LECTURE SCRIPT

# Ecosystems, Land Use, Agriculture, Water, Salinization & Biodiversity: Case of Uzbekistan

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*For Master's Program Students*

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*Total lecture duration: approximately 60–75 minutes*

*16 slides* | *4 discussion prompts* | *Interactive Q&A closing*

## Lecture Structure Overview

This lecture is organized into four thematic blocks:

**Block I – Context & Background** (Slides 1–6, ~20 min): Ecological profile, agricultural metrics, production trends, and resource use patterns.

**Block II – Key Challenges** (Slides 7–12, ~25 min): Water scarcity, soil degradation, land pressure, modernization gap, and biodiversity.

**Block III – Policy Recommendations** (Slides 13–15, ~15 min): Economic instruments, institutional and technical strategies.

**Block IV – Discussion & Closing** (Slide 16, ~10–15 min): Guided discussion questions for Master-level engagement.

# Block I: Context & Background

### SLIDE 1: Title Slide

*⏱ 2–3 minutes*

*[Display title slide. Pause briefly to let students read.]*

Good morning/afternoon, everyone. Welcome to today's lecture on a topic that is directly relevant to every person in this room — because it concerns the land beneath our feet, the water we drink, and the food that sustains our families.

Today we will examine the interconnected challenges of ecosystems, land use, agriculture, water resources, salinization, and biodiversity in Uzbekistan. This is not an abstract discussion for us. You live in this country. Many of you come from rural areas. You understand these problems personally.

As Master's students, I expect you to engage with this material analytically. I will present data, but I also want you to question it, critique the policy responses, and think about what 'you' would recommend differently. There will be several discussion prompts throughout the lecture, and we will end with an extended Q&A.

Let's begin.

### SLIDE 2: Ecological-Geographic Profile

*⏱ 3–4 minutes*

*[Click to slide 2. Walk through each row.]*

Before we dive into problems, let's establish our baseline. This slide gives you the ecological 'passport' of Uzbekistan — the key parameters that define our environmental constraints.

**Total area and population:** 447,400 square kilometers with 37.4 million people as of 2025. That gives us a density of about 84 people per square kilometer, but this number is misleading because so much of our territory is desert — the Kyzylkum alone covers nearly 40% of the country.

**Arable land:** Only 13.9% of our territory is arable. That's 4.07 million hectares. The rest is overwhelmingly pasture — 71% — plus about 10.7% forest. This means every hectare of arable land is precious and must be managed with extreme care.

**Climate:** We have an arid continental climate with average temperatures around 13°C and very low rainfall — 100 to 300 millimeters annually. For context, rain-fed agriculture typically requires at least 500 millimeters. This means virtually all of our crop production depends on irrigation.

**Water resources:** Our two lifelines are the Amu Darya and Syr Darya river basins. More than 90% of all water withdrawals go to agriculture. This is an extraordinarily high ratio — the global average for agricultural water use is closer to 70%.

**Rural population and GDP share:** Nearly half our population — 49% — lives in rural areas, and agriculture still accounts for 23.4% of GDP as of 2024. This makes agricultural policy simultaneously an economic, social, and environmental challenge.

**Biodiversity:** We have four major ecoregions and over 27,000 documented species. But the elephant in the room — or rather, the dry lake in the room — is the Aral Sea crisis, which has devastated an entire ecosystem. We'll come back to this.

### SLIDE 3: Agriculture: Key Metrics

*⏱ 2–3 minutes*

*[Click to slide 3. Let students absorb the six stat cards.]*

Let me draw your attention to the key numbers. Each of these cards tells part of the story.

24.1 million hectares of agricultural land — that's nearly two-thirds of our total territory. But remember, most of that is pasture, not cropland. The 23.4% GDP share tells us agriculture remains a backbone of our economy. 3.4 million people — that's roughly one in four employed persons working in agriculture.

Now look at the bottom row. 49% rural population means agricultural transformation directly affects half the country's citizens. Cotton production has fallen to about 1.5 million tonnes — we will see why in a moment. And wheat at 6 million tonnes remains below our self-sufficiency target of 7 million.

These numbers frame our core tension: a large, economically significant agricultural sector operating within severe ecological constraints.

## SLIDE 4: Cotton Production Trends

*⏱ 3–4 minutes*

*[Click to slide 4. Point to the chart's declining trajectory.]*

This chart tells one of the most important economic stories of independent Uzbekistan. In 1990, we produced 3.3 million tonnes of raw cotton. By 2021, that had fallen to about 1.5 million tonnes — a decline of approximately 55% over three decades.

Why? Three interrelated factors:

**First, water scarcity.** Cotton is a thirsty crop. As water availability has declined and as we have become more aware of the ecological costs of irrigation, cotton acreage has been reduced.

**Second, policy shifts.** The government has deliberately promoted crop diversification, encouraging farmers to shift toward fruits, vegetables, and other high-value crops. The state procurement system for cotton has been gradually liberalized.

**Third, the end of forced labor.** International pressure, particularly through the Cotton Campaign and ILO monitoring, led Uzbekistan to end the systematic mobilization of citizens for the cotton harvest. This was a major human rights achievement, but it also raised production costs.

For you as Master's students, the question is: was this decline inevitable? Was it desirable? We will return to this in the recommendations section.

## SLIDE 5: Wheat Production Trends

*⏱ 2–3 minutes*

*[Click to slide 5. Highlight the 2017–2018 dip.]*

Wheat tells a different story. Production has been relatively stable around 6–7 million tonnes, but notice the sharp dip in 2017 and especially 2018, when output fell to just 5.4 million tonnes.

This drop was driven primarily by water shortages. 2017–2018 was a particularly dry period across Central Asia, and it exposed the vulnerability of our wheat production to climate variability.

The self-sufficiency target is approximately 7 million tonnes. We have not consistently reached it. The gap is filled partly by flour imports from Kazakhstan. This is a food security consideration that policymakers take very seriously.

Average wheat yields in Uzbekistan are 4.5 to 5 tonnes per hectare on irrigated land. Compare this with 7–8 tonnes per hectare in Turkey or parts of China. That yield gap represents unrealized potential — and a research opportunity for many of you.

### SLIDE 6: Water Use & Agricultural Employment

*⏱ 3–4 minutes*

*[Click to slide 6. Discuss the doughnut chart first, then the employment bars.]*

The doughnut chart on the left should shock you, even though you've probably seen this data before. Agriculture consumes 92% of all water withdrawals in Uzbekistan. Services, industry, energy, and fishery together account for only 8%.

This is not sustainable. As our economy diversifies and urbanizes, competition for water will intensify. The question is not whether agricultural water use will decline, but how — and how we manage the transition.

On the right, you see agricultural employment trends. Employment peaked around 2016–2017 at about 3.65 million and has since slightly declined to 3.44 million in 2022. This reflects both mechanization and the general drift of labor toward services and construction.

But 3.4 million people in agriculture is still enormous. Any shock to this sector — whether from water scarcity, market disruption, or policy error — has immediate social consequences.

# Block II: Key Environmental & Agricultural Challenges

### SLIDE 7: Section Divider — Key Challenges

*⏱ 30 seconds*

*[Click to section divider. Brief transition.]*

Now we move into the heart of the lecture. We’ve established the context. Let’s examine the critical challenges. I will cover five interconnected issues: water scarcity, soil degradation, land pressure, the modernization gap, and biodiversity threats.

### SLIDE 8: Water Scarcity & Irrigation Challenges

*⏱ 5–6 minutes*

*[Click to slide 8. Walk through each point systematically.]*

**Irrigation dependency.** More than 90% of our agriculture is irrigated, but water use efficiency is only 30–35%. That means for every cubic meter of water we withdraw, we lose 65–70% to evaporation, seepage through unlined canals, and field-level waste through flood irrigation. Countries like Israel achieve 85–90% efficiency with drip and sprinkler systems.

**Secondary salinization.** When you over-irrigate with poor drainage, salts accumulate in the topsoil. Over 50% of our irrigated land is now classified as moderately to severely salinized. This is a vicious cycle: salinized soils require even more water to leach the salts, which causes more waterlogging and more salinization.

**Transboundary dimensions.** Our water doesn’t originate within our borders. The Amu Darya and Syr Darya are fed by glaciers in Tajikistan and Kyrgyzstan. Upstream dam projects — particularly the Rogun Dam in Tajikistan and the Kambarata cascade in Kyrgyzstan — create uncertainty about downstream flow. This is fundamentally a geopolitical challenge.

**Climate change.** Scientific projections indicate a 10–15% decline in glacier-fed river discharge by 2050. Simultaneously, rising temperatures will increase evapotranspiration, meaning crops will need more water even as less is available. This is what hydrologists call the ‘double squeeze.’

*[Pause. Read the discussion prompt on the slide.]*

*Discussion prompt: How can Integrated Water Resources Management frameworks address the water-energy-food security nexus in Central Asia?* Take a moment to think about this. We will discuss it at the end, but I want it in your minds as we proceed.

### SLIDE 9: Soil Degradation & Desertification

*⏱ 4–5 minutes*

*[Click to slide 9. Point to the three stat callouts.]*

Three numbers tell the soil story.

**50%** of irrigated land is moderately to severely salinized, with soil electrical conductivity exceeding 4 deciSiemens per meter in many areas of Bukhara, Khorezm, and Karakalpakstan.

**722 thousand hectares** are affected by irrigation erosion across the republic. This is erosion caused not by rain but by water flowing across poorly graded fields.

**40 to 150 million tonnes** of salt and dust aerosols rise from the dried Aral Sea bed every year, carrying pesticide residues and heavy metals across hundreds of kilometers.

The historical cause is clear. Decades of cotton monoculture under the Soviet 'White Gold' policy stripped the soil of organic matter. In irrigated zones, soil organic content has fallen to just 0.5–1.0%, compared to 3–5% in healthy agricultural soils. Excessive mineral fertilizer application — 250 to 300 kilograms per hectare — disrupted the soil microbiome.

The result: yield losses in cotton on salinized land reach 30–40%. And the Aral Sea disaster continues to export ecological damage in the form of toxic dust storms that cause elevated rates of respiratory disease, cancer, and infant mortality in Karakalpakstan.

### SLIDE 10: Land Scarcity & Competing Uses

*⏱ 4–5 minutes*

*[Click to slide 10. Explain the indexed chart on the left, then the insights panel.]*

This multi-line chart is important because it shows diverging trajectories. All four variables are indexed to 1988–1992 as the base period, set at 100.

**Population** grew steadily to 126 by 2008–2012 — a 26% increase.

**Arable land per capita** fell from 100 to 76 — a 24% decline. In absolute terms, that means per capita arable land dropped from 0.23 hectares in 1991 to approximately 0.11 hectares today.

**Water per capita** followed a similar decline to 79, meaning each person has access to 21% less water than the previous generation.

**But GDP per capita** nearly doubled, reaching 197. This tells us economic growth has decoupled from natural resource availability. We are producing more value from less land and less water — but we cannot assume this decoupling can continue indefinitely.

The right panel summarizes: urbanization converts 10–15 thousand hectares of farmland annually. Each year, we lose agricultural land permanently to buildings, roads, and industrial zones.

*The key concept here is Ecosystem Services Valuation — ESV.* This is a methodology for quantifying the economic value of ecosystem functions: water purification, carbon sequestration, pollination, flood regulation. When we convert agricultural land to urban use, we lose not just food production but these hidden services. ESV gives policymakers a tool to make land-use decisions that account for the full value of natural capital.

## SLIDE 11: Agricultural Modernization Gap

*⏱ 4–5 minutes*

*[Click to slide 11. Refer to the yield comparison table.]*

Let me be direct. Our agricultural productivity lags significantly behind comparable countries.

Cotton yields in Uzbekistan average 2.5–2.8 tonnes per hectare of raw cotton. Turkey and China achieve 4–5 tonnes — a gap of 40–50%. Wheat: we produce 4.5–5.0 tonnes per hectare versus 7–8 globally. Fruits and vegetables: 15–20 tonnes versus 30–45.

Why does this gap exist? Four main drivers:

**Limited precision agriculture:** soil testing, satellite-guided application, variable-rate irrigation — these are rare on Uzbek farms.

**Aging machinery:** much of our fleet dates to the Soviet era or early 2000s.

**Weak research-to-farm linkages:** our agricultural research institutes produce findings that never reach the field.

**Insufficient extension services:** the 2019 farm reforms created cotton-textile clusters, but many cluster operators are businesspeople, not agronomists.

*Discussion prompt: What institutional mechanisms can accelerate technology transfer from research stations to farm-level practice?* Think about models from other countries — Ethiopia’s agricultural extension system, India’s Krishi Vigyan Kendras, Israel’s technology parks. What could work in our context?

### SLIDE 12: Protected Areas & Biodiversity Threats

*⏱ 3–4 minutes*

*[Click to slide 12. Point to chart showing growth, then threat panel.]*

There is good news and bad news here. The good news: protected natural areas in Uzbekistan have been expanding steadily, from about 850 thousand hectares in 2010 to 1.65 million hectares in 2022. The government has created new nature reserves and expanded existing ones.

The bad news is the severity of ongoing threats.

The Aral Sea desiccation eliminated endemic fish species and destroyed vast wetland habitats. The Tugai forests along river banks are disappearing. Overgrazing on 71% of our pastureland is causing rangeland degradation. Agricultural runoff carrying pesticide and fertilizer residues pollutes river ecosystems downstream. And infrastructure expansion fragments habitats.

Biodiversity loss is not just an environmental concern. It has economic implications through the loss of pollination services, pest regulation, and genetic resources for crop breeding.

## Block III: Policy Recommendations

### SLIDE 13: Section Divider — Recommendations

*⏱ 30 seconds*

*[Click to section divider. Transition.]*

We have identified the problems. Now, what can be done? I will present recommendations in two categories: economic instruments and institutional-technical strategies. These are drawn from both international evidence and Uzbekistan-specific research.

### SLIDE 14: Economic Instruments for Resource Efficiency

*⏱ 5–6 minutes*

*[Click to slide 14. Walk through each recommendation.]*

**Volumetric water pricing.** This is perhaps the single most impactful reform. Currently, water is essentially free for farmers — which means there is zero economic incentive to conserve it. International evidence from Australia's Murray-Darling Basin and Israel's water metering systems shows that when water is priced at or near marginal cost, efficiency gains of 15–25% are achievable within 5–10 years. The challenge in Uzbekistan is implementation: we need water metering infrastructure, institutional capacity to bill and collect, and social safety nets for smallholders who cannot absorb the cost.

**Market liberalization.** For water pricing to work, agricultural output markets must also be liberalized. If the government fixes cotton and wheat prices below market rates, farmers cannot generate the revenue needed to invest in water-saving technology. The cotton market has been partially liberalized since 2020, but the state still influences prices through cluster contracts.

**Fiscal rebalancing.** The current land tax is based on area, not on how much water a farmer uses. This means a farmer who flood-irrigates pays the same tax as one who uses drip irrigation. Shifting to water-consumption-based charges would create a direct financial incentive for conservation.

**Investment incentives.** Drip irrigation systems achieve return on investment within 3–5 years in horticulture. Laser land leveling can reduce water use by 10–15% with minimal cost. But farmers need access to affordable credit and technical assistance to adopt these technologies. Subsidized loans, tax breaks for technology adoption, and public co-financing mechanisms are all proven approaches.

### SLIDE 15: Institutional & Technical Strategies

*⏱ 4–5 minutes*

*[Click to slide 15. Walk through the six card grid.]*

Let me briefly highlight each of these six strategies:

**IWRM and WUAs:** Integrated Water Resources Management requires participatory governance. Water User Associations — WUAs — exist in Uzbekistan but most are underfunded and lack real authority. Strengthening them means giving them legal standing, financial independence, and decision-making power over water allocation.

**Conservation agriculture:** This means minimum tillage, crop rotation, and cover crops. These practices rebuild soil organic matter, reduce erosion, and improve water retention. The challenge is that they require different machinery and farmer training.

**SDG and NDC alignment:** Uzbekistan has committed to Sustainable Development Goals and submitted Nationally Determined Contributions under the Paris Agreement. National Action Plans must be designed so that domestic agricultural policy actually delivers on these international commitments.

**Green climate finance and PPP:** The Green Climate Fund, the World Bank, the Asian Development Bank, and bilateral donors all have funding streams for climate-smart agriculture. Public-private partnerships can leverage this financing to scale up technology adoption.

**Crop diversification:** Shifting from cotton and wheat toward high-value horticulture — grapes, cherries, pomegranates, dried fruits — can increase farm income while reducing water use per unit of GDP generated. Uzbekistan has a comparative advantage in these crops but lacks the cold chain infrastructure to access export markets.

**Cold chain and extension:** This is the missing link. Post-harvest losses in fruits and vegetables exceed 25–30% due to inadequate cold storage, processing, and transport. Digital agriculture tools — soil sensors, weather apps, satellite imagery — can help farmers make better decisions, but only if the extension system delivers them.

# Block IV: Discussion & Closing

### SLIDE 16: Thank You — Questions & Discussion

*⏱ 10–15 minutes*

*[Click to final slide. Open the floor.]*

We have covered a lot of ground today. Let me now open the floor for discussion. I have three specific questions I'd like you to think about, but you are also welcome to raise any point from the lecture.

#### Discussion Question 1

**How can Uzbekistan balance cotton export revenue with water conservation?**

*Prompts to guide discussion:* Cotton still generates significant export revenue and supports textile clusters. Is it realistic to further reduce cotton acreage? What are the trade-offs? Could organic or premium cotton be a niche strategy that uses less water but generates higher value? What would happen to the textile workforce?

#### Discussion Question 2

**What role can ecosystem services valuation play in land-use planning?**

*Prompts to guide discussion:* If we could put a dollar value on the water purification provided by wetlands or the carbon stored in soils, how would that change land conversion decisions? What are the methodological challenges of ESV in a developing country context? Are there examples from other countries we could adapt?

#### Discussion Question 3

**Compare IWRM implementation challenges in Uzbekistan vs. other arid countries.**

*Prompts to guide discussion:* Australia, Israel, Morocco, and Jordan all face water scarcity. What institutional arrangements have worked? How do governance structures differ? What lessons are transferable to Central Asia, where transboundary rivers add an extra layer of complexity?

*[Allow 3–5 minutes per question. Encourage students to draw on personal experience and regional knowledge. Summarize key points from each discussion.]*

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**Closing Statement**

Thank you all for your engagement today. The challenges we discussed are not abstract policy problems — they are the reality of Uzbekistan in the 21st century. Water is finite. Soil does not regenerate quickly. Biodiversity, once lost, does not come back.

But the solutions are within reach. Economic incentives, institutional reforms, technology adoption, and — critically — the next generation of professionals like you who understand both the science and the policy dimensions.

Your Master’s research can contribute directly to these solutions. If any of these topics interest you as dissertation or thesis material, I am happy to discuss further.

Thank you.

*[End of lecture.]*