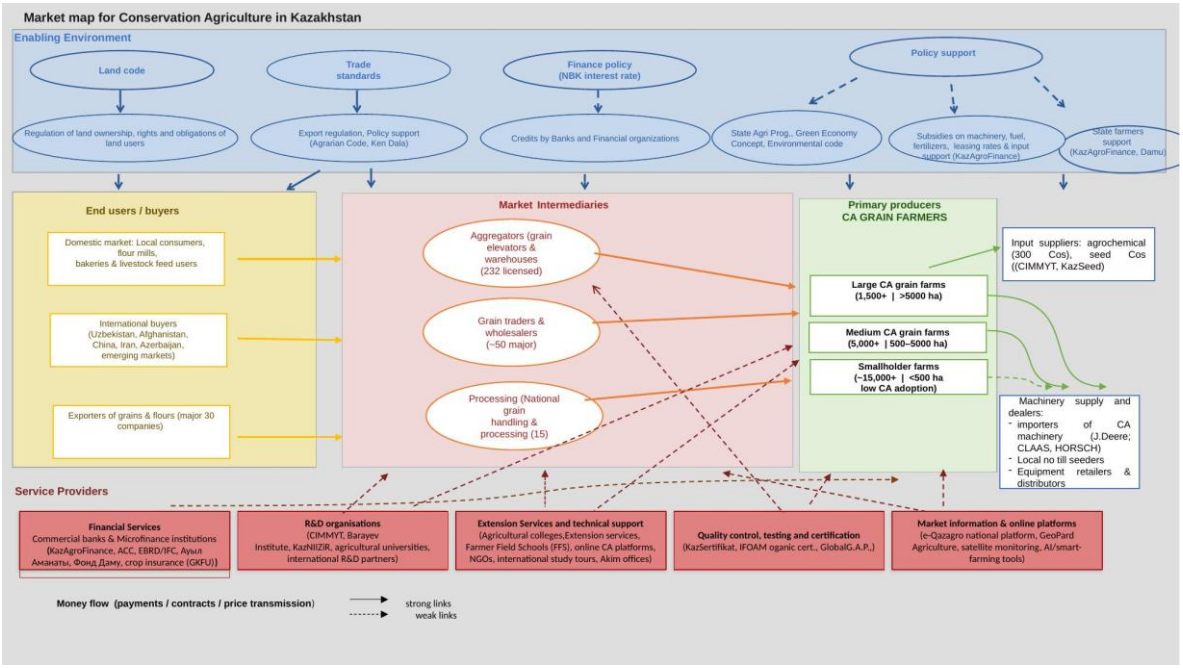


Figure A1.2 — Problem tree for Conservation Agriculture in Kazakhstan

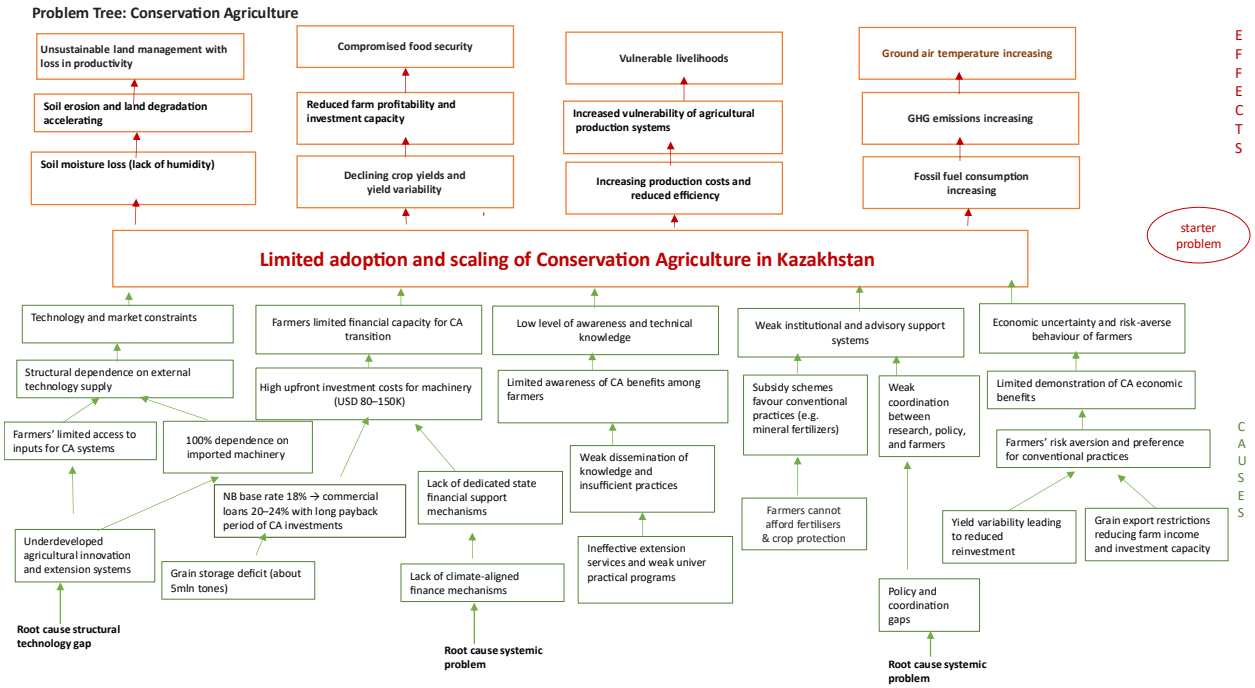
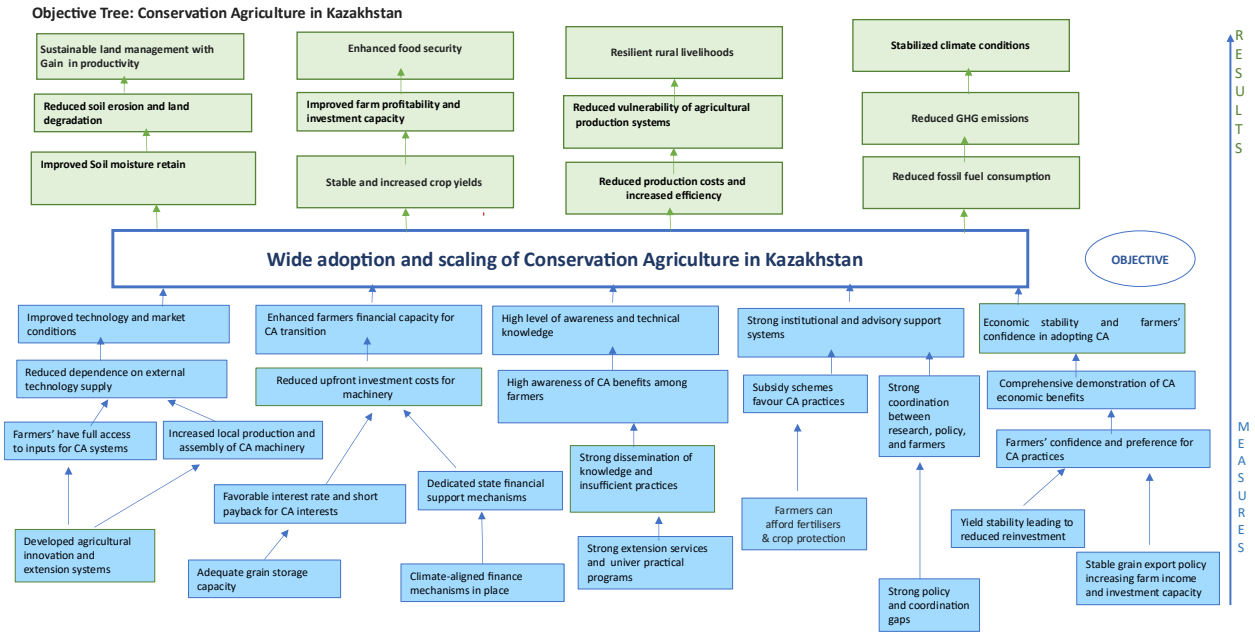


Figure A1.3 — Objective tree for Conservation Agriculture in Kazakhstan



A1.2 Agroforestry for Erosion Control and Soil Protection

Figure A1.4 — Market system map for Agroforestry / Shelterbelt Restoration in Kazakhstan

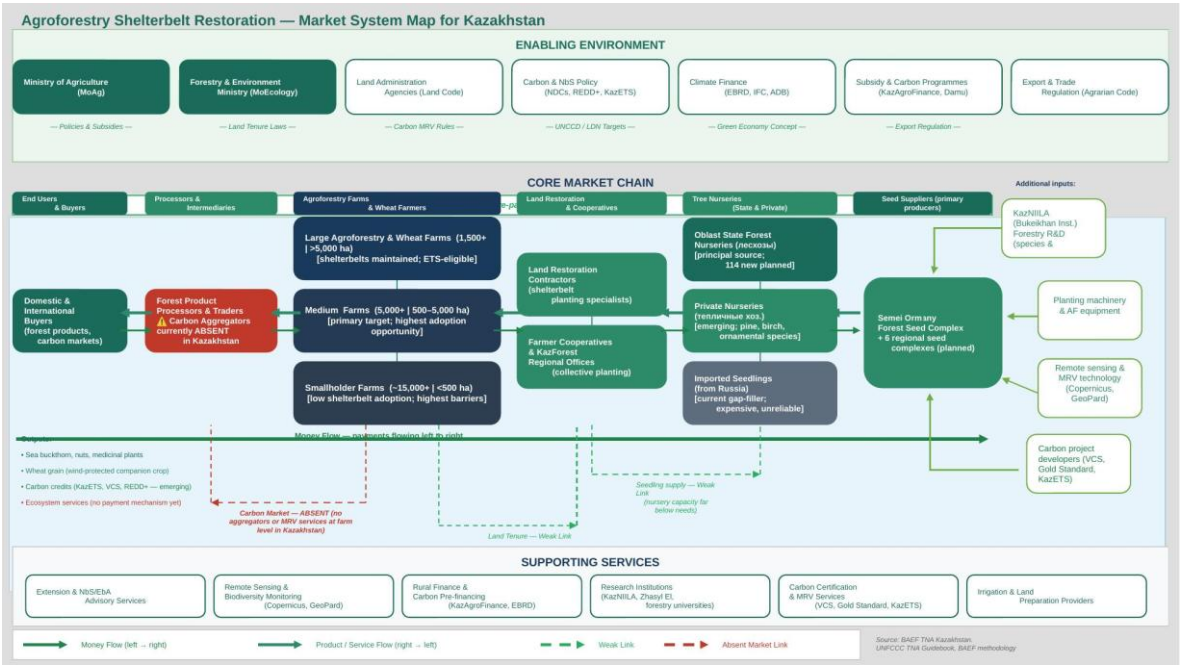


Figure A1.5 — Problem tree for Agroforestry for Erosion Control and Soil Protection in Kazakhstan

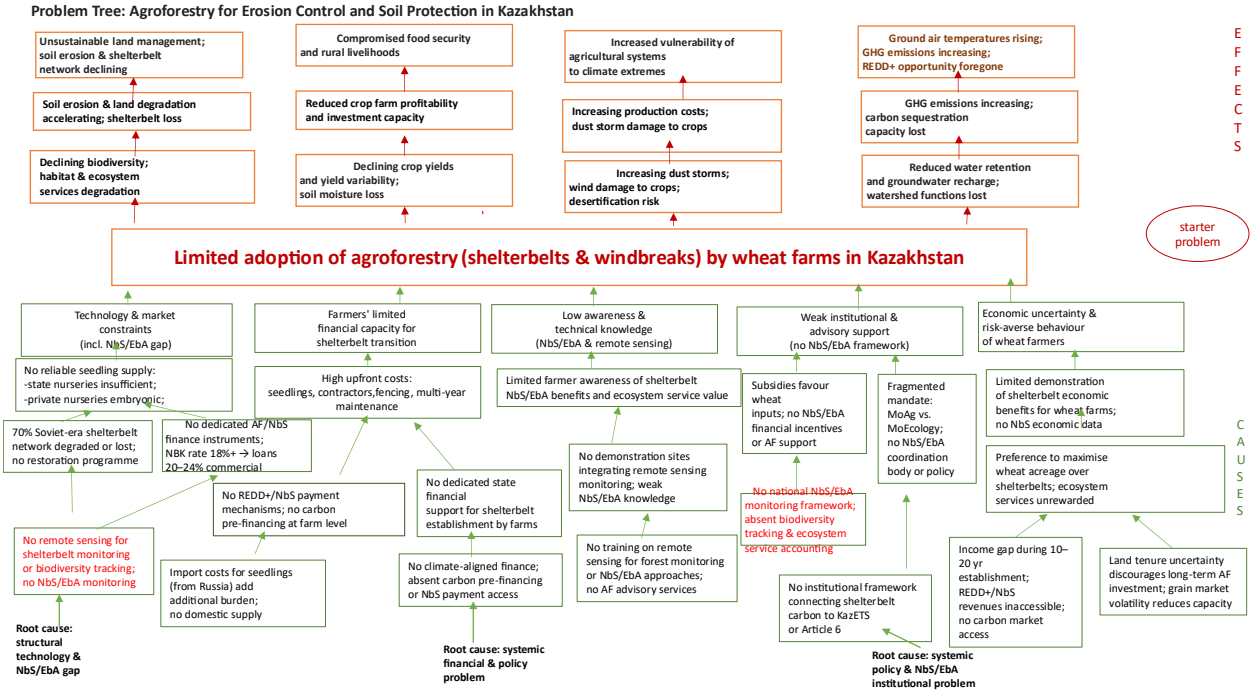
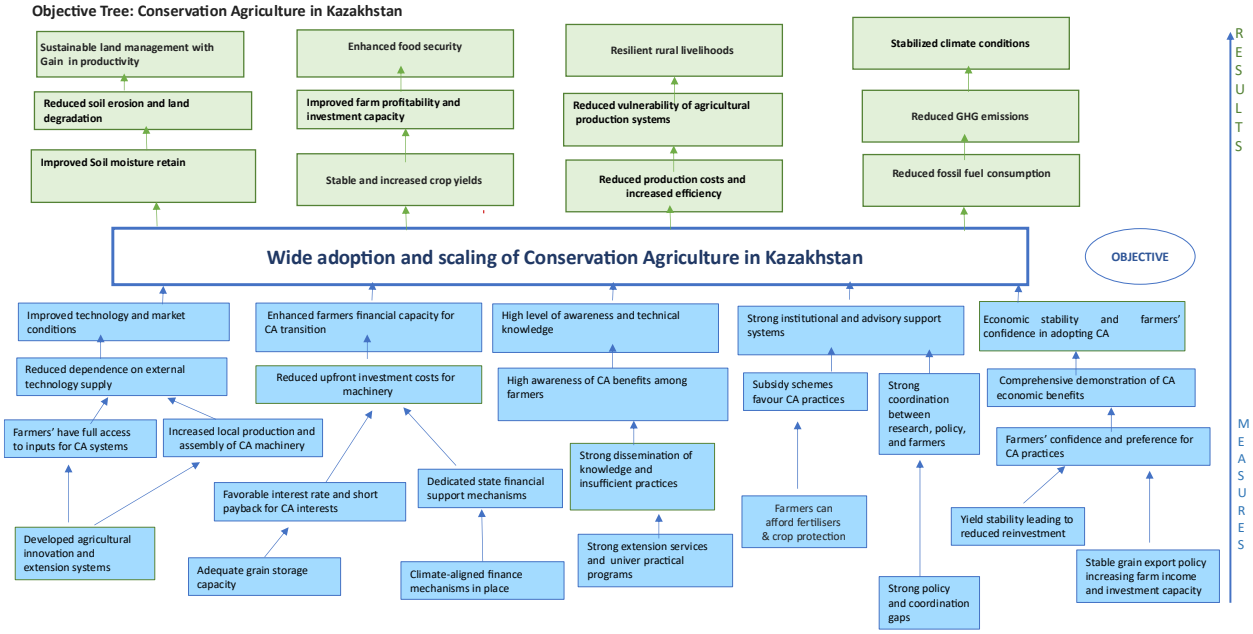


Figure A1.6 — Objective tree for Agroforestry for Erosion Control and Soil Protection in Kazakhstan



A1.3 Climate-Smart Soil Management

Figure A1.7 — Market map for Climate-Smart Soil Management in Kazakhstan

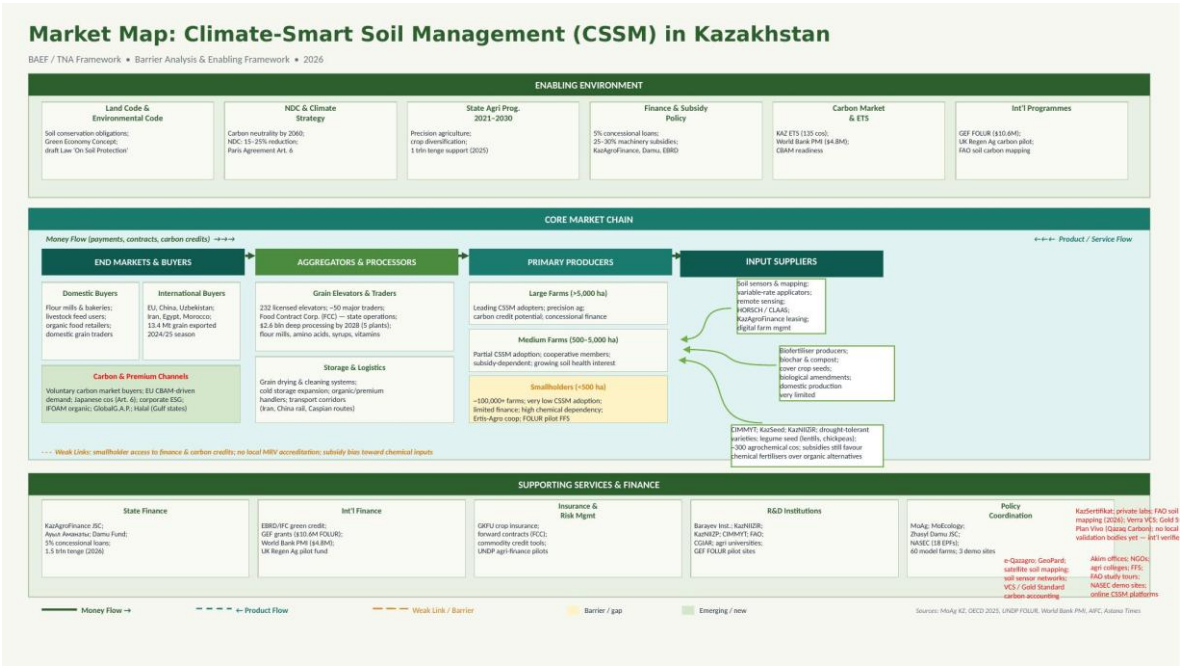


Figure A1.8 — Problem tree for Climate-Smart Soil Management in Kazakhstan

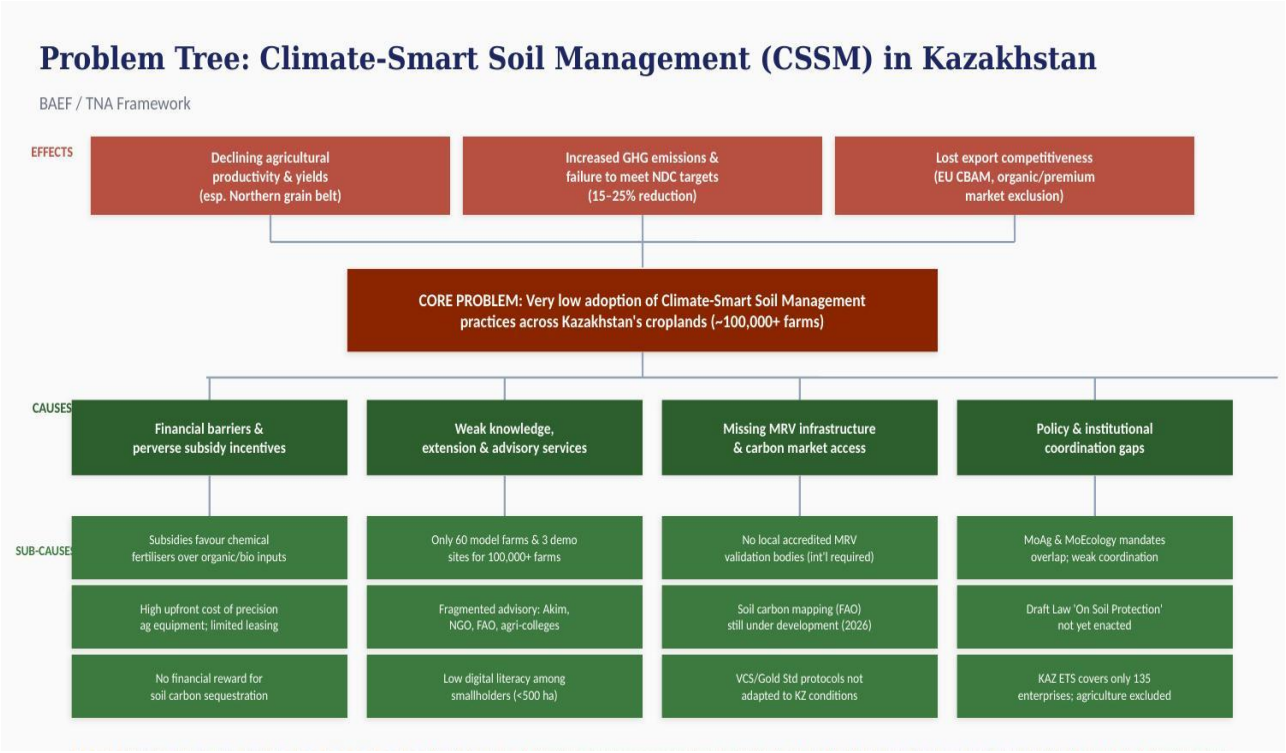
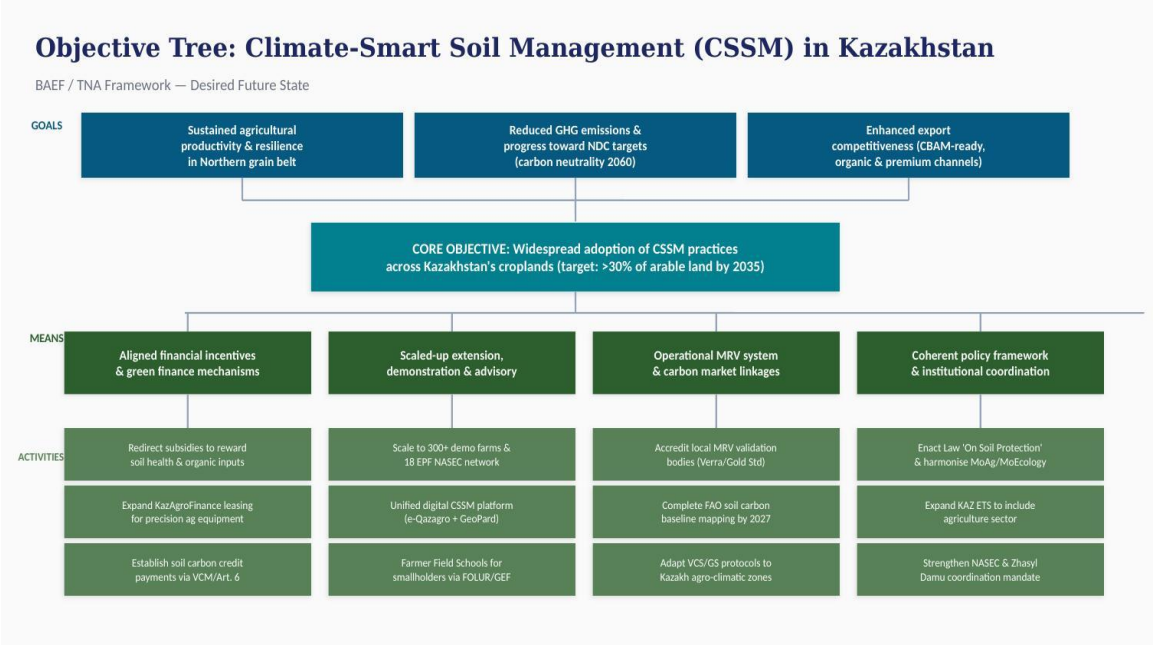


Figure A1.9 — Objective tree for Climate-Smart Soil Management in Kazakhstan



A1.4 Drip Irrigation

Figure A1.10 — Market map for Drip Irrigation in Kazakhstan

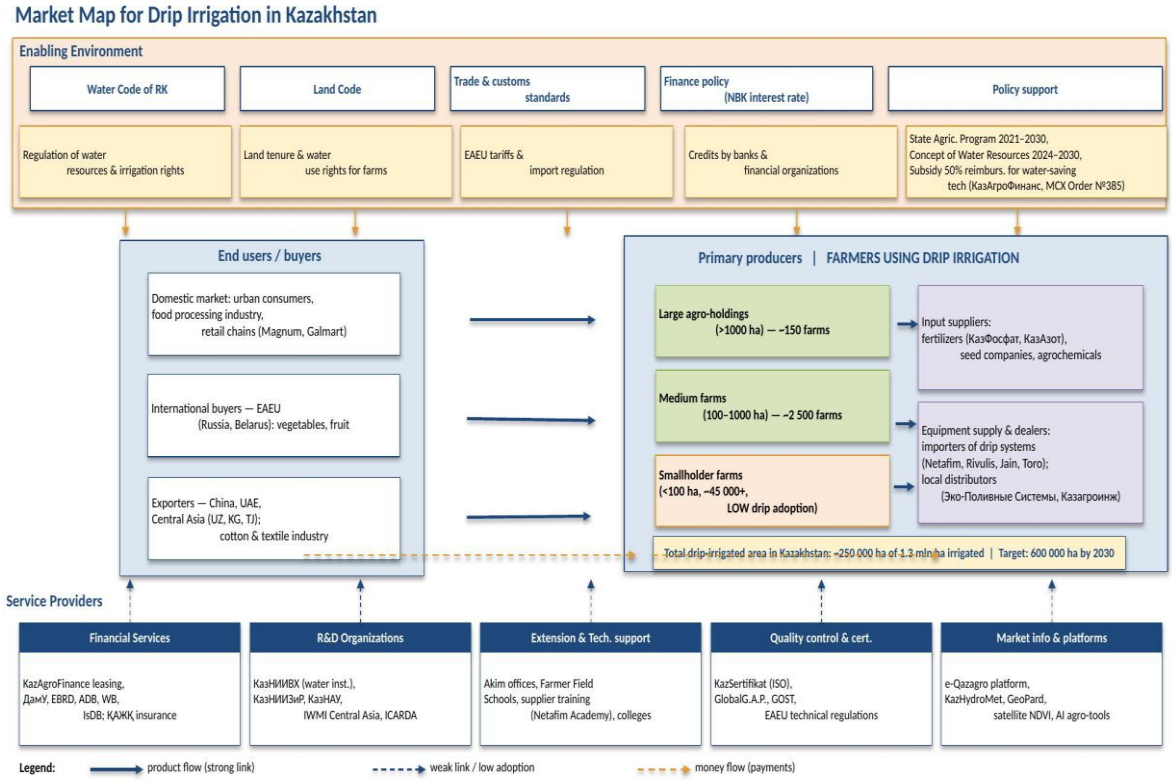


Figure A1.11 — Problem tree for Drip Irrigation in Kazakhstan

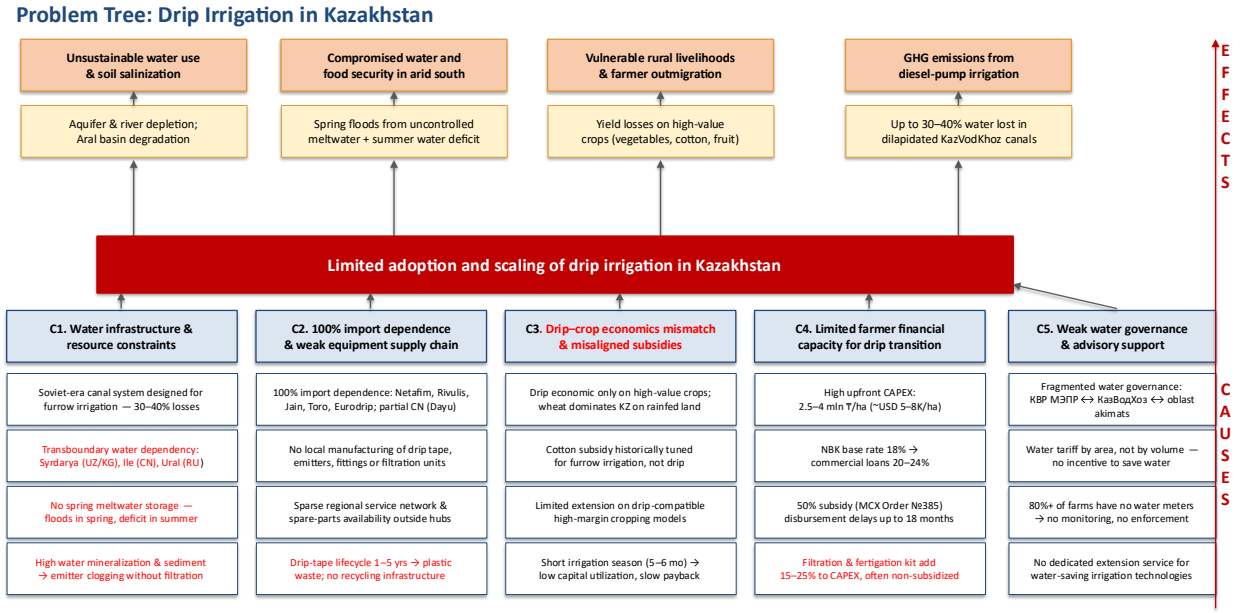
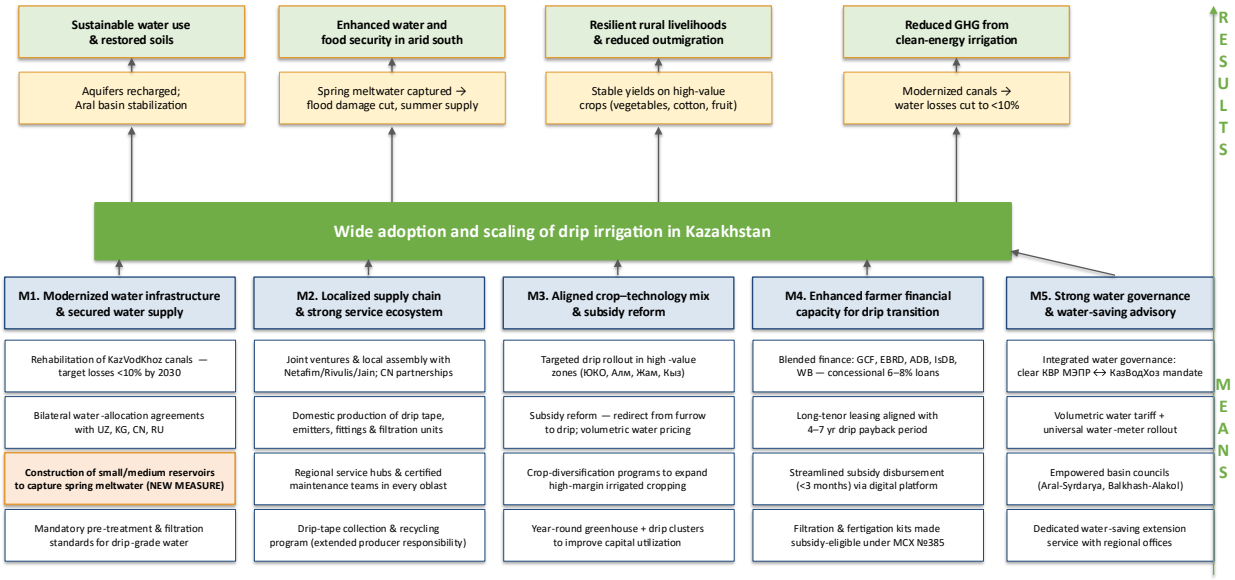


Figure A1.12 — F

Objective Tree: Drip Irrigation in Kazakhstan



Annex 2: List of stakeholders involved

The barrier analysis and measure development were conducted in close consultation with the National TNA Sectoral Working Group for Agriculture (water focus). The Working Group was convened by the National TNA Team in coordination with the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan. An online questionnaire administered via Google Forms.

Table A2.1 Stakeholders involved in TNA Step 2 (Barrier Analysis and Enabling Framework). Note: Email addresses and telephone numbers are withheld pending confirmation of consent for publication. The National TNA Team will complete contact details in the final published version in accordance with data protection requirements.

Name	Affiliation (organisation, role)	Form of consultation
Nurmanova Malika Rakhmetovna	MoA / Department of Plant Production	Questionnaire
Kazken Madina Meyramkyzy	Climate and Environmental Policy specialist, former Project manager of GCIP-Kazakhstan	Questionnaire
Untabaev Oyrat Maratbekovich	S. Seifullin Agrotechnical University	Questionnaire
Kauazov Azamat Maratovich	The Coordinator of the Central Asia Climate Information Portal (CACIP) of the Regional Environmental Centre for Central Asia (CAREC)	Questionnaire, Interview
Ismailova Aru	Senior Manager, Expert Assessment Division, IGTIC	Questionnaire
Eltay Aizat Galikyzy	Head of Division, RSE “Kazhydromet”	Questionnaire
Omarov Maulen Baydildaevich	Head of the Department for Restoration of the Qualitative State of Disturbed and Degraded Lands, Sectoral Development Department, State Institute for Land Surveying Works, Committee for Land Resources Management, Ministry of Agriculture of the Republic of Kazakhstan	Questionnaire, Interview
Songbergen Kanzhar	Senior Expert, Department of Soil Resources and Climate-Resilient Agriculture Development, Committee for Land Resources Management, Ministry of Agriculture of the Republic of Kazakhstan	Questionnaire
Satbaldieva Zhanat Zhumadilovna	Senior Manager, Sectoral Competence Department 2 (SCD-2), “Zhasyl Damu” JSC	
Akhmetaev Bauyrzhan Nurtaevich	Deputy Director of the Department of Agro-Industrial Complex and Food Industry, National Chamber of Entrepreneurs of the Republic of Kazakhstan “Atameken”	Questionnaire
Saimov Alibek	Head of LLP “Soil Solutions”	Questionnaire
Lopukhin Vadim Vladimirovich	President of the Association of Organic Agriculture in Kazakhstan	Questionnaire

Annex 3: Stakeholder questionnaire — methodology and full numeric results

An online questionnaire was administered to the Sectoral Working Group through Google Forms (April–May 2026). The questionnaire covered all four prioritised technologies. For each technology, respondents rated (i) barriers on a 5-point Likert scale of impact, and (ii) measures on a 3-point Likert scale of priority. The numeric encoding used in the analysis is shown below.

Table A3.1 Barrier importance scale

Code	Russian original	Description
1	Insignificant	Easy starter; no priority intervention required
2	Less important	Secondary barrier
3	Important	Substantial barrier requiring attention
4	Key	Barrier with high impact on technology diffusion
5	Critical (blocking)	Blocking barrier; without resolution diffusion impossible

Table A3.2 Measure priority scale

Code	Russian original	Description
1	Low	Auxiliary measure
2	Medium	Useful measure
3	High	First-priority measure

Twelve respondents completed all sections of the questionnaire, with a subset of eight respondents completing the drip-irrigation section (Technologies 1–3 attracted 12 respondents each; Technology 4 attracted 8), giving a total of 906 individual ratings across all four technologies

Summary of the highest-rated barriers and measures (top three per technology) reproduced from the questionnaire analysis:

Table A3.3. Stakeholder screening of barriers — importance scale

Barrier description	Category	1 Insig.	2 Less imp.	3 Imp.	4 Key	5 Critical	Mean score
Technology 1 — Conservation Agriculture (No-Till and Crop Rotation)							
Farmer knowledge gaps and equipment-service deficit	*Human capacity*	1 (8%)	1 (8%)	2 (17%)	4 (33%)	4 (33%)	**3.75**
Entrenched culture of traditional ploughing	*Social, cultural and behavioural*	—	1 (8%)	5 (42%)	2 (17%)	4 (33%)	**3.75**
Access to machinery and finance	*Economic and financial*	—	—	6 (50%)	5 (42%)	1 (8%)	**3.58**
Absence of market incentives and price volatility	*Market conditions*	1 (8%)	—	4 (33%)	5 (42%)	2 (17%)	**3.58**
Low awareness and lack of local data	*Information and awareness*	—	1 (8%)	5 (42%)	4 (33%)	2 (17%)	**3.58**
Transition-period risk and subsidy instability	*Economic and financial*	1 (8%)	1 (8%)	3 (25%)	5 (42%)	2 (17%)	**3.50**
Absence of monitoring infrastructure and zonal variability	*Technical*	1 (8%)	1 (8%)	6 (50%)	1 (8%)	3 (25%)	**3.33**
Insecure land-use rights and absence of results-based payments	*Legal and regulatory*	2 (17%)	3 (25%)	3 (25%)	1 (8%)	3 (25%)	**3.00**

Barrier description	Category	1 Insig.	2 Less imp.	3 Imp.	4 Key	5 Critical	Mean score
Fragmented services, R&D and supply chains	*Institutional capacity*	2 (17%)	4 (33%)	4 (33%)	1 (8%)	1 (8%)	2.58
Gender inequality in access to CA and training	*Gender equality*	7 (58%)	2 (17%)	3 (25%)	—	—	1.67
Technology 2 — Agroforestry for Erosion Control and Soil Protection							
Long-term financing gap	*Economic and financial*	—	—	4 (33%)	4 (33%)	4 (33%)	4.00
Insecure land-use rights and absence of MRV/REDD+	*Legal and regulatory*	—	1 (8%)	3 (25%)	4 (33%)	4 (33%)	3.92
Subsidy mismatch and market volatility	*Economic and financial*	1 (8%)	—	4 (33%)	3 (25%)	4 (33%)	3.75
No market infrastructure for ecosystem services	*Market conditions*	1 (8%)	—	4 (33%)	3 (25%)	4 (33%)	3.75
Advisory and nursery gaps	*Human capacity*	—	2 (17%)	3 (25%)	3 (25%)	4 (33%)	3.75
Low awareness and absence of a demonstration base	*Information and awareness*	1 (8%)	—	5 (42%)	4 (33%)	2 (17%)	3.50
Institutional fragmentation and absence of monitoring	*Institutional capacity*	1 (8%)	1 (8%)	4 (33%)	4 (33%)	2 (17%)	3.42
Wheat-monoculture mindset and rational risk-aversion	*Social, cultural and behavioural*	—	3 (25%)	3 (25%)	4 (33%)	2 (17%)	3.42
Absence of remote-sensing infrastructure	*Technical*	2 (17%)	—	5 (42%)	2 (17%)	3 (25%)	3.33
Gender inequality in access to agroforestry programmes	*Gender equality*	5 (42%)	4 (33%)	2 (17%)	1 (8%)	—	1.92
Technology 3 — Climate-Smart Soil Management (Mulch, Biochar, Compost)							
No market incentives, carbon-market access or feedstock base	*Market conditions*	1 (8%)	—	2 (17%)	4 (33%)	5 (42%)	4.00
Adaptation finance gap	*Economic and financial*	—	1 (8%)	2 (17%)	6 (50%)	3 (25%)	3.92
Subsidies actively finance soil degradation	*Economic and financial*	—	2 (17%)	1 (8%)	5 (42%)	4 (33%)	3.92
Farmer knowledge gaps and demonstration-base deficit	*Human capacity*	—	1 (8%)	5 (42%)	1 (8%)	5 (42%)	3.83
Inertia of chemicalised farming	*Social, cultural and behavioural*	—	1 (8%)	5 (42%)	1 (8%)	5 (42%)	3.83
Low awareness and absence of early warning	*Information and awareness*	—	2 (17%)	4 (33%)	1 (8%)	5 (42%)	3.75
Absence of soil monitoring and zonal variability	*Technical*	—	1 (8%)	5 (42%)	2 (17%)	4 (33%)	3.75
Fragmentation, absence of monitoring and payments	*Institutional capacity*	1 (8%)	—	6 (50%)	1 (8%)	4 (33%)	3.58
Legal and institutional vacuum	*Legal and regulatory*	1 (8%)	1 (8%)	4 (33%)	3 (25%)	3 (25%)	3.50
Gender inequality in access to CSSM and training	*Gender equality*	4 (33%)	2 (17%)	5 (42%)	1 (8%)	—	2.25
Technology 4 — Drip Irrigation							

Barrier description	Category	1 Insig.	2 Less imp.	3 Imp.	4 Key	5 Critical	Mean score
Degradation of KazVodKhoz canals and absence of spring meltwater storage	*Technical and infrastructure*	—	—	—	2 (25%)	6 (75%)	**4.75**
Transboundary dependence and poor irrigation water quality	*External and regulatory*	—	—	—	3 (38%)	5 (63%)	**4.62**
High capital costs and expensive cost of capital	*Economic and financial*	—	—	1 (13%)	2 (25%)	5 (63%)	**4.50**
Complete import dependence, no domestic manufacturing, weak service network and plastic waste	*Market conditions and supply chain*	—	1 (13%)	—	2 (25%)	5 (63%)	**4.38**
Subsidy payment delays of up to 18 months and non-coverage of filtration and fertigation	*Economic and financial*	—	—	2 (25%)	1 (13%)	5 (63%)	**4.38**
Mismatch between drip economics, cropping structure and misaligned subsidies	*Economic and financial*	—	1 (13%)	—	4 (50%)	3 (38%)	**4.12**
Weak agricultural extension on drip-compatible models and water saving	*Human capacity*	—	—	4 (50%)	1 (13%)	3 (38%)	**3.88**
Fragmented water governance and an area-based tariff without water meters	*Institutional and regulatory*	—	—	3 (38%)	3 (38%)	2 (25%)	**3.88**
Cross-cutting barriers: furrow-irrigation culture and gender exclusion	*Social, cultural and behavioural*	1 (13%)	1 (13%)	2 (25%)	4 (50%)	—	**3.12**

Table A3.4. Measure priority scale — full results

Measure description	Category	Low (1)	Medium (2)	High (3)	Mean score
Technology 1 — Conservation Agriculture (No-Till and Crop Rotation)					
Preferential leasing and machinery cooperatives	*Economic and financial*	—	4 (33%)	8 (67%)	**2.67**
Improved training programmes and technical support services	*Human capacity*	—	4 (33%)	8 (67%)	**2.67**
Transition payments and subsidy reform	*Economic and financial*	—	5 (42%)	7 (58%)	**2.58**
National agricultural advisory network	*Institutional capacity*	—	5 (42%)	7 (58%)	**2.58**
CA adaptation calculator	*Information and awareness*	—	5 (42%)	7 (58%)	**2.58**
Marketing campaign and improved communication	*Social, cultural and behavioural*	—	6 (50%)	6 (50%)	**2.50**
Land reform and payments for ecosystem services	*Legal and regulatory*	3 (25%)	3 (25%)	6 (50%)	**2.25**
Zonal practice packages	*Technical*	2 (17%)	6 (50%)	4 (33%)	**2.17**
CA grain certification	*Market conditions*	3 (25%)	6 (50%)	3 (25%)	**2.00**

Measure description	Category	Low (1)	Medium (2)	High (3)	Mean score
Gender inclusion	*Gender equality*	9 (75%)	3 (25%)	—	1.25
Technology 2 — Agroforestry for Erosion Control and Soil Protection					
Adaptation finance fund	*Economic and financial*	—	3 (25%)	9 (75%)	2.75
NbS/EbA support window in KazAgroFinance	*Economic and financial*	—	3 (25%)	9 (75%)	2.75
PES scheme and carbon platform	*Market conditions*	1 (8%)	3 (25%)	8 (67%)	2.58
Land reform and MRV methodology	*Legal and regulatory*	3 (25%)	2 (17%)	7 (58%)	2.33
NbS training modules and nursery expansion	*Human capacity*	1 (8%)	7 (58%)	4 (33%)	2.25
Shelterbelt-effect research and publications	*Social, cultural and behavioural*	—	9 (75%)	3 (25%)	2.25
Remote-sensing integration	*Technical*	2 (17%)	5 (42%)	5 (42%)	2.25
NbS/EbA coordination body and monitoring system	*Institutional capacity*	2 (17%)	7 (58%)	3 (25%)	2.08
Agroforestry adaptation calculator and demonstration plots	*Information and awareness*	3 (25%)	5 (42%)	4 (33%)	2.08
Gender inclusion	*Gender equality*	7 (58%)	5 (42%)	—	1.42
Technology 3 — Climate-Smart Soil Management (Mulch, Biochar, Compost)					
Subsidies for soil-health inputs	*Economic and financial*	—	2 (17%)	10 (83%)	2.83
Transition finance fund	*Economic and financial*	—	3 (25%)	9 (75%)	2.75
Land reform and soil-protection law	*Legal and regulatory*	1 (8%)	4 (33%)	7 (58%)	2.50
Training and demonstration network	*Human capacity*	—	6 (50%)	6 (50%)	2.50
Certification and carbon aggregation	*Market conditions*	1 (8%)	5 (42%)	6 (50%)	2.42
Soil-management coordination body	*Institutional capacity*	—	7 (58%)	5 (42%)	2.42
Training programme for sustainable land use	*Social, cultural and behavioural*	1 (8%)	5 (42%)	6 (50%)	2.42
Soil monitoring and zonal packages	*Technical*	2 (17%)	4 (33%)	6 (50%)	2.33
Soil adaptation returns calculator and early warning	*Information and awareness*	1 (8%)	8 (67%)	3 (25%)	2.17
Gender inclusion	*Gender equality*	7 (58%)	5 (42%)	—	1.42
Technology 4 — Drip Irrigation					
Bilateral water agreements and national water-quality and filtration standards	*External and regulatory*	—	—	8 (100%)	3.00

Measure description	Category	Low (1)	Medium (2)	High (3)	Mean score
Rehabilitation of KazVodKhoz canals and construction of small and medium meltwater reservoirs	*Technical and infrastructure*	—	1 (13%)	7 (88%)	**2.88**
Supply-chain localisation, regional service hubs and a tape-collection scheme	*Market conditions and supply chain*	—	2 (25%)	6 (75%)	**2.75**
Blended finance and long-term leasing	*Economic and financial*	—	2 (25%)	6 (75%)	**2.75**
Digital subsidy-payment platform and extension of subsidies to filtration and fertigation	*Economic and financial*	—	3 (38%)	5 (63%)	**2.62**
Integrated water governance, volumetric tariff and universal water meters	*Institutional and regulatory*	—	3 (38%)	5 (63%)	**2.62**
Peer-to-peer drip-culture campaigns and explicit gender targets	*Social, cultural and behavioural*	—	4 (50%)	4 (50%)	**2.50**
Targeted rollout in high-value zones, cotton-subsidy reform and greenhouse clusters	*Economic and financial*	1 (13%)	3 (38%)	4 (50%)	**2.38**
National extension network for drip models, water saving and crop diversification	*Human capacity*	—	5 (63%)	3 (38%)	**2.38**