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# From Reactive Administration to Predictive Agricultural Governance: Artificial Intelligence and the Transformation of Risk Management in the Jordanian Ministry of Agriculture

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# From Reactive Administration to Predictive Agricultural Governance: Artificial Intelligence and the Transformation of Risk Management in the Jordanian Ministry of Agriculture

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## Abstract

This dissertation examines how artificial intelligence can strengthen risk management within the Jordanian Ministry of Agriculture in Amman by shifting institutional practice from reactive administration toward predictive governance. The study is grounded in a national context shaped by severe water scarcity, climate pressure, pest threats, supply vulnerability, and the need for more agile public-sector decision-making. Official Jordanian sources show that the Ministry of Agriculture has already committed itself to digital modernization through electronic agricultural services, smart applications, and increased digital service delivery, while Jordan's National Food Security Strategy calls for regular and systemic data collection, monitoring, evaluation, reporting, and the digitization of food-security processes and services (Government Budget Department, 2025; Hashemite Kingdom of Jordan, 2021). At the same time, Petra reported in 2024 that Jordan launched a national food security management system designed to track food stocks, predict supply conditions, and support food-security decision-making across the Kingdom (Jordan News Agency, 2024). FAO's Jordan country materials and regional documentation further confirm the structural vulnerability of the agricultural sector under conditions of water scarcity and limited arable land (FAO, n.d.; FAO, 2024a).

The dissertation argues that Jordan has now moved beyond the stage where digitalization alone is sufficient. What is required is an integrated model of AI-enabled agricultural risk governance that combines interoperable data systems, predictive analytics, explainable decision support, human oversight, and governance assurance. This position is supported by recent academic and policy literature. NIST's Artificial Intelligence Risk Management Framework identifies trustworthiness characteristics such as validity and reliability, safety, security and resilience, accountability and transparency, explainability and interpretability, privacy enhancement, and fairness with harmful bias managed (NIST, 2023). OECD principles similarly emphasize transparency, explainability, human oversight, and accountability (OECD, 2024). Recent public-sector AI scholarship further

argues that good governance of AI-supported public services must serve both effective administrative order and the just treatment and wellbeing of citizens (Mišić et al., 2025).

The central contribution of this dissertation is the design of a Jordan-specific institutional model: the AI-Enabled Agricultural Risk Governance Framework (AI-ARGF). The framework is structured around five layers: integrated risk data, predictive analytics, explainable decision support, operational response, and governance assurance. It is intended to support the Ministry's ability to anticipate threats, prioritize interventions, strengthen food-security monitoring, improve pest and climate risk response, and allocate scarce administrative attention more intelligently. The dissertation concludes that AI should not be treated as a procurement trend or an isolated technical tool. In the Jordanian Ministry of Agriculture, AI is best understood as a governable institutional capability that must be designed, supervised, explained, audited, and aligned with public value.

**Keywords:** *artificial intelligence, agricultural risk management, Jordan, Ministry of Agriculture, predictive governance, food security, public-sector AI*

## Executive Summary

Jordan's agricultural sector operates under severe ecological and administrative pressure. FAO notes that Jordan has limited arable land due to aridity and water scarcity, while the National Food Security Strategy frames food security as a multi-institutional issue requiring governance, coordination, data systems, and strategic planning (FAO, n.d.; Hashemite Kingdom of Jordan, 2021). This combination of ecological exposure and institutional complexity makes agricultural risk management a strategic state function rather than a narrow technical exercise.

The Ministry of Agriculture is already moving toward digital transformation. The 2025 budget chapter identifies the shift to a digital green economy, the launch of electronic agricultural services, and the use of applications and smart solutions in agriculture as explicit priorities. The same document refers to increasing the number of digital services and increasing users of the Ministry's smart applications (Government Budget Department, 2025). Separately, the ARDI environmental and social systems assessment describes an improved portfolio of agriculture-relevant digital applications and services, including the development and management of an early warning system offering alerts to farmers in case of risks such as natural disasters (World Bank, 2022).

Jordan's AI policy environment creates an additional enabling condition. The Jordanian Artificial Intelligence Strategy and Implementation Plan 2023–2027 includes a five-year implementation plan with 68 projects and identifies practical AI deployment in priority sectors, including agriculture and digital government. The strategy brochure explicitly mentions the use of AI in the agriculture sector through UAVs to classify soil fertility and through early warning systems for frost affecting producers (Ministry of Digital Economy and Entrepreneurship, 2023).

The dissertation's main argument is that these developments remain fragmented unless they are organized into a single institutional architecture for AI-enabled agricultural risk governance. The proposed AI-ARGF model therefore translates Jordan's digital and policy momentum into a ministry-wide design for predictive governance. It does so through five linked components: data integration, analytics, explanation, operational response, and governance assurance. The framework is intentionally designed for public administration rather than for farm-level automation alone. Its purpose is to improve anticipation, prioritization, coordination, and accountability inside the Ministry of Agriculture in Amman.

The dissertation recommends that the Ministry establish AI governance before scale, begin with explainable high-value pilot use cases, treat human oversight as mandatory, and evaluate AI not only by prediction accuracy but also by workflow usability, transparency, documentation quality, and public-sector legitimacy. In practical terms, the strongest pilot domains are pest surveillance, food-security alert support, climate and frost warning, and risk-based inspection prioritization.

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# Chapter One: Introduction

## 1.1 Background of the Study

Risk management in agriculture has become a strategic governance function rather than a narrow technical practice. Ministries of agriculture are expected not merely to respond to crises but to detect them early, rank competing threats, coordinate interventions, and protect the long-term resilience of food systems. This is particularly true in settings where ecological constraints, trade dependence, and institutional fragmentation interact. Jordan represents a compelling case because its agricultural system operates under chronic water scarcity, climate pressure, and severe resource constraints while remaining important to livelihoods, food security, and rural stability.

FAO states that Jordan has limited arable land due to its arid climate and water scarcity, and the National Food Security Strategy describes water limitation as one of the country's most important structural challenges (FAO, n.d.; Hashemite Kingdom of Jordan, 2021). The strategy notes that Jordan is among the world's poorest countries in water and that water scarcity affects agriculture, health, livelihoods, agro-biodiversity, climate adaptation, and the environment. The same strategy also emphasizes that food security in Jordan depends on a broad spectrum of sectors and institutions and that doing "business as usual" will not be sufficient to meet the country's obligations by 2030 (Hashemite Kingdom of Jordan, 2021).

At the same time, Jordan is not institutionally static. The National Food Security Strategy calls for a stronger institutional framework, a database and monitoring system for food security in Jordan, regular and systemic food-security data collection, and the digitization of processes, procedures, and services (Hashemite Kingdom of Jordan, 2021). Petra's coverage of the national food security management system launched in October 2024 adds that the system is designed to track food stocks, predict supply conditions, and guide decision-making processes related to food security across the Kingdom (Jordan News Agency, 2024). In parallel, the Government Budget Department's 2025 chapter for the Ministry of Agriculture identifies digital services, smart applications, and smart agricultural solutions as explicit ministerial priorities (Government Budget Department, 2025).

These developments indicate that Jordan's Ministry of Agriculture has entered a transitional stage: it is no longer a purely reactive bureaucracy, but it has not yet become a fully predictive

institution. It has digital ambitions and selected monitoring systems, but not yet a unified governance model capable of transforming distributed administrative data into explainable risk intelligence. This dissertation addresses that gap.

## 1.2 Research Problem

The central problem is that the existence of digital systems does not automatically create predictive governance. Data can remain siloed, late, uneven in quality, or disconnected from institutional decision rules. In ministries, this problem is often masked by the language of modernization: dashboards are created, applications are launched, and services are digitized, yet risk management may remain reactive because the institution lacks a coherent architecture for turning data into anticipatory, prioritized, and accountable action.

In Jordan's Ministry of Agriculture, this problem is acute because agricultural risks are interconnected. Food-security exposure, pest outbreaks, water stress, climatic shocks, phytosanitary threats, input regulation, and field-level advisory functions all influence one another. The National Food Security Strategy itself identifies fragmentation, poor coherence between policies and strategies, lack of uniform data sources, and weak monitoring and follow-up systems as major challenges affecting the agricultural sector (Hashemite Kingdom of Jordan, 2021). These are precisely the kinds of conditions that reduce the value of raw data while increasing the need for institutional risk intelligence.

The governance problem is equally important. Public-sector use of AI cannot be justified by efficiency claims alone. NIST (2023) and OECD (2024) both make clear that trustworthy AI requires explainability, accountability, transparency, resilience, and human oversight. In public administration, these requirements are not peripheral ethics issues; they are part of the legal and institutional conditions for legitimacy. The research problem of this dissertation is therefore not simply how AI can be used in agriculture, but how it can be institutionalized within the Jordanian Ministry of Agriculture in a manner that improves anticipation and response while remaining governable, reviewable, and publicly defensible.

### 1.2.1 Problem Architecture

The problem addressed in this dissertation is multi-layered rather than singular. At the structural level, Jordan's agricultural administration operates under scarcity conditions that reduce tolerance for delay, fragmentation, and weak prioritization. FAO's Jordan materials emphasize

that water scarcity is a major constraint on the sector, while the national food-security strategy underscores systemic exposure to import dependence, logistics risk, and market fluctuation. At the organizational level, however, information relevant to these risks remains distributed across food-security monitoring, agricultural services, extension, surveillance, and program management functions. The core issue is therefore not merely lack of data, but the absence of a ministry-wide architecture that converts heterogeneous signals into timely, comparable, and actionable risk intelligence (FAO, n.d.; Hashemite Kingdom of Jordan, 2021; Jordan News Agency, 2024).

A second dimension of the problem concerns decision latency. Agricultural threats such as pest spread, climatic stress, supply disruption, and disease escalation impose costs that are highly sensitive to timing. Once intervention is delayed, the Ministry's options become more expensive, narrower, and less effective. The 2025 Ministry of Agriculture budget chapter makes clear that Jordan is already investing in digital services, smart agricultural applications, product tracking, and the Agricultural Risks Fund. Yet these elements remain closer to enabling infrastructure than to an integrated predictive-governance model. The administrative challenge is to connect them within a disciplined cycle of sensing, prioritization, response, and review rather than leave them as parallel initiatives (Government Budget Department, 2025).

### 1.2.2 Knowledge Gap and Scholarly Justification

The academic gap is equally clear. The agricultural AI literature has advanced rapidly in areas such as crop monitoring, detection, classification, forecasting, and input optimization, but much of this work is oriented toward farm-level or production-level performance. Reviews by Ghaffarian et al. (2022) and Aijaz et al. (2025) show substantial progress in predictive agricultural analytics, yet they do not resolve the institutional question faced by public ministries: how should AI be governed when its outputs shape inspection priorities, alerts, supervisory attention, or resource allocation? Conversely, the public-sector AI literature increasingly addresses governance, accountability, and public value, but it remains weakly connected to agriculture-specific administrative settings. This dissertation is positioned in that unresolved space.

The dissertation therefore advances a dual justification. Scholarly, it connects agricultural risk management, AI governance, and public administration in a single analytical frame. Practically, it addresses a real policy window in Jordan, where agricultural digitalization, food-security monitoring, and public-sector AI strategy are already visible but not yet integrated into

one coherent governance model. The study does not claim that Jordan lacks digital initiatives; it argues that the country lacks a ministry-level theory of how such initiatives should be institutionally aligned, governed, and scaled (Batool et al., 2025; Hjaltalin & Sigurdarson, 2024; Wilson, 2022).

### 1.2.3 Administrative and Governance Gap

The decisive gap is administrative. Ministries do not fail to realize value from AI merely because models are inaccurate; they fail because technology is introduced without a commensurate redesign of authority, routines, data stewardship, documentation, and human review. Engstrom and Haim (2023) describe government AI as a sociotechnical design problem, not simply a computational one. Chen et al. (2023) similarly show that AI in the public sector interacts with a broad set of public values and governance constraints. For the Jordanian Ministry of Agriculture, this means that any future AI system must be assessed not only by predictive performance, but by whether it can be explained, contested, documented, audited, and embedded within lawful administrative workflow.

In this dissertation, the research problem is therefore sharpened as follows: Jordan does not primarily need more isolated agricultural applications; it needs an institutional model for AI-enabled risk governance. Such a model must identify where data resides, how risk is classified, how model outputs are interpreted, who remains accountable for decisions, and how organizational learning is built into the lifecycle of deployment. Without that institutional architecture, AI adoption will remain fragmented, pilot-driven, and strategically shallow (Chen et al., 2023; Criado & Ortiz-de-Zárate Alcarazo, 2022; National Institute of Standards and Technology, 2023).

## 1.3 Aim of the Study

The aim of this study is to develop a Jordan-specific framework for AI-enabled agricultural risk governance in the Ministry of Agriculture in Amman that is technically useful, administratively realistic, and normatively defensible.

## 1.4 Research Objectives

• To analyze the Jordanian policy and institutional environment relevant to digital and AI-enabled agricultural governance.

• To synthesize the academic literature on agricultural risk management, AI in agriculture, and public-sector AI governance.

• To identify the principal risk domains relevant to the Jordanian Ministry of Agriculture.

• To design a conceptual and operational framework for AI-enabled agricultural risk governance tailored to Jordan.

• To propose an implementation roadmap and governance protocol suitable for phased adoption within the Ministry of Agriculture.

### 1.5 Research Questions

1. What are the principal agricultural risk domains confronting the Jordanian Ministry of Agriculture?

2. How can AI improve risk detection, forecasting, prioritization, and intervention in those domains?

3. What governance safeguards are necessary for legitimate public-sector use of AI in agricultural risk management in Jordan?

4. What institutional model would enable the Ministry of Agriculture in Amman to move from reactive administration to predictive governance?

### 1.6 Significance of the Study

Academically, this study addresses a gap between two bodies of literature that are usually discussed separately: AI in agriculture, which often focuses on precision farming and production optimization, and AI governance, which often remains generic and detached from sector-specific ministries. By linking these literatures, the dissertation contributes a public-administration view of agricultural AI focused on institutional risk governance rather than only farm-level automation.

Practically, the dissertation is relevant to Jordan because the documentary record shows that the Ministry of Agriculture and associated national institutions have already laid partial foundations for digital risk governance through smart services, food-security monitoring, and early-warning initiatives (Government Budget Department, 2025; Jordan News Agency, 2024; World Bank, 2022). The missing piece is a coherent model for institutional integration and governance.

Policy-wise, the study is significant because it frames AI adoption as a governance design problem rather than a simple procurement exercise. This shift is essential in the public sector, where explainability, due process, and public legitimacy matter as much as technical performance.

## 1.7 Scope and Delimitations

This dissertation is limited to the Jordanian Ministry of Agriculture, with primary institutional attention on Amman as the core administrative site. It does not seek to evaluate all farm-level adoption of AI in Jordan, nor does it attempt to measure the entire agri-food economy. Its analytical unit is the Ministry's risk-governance capability.

The manuscript is written in dissertation style but does not fabricate completed fieldwork. Interview-based results, survey findings, or model-performance metrics would require formal access, ethics clearance, and empirical data collection. Accordingly, the present study is strongest as a doctoral-quality conceptual and documentary foundation for a full empirical dissertation.

## 1.8 Definition of Key Terms

**Artificial intelligence:** Machine-based systems that can, for explicit or implicit objectives, infer from inputs and generate outputs such as predictions, recommendations, or decisions influencing real or virtual environments (NIST, 2023; OECD, 2024).

**Risk management:** The systematic identification, assessment, prioritization, and mitigation of threats and uncertainties affecting organizational objectives.

**Risk governance:** A broader institutional concept that includes not only management actions but also accountability, oversight, rules, review mechanisms, and value-based controls around risk-related decisions.

**Explainability:** The capacity of an AI system to provide meaningful information about how and why outputs were produced so that human users can interpret, evaluate, and contest them when necessary.

## 1.9 Structure of the Dissertation

The dissertation is organized into seven chapters. Chapter One introduces the problem, context, and research design logic. Chapter Two reviews the literature on agricultural risk management, AI in agriculture, and public-sector AI governance. Chapter Three presents the

methodology. Chapter Four provides documentary findings on Jordanian institutional readiness and need. Chapter Five develops the AI-Enabled Agricultural Risk Governance Framework. Chapter Six translates the framework into an implementation roadmap and policy recommendations. Chapter Seven discusses the study’s contribution, limitations, and directions for future research.

# Chapter Two: Literature Review

## 2.1 Introduction

The literature relevant to this study lies at the intersection of agricultural risk management, artificial intelligence in agriculture, public-sector AI governance, and trustworthy AI. The central claim emerging from the literature is that AI is most valuable under conditions of uncertainty when it is embedded within institutional decision systems rather than treated as an isolated technical instrument. This chapter therefore reviews the literature not only for descriptive background, but to derive the theoretical scaffolding for a Ministry-level governance framework.

## 2.2 Agricultural Risk Management and Data-Driven Systems

Agriculture is inherently exposed to uncertainty because biological production is shaped by climate, water availability, disease dynamics, market volatility, logistics, and regulatory conditions. Risk management in agriculture therefore extends beyond loss control; it includes anticipation, adaptation, and resilience. As production systems become more data-rich, agricultural risk management has increasingly adopted digital and analytical approaches intended to improve foresight.

Ghaffarian et al. (2022), in a systematic mapping review of machine learning-based farm risk management, found that machine learning use in this field had expanded rapidly and that production risk was the dominant focus. They also noted, however, that comparatively few studies addressed vulnerability and resilience. This finding is important for the present dissertation because ministries do not manage production risk alone. They also manage vulnerability, system exposure, institutional preparedness, and coordinated response.

Jordan’s food-security strategy implicitly confirms this broader understanding. It addresses governance, logistics, markets, water limitation, institutions, and data systems rather than treating food security as a purely production-side issue (Hashemite Kingdom of Jordan, 2021). For a ministry operating under scarcity, the relevant question is not merely whether more data exists, but whether that data can be transformed into timely and defensible institutional action.

### 2.3 AI in Agriculture: From Precision Farming to Risk Intelligence

The dominant AI-in-agriculture literature often centers on precision agriculture, crop disease detection, irrigation management, yield forecasting, and sensor-based optimization. These streams are important, but they do not automatically address the governance needs of ministries. A ministry of agriculture does not behave like a single farm or agribusiness. It coordinates regulation, inspection, food-security oversight, extension, resource allocation, and public accountability across multiple domains.

Recent reviews have broadened the picture by emphasizing the role of AI in monitoring, anomaly detection, real-time advisory systems, and sustainability-related optimization. This broader literature makes it possible to reinterpret AI not simply as a production technology but as a potential risk-intelligence infrastructure. Under such a reading, AI supports pattern detection, prioritization, and early warning under uncertainty. That interpretation is directly relevant to Jordan, where water scarcity, pest pressures, and food-security dependence elevate the value of anticipatory intelligence.

### 2.4 Public-Sector AI Governance

Public-sector AI governance literature has become substantially more sophisticated in recent years. Batool et al. (2025) argue that AI governance must be understood through questions of who governs, what is governed, when governance occurs across the lifecycle, and how governance is operationalized through policies, standards, structures, and practices. This literature is especially relevant for ministry contexts because institutional legitimacy depends on lifecycle controls rather than on post hoc assurances.

Mišić et al. (2025) develop a particularly useful framework for the governance of AI-supported public services. They argue that good governance must satisfy both “good order” and “good society,” identifying core values such as responsiveness, effectiveness, procedural justice, resilience, counterbalance, wellbeing, and social justice. This framing is central to the present study because Ministry of Agriculture decisions affect citizens, farmers, traders, and rural livelihoods. A technically strong model that undermines fairness or accountability would still be a governance failure.

Wilson (2022) adds a cautionary note by showing that national AI strategies often express public interest goals without always specifying concrete mechanisms for public participation,

oversight, or contestability. This matters in Jordan because national strategy support for AI adoption is necessary but not sufficient. Ministry-level governance protocols still need to be explicitly designed.

### 2.5 Trustworthy, Explainable, and Governable AI

NIST's Artificial Intelligence Risk Management Framework (2023) offers one of the strongest applied governance models available for institutional adaptation. The framework identifies trustworthiness characteristics including validity and reliability, safety, security and resilience, accountability and transparency, explainability and interpretability, privacy enhancement, and fairness with harmful bias managed. Importantly, it organizes AI risk management around four functions: Govern, Map, Measure, and Manage. This structure is useful for public ministries because it translates abstract values into operational responsibilities and review processes.

OECD's AI Principles (2024) reinforce this orientation by emphasizing transparency and explainability, robustness, security, human rights, human oversight, and accountability. These principles are particularly relevant in public administration because AI systems may shape the prioritization of inspections, the deployment of resources, or the interpretation of vulnerability. In such contexts, explainability is not an optional enhancement; it is part of what makes the technology institutionally acceptable.

Laato et al. (2022) further show that explanations for end users should support understandability, transparency, trustworthiness, controllability, and fairness. In the Ministry of Agriculture, the relevant end users are analysts, inspectors, directors, planners, and senior administrators rather than only technical developers. A system that is accurate but incomprehensible to those users is not governance-ready.

### 2.6 Jordanian Context and Literature Gap

Jordan's policy environment makes this study unusually timely. The National Food Security Strategy establishes a governance and data agenda; the Ministry's 2025 budget chapter identifies digital services and smart agricultural applications; Petra reports the launch of a national food security management system designed to track and predict supply conditions; the World Bank's ARDI documentation describes a digital portfolio including early warning alerts to farmers; and

FAO documents Jordan's use of SusaHamra as an official digital monitoring and early warning system for red palm weevil (FAO, 2024b; Government Budget Department, 2025; Jordan News Agency, 2024; World Bank, 2022).

What appears to be missing is a unified ministry-level framework that integrates these strands into one coherent model of AI-enabled agricultural risk governance. The literature offers useful fragments: predictive analytics, governance principles, explainability, and public-sector values. The Jordanian policy record offers a plausible institutional setting. The doctoral contribution of this study is to bring these fragments together into a context-specific institutional architecture.

## 2.7 Conceptual Framework of the Study

The conceptual argument of this dissertation is that ministries can move from reactive administration to predictive governance through a layered model combining data integration, analytics, explanation, operational response, and governance assurance. This framework does not treat AI as a replacement for administrative judgment; it treats AI as a structured decision-support capability embedded in institutional rules. In this sense, the study draws simultaneously on agricultural risk management, public administration, and trustworthy-AI theory.

## 2.8 Theoretical and Analytical Framework

A doctoral study requires more than a descriptive conceptual model; it requires an explicit analytical frame that clarifies how the evidence will be interpreted and what claims the dissertation is positioned to make. This study uses a composite framework made up of three mutually reinforcing lenses: risk governance, sociotechnical design, and public value. Together, these lenses explain why AI in the Ministry of Agriculture must be treated not as an isolated technical tool but as a governed institutional capability.

### 2.8.1 Risk Governance Lens

The first lens is risk governance. NIST's Artificial Intelligence Risk Management Framework is particularly useful because it treats AI deployment as a lifecycle problem governed through the interrelated functions of govern, map, measure, and manage. The value of this lens is that it shifts attention from raw prediction accuracy toward the broader question of how ministries classify risks, document assumptions, monitor performance, and assign accountability. For the present dissertation, the risk-governance lens is used to interpret the Ministry's needs in areas such as

food-security monitoring, surveillance, inspection targeting, and response escalation. It supports the argument that AI should be designed as a structured capability for uncertainty reduction under public accountability rather than as a free-standing analytics product (National Institute of Standards and Technology, 2023; OECD, 2024).

### 2.8.2 Sociotechnical Design Lens

The second lens is sociotechnical design. Government AI systems are never reducible to algorithms alone; they depend on data quality, organizational routines, legal permissions, staff skills, workflow design, and the interpretive practices of frontline and managerial actors. Engstrom and Haim (2023) argue that government AI regulation must confront the challenge of sociotechnical design because public harms and failures are often produced by the interaction of models with institutions, not by code in isolation. Chen et al. (2023) likewise emphasize that public-sector AI affects values through interactions among technical components, governance rules, organizations, and stakeholders. Criado and Ortiz-de-Zárate Alcarazo (2022) add that administrative actors frame AI through existing institutional understandings, which in turn shape adoption, use, and resistance. This lens is essential for Jordan because the Ministry's challenge is not simply whether a model can predict frost, pests, or supply pressure, but whether the Ministry can incorporate such outputs into credible organizational practice.

### 2.8.3 Public Value Lens

The third lens is public value. In public administration, technological improvement cannot be judged solely through speed, automation, or efficiency. Mišić et al. (2025) argue that good governance of public-sector AI must satisfy both 'good order' and 'good society' values, including effectiveness, responsiveness, procedural justice, resilience, wellbeing, and social justice. Hjaltalin and Sigurdarson (2024) similarly show that national AI strategies frame public-sector AI through public values such as agility, inclusion, and information empowerment, while Wilson (2022) warns that national AI strategy rhetoric can obscure democratic trade-offs if public values are under-specified. In the context of Jordanian agricultural governance, the public-value lens is necessary because AI-supported decisions may influence whose farms receive attention first, which threats are escalated, how scarce inspection or surveillance resources are allocated, and how institutional trust is sustained.

## 2.9 Analytical Propositions

The combined framework yields four analytical propositions that guide the dissertation. First, AI readiness in the Ministry of Agriculture is expected to depend less on abstract digital ambition than on the alignment of data governance, workflow design, and leadership authority. Second, the highest-value AI use cases are expected to be bounded, high-frequency, and explainable, rather than politically ambiguous or fully automated. Third, explainability and human review are expected to function as mediating conditions for institutional trust and operational uptake. Fourth, ministry-wide scale is expected to depend on organizational capability-building and governance assurance, not on procurement alone (Batool et al., 2025; Engstrom & Haim, 2023; Mišić et al., 2025).

*Table 1. Theoretical lenses informing the analysis of AI-enabled agricultural risk governance*

| Lens | Core analytical question | What it foregrounds | Why it matters for the Ministry |
|---|---|---|---|
| Risk governance | How should AI-related risk be classified, monitored, and controlled? | Lifecycle governance, documentation, oversight, revalidation | Ensures that prediction is embedded in accountable administrative process |
| Sociotechnical design | How do data, routines, authority, and technology interact? | Workflow fit, data quality, staff capability, institutional adoption | Prevents the Ministry from treating AI as software detached from organizational reality |
| Public value | What counts as legitimate value in public-sector AI use? | Fairness, responsiveness, resilience, transparency, social legitimacy | Keeps agricultural AI aligned with public mission rather than narrow efficiency |

# Chapter Three: Methodology

## 3.1 Research Design

This study adopts a qualitative-dominant mixed-methods case study design focused on the Jordanian Ministry of Agriculture in Amman. A case study design is appropriate because the research problem is institutionally specific, context sensitive, and rooted in governance processes rather than in an abstract technological field. The case study also allows the dissertation to connect documentary evidence, policy structures, and proposed institutional design within a single analytical frame.

## 3.2 Research Philosophy

The study is grounded in pragmatism. Pragmatism is suitable because the dissertation is problem-centered rather than method-centered. The aim is not to defend one epistemological camp, but to produce a framework that is analytically rigorous and practically usable. This makes it possible to combine documentary analysis, conceptual synthesis, and future-oriented empirical design.

## 3.3 Research Site and Unit of Analysis

The research site is the Jordanian Ministry of Agriculture in Amman, including central administrative units and the directorates most relevant to food security, plant protection, veterinary and laboratory services, extension, planning, and digital service delivery. The unit of analysis is the Ministry's risk-governance capability rather than individual farmers or isolated technologies.

## 3.4 Data Collection Methods

The primary method used in the current manuscript is documentary analysis. The source base includes the National Food Security Strategy, the Ministry's budget chapter, the Jordanian AI strategy brochure, Petra reporting on the food-security management system, the World Bank's ARDI assessment, and FAO material on Jordan and SusaHamra. In a full doctoral study, documentary analysis would be followed by semi-structured interviews with Ministry officials and partner institutions, and then by expert validation through a Delphi-style process.

### 3.5 Sampling Strategy

For a future empirical phase, purposive and criterion-based sampling would be most appropriate. Participants would be selected because of their direct relevance to risk-sensitive agricultural governance, data systems, inspection, laboratory services, food security, extension, climate adaptation, or digital transformation.

### 3.6 Data Analysis

The dissertation uses thematic and framework analysis. Documentary materials are read for evidence related to institutional readiness, risk domains, data architecture, governance safeguards, explainability needs, and implementation barriers. A future empirical phase would combine inductive coding of interviews with deductive coding based on the NIST, OECD, and public-sector AI governance frameworks.

### 3.7 Validity, Reliability, and Trustworthiness

Rigor in this kind of dissertation depends on transparency of method, triangulation of sources, conceptual coherence, and explicit differentiation between documentary findings and future empirical claims. The current manuscript maintains that distinction by using only verifiable documentary evidence while marking interview or pilot-testing stages as future research design elements.

### 3.8 Ethical Considerations

A full doctoral study would require institutional ethics approval and access permissions. Ethical issues would include informed consent, confidentiality, data sensitivity, and the handling of potentially restricted administrative information. Because the topic concerns public-sector AI, ethical analysis also extends to fairness, explainability, accountability, and the avoidance of unjustified automated effects.

### 3.9 Limitation of the Present Stage

The main limitation of the present manuscript is that it is conceptually and methodologically advanced but not yet field-validated. That limitation does not diminish its usefulness. At the dissertation-development stage, constructing a grounded and defensible design framework is a necessary step before empirical execution.

Table 2. Principal agricultural risk domains relevant to the Jordanian Ministry of Agriculture

| Risk domain | Why it matters in Jordan | Potential AI contribution |
|---|---|---|
| Water scarcity and climate stress | Jordan's agriculture operates under chronic water pressure, climatic variability, and adaptation constraints. | Forecast stress exposure, identify high-risk zones, and support adaptive advisory targeting. |
| Plant pests and diseases | Economic crops and date palms remain vulnerable to transboundary pests and localized outbreaks. | Detect patterns, rank hotspots, and support early-warning and inspection prioritization. |
| Food-security exposure | Jordan remains vulnerable to supply disruption and market volatility for several major commodities. | Track signals, flag anomalies, and support anticipatory food-security decision-making. |
| Inspection and compliance risk | Limited administrative capacity requires prioritization across sites, products, and cases. | Risk-score entities or locations for more efficient inspection allocation. |
| Extension and advisory responsiveness | Farmers need timely information during climatic, market, or phytosanitary stress. | Improve targeting and timing of extension alerts and guidance. |

# Chapter Four: Jordanian Context and Documentary Findings

## 4.1 Introduction

This chapter presents a documentary analysis of the Jordanian context for AI-enabled agricultural risk governance. Because no interviews or original surveys are claimed in this manuscript, the findings are explicitly documentary and analytical rather than falsely empirical. The goal is to determine whether the available policy and institutional record supports the need for, and plausibility of, a ministry-wide AI risk-governance model.

## 4.2 Finding One: The Ministry's policy direction already supports digital risk governance

The 2025 budget chapter for the Ministry of Agriculture states that the Ministry's priorities include shifting to a digital green economy, launching electronic agricultural services, and advancing applications and smart solutions in agriculture. The same document refers to increasing the number of digital services and increasing the number of users of the Ministry's smart applications, while also mentioning the conversion of 180 services into digital services (Government Budget Department, 2025). This is strong evidence that AI-based risk governance would not represent a policy rupture. Rather, it would deepen an already stated digital trajectory.

## 4.3 Finding Two: Jordan's food-security architecture already depends on data, monitoring, and prediction

The National Food Security Strategy provides documentary evidence that Jordan's food-security governance agenda already depends on data systems and monitoring. The strategy calls for the establishment of a database and monitoring system for food security in Jordan, a regular and systemic data collection system, and a monitoring, evaluation, learning, and reporting system. It also explicitly calls for digitizing processes, procedures, and services (Hashemite Kingdom of Jordan, 2021). Petra's report on the national food security management system complements this by stating that the new system helps track food stocks, predict supply conditions, and guide decision-making across the Kingdom (Jordan News Agency, 2024).

### 4.4 Finding Three: Early-warning logic already exists in Jordanian agricultural programming

The World Bank's ARDI environmental and social systems assessment shows that digital applications and services are already being framed as risk-response mechanisms within Jordanian agricultural programming. The document refers to the development and management of an Early Warning System offering alerts to farmers in case of risks such as natural disasters and links this to a broader portfolio of digital applications and extension support (World Bank, 2022). This finding matters because it demonstrates that early-warning logic is not foreign to the Jordanian agriculture policy environment.

### 4.5 Finding Four: Jordan already has a practical example of digital pest monitoring and early warning

FAO documents that the SusaHamra system was launched in Jordan in 2024 as the official national red palm weevil monitoring application and describes it as a digital monitoring and early warning system. The platform includes a mobile application for field data collection and a cloud platform for processing, analysis, and mapping (FAO, 2024b). This is one of the strongest operational findings in the documentary record because it shows that Jordan has already accepted platform-based agricultural monitoring and early-warning logic within an official context.

### 4.6 Finding Five: The ecological context justifies predictive governance

Jordan's ecological constraints make predictive governance especially valuable. FAO's country materials note the country's limited arable land and water scarcity, while the food-security strategy identifies water limitation as one of the country's most serious challenges (FAO, n.d.; Hashemite Kingdom of Jordan, 2021). In such a setting, late response is unusually costly. Scarcity increases the administrative value of foresight, prioritization, and efficient intervention sequencing.

### 4.7 Finding Six: National AI strategy creates a legitimation platform for agricultural AI

Jordan's AI strategy and implementation plan provide a policy window for agricultural AI. The official strategy brochure states that the implementation plan covers 2023 to 2027, includes 68

projects, and identifies practical AI deployment across priority sectors including digital government and agriculture. It explicitly mentions using AI in agriculture through UAVs to classify soil fertility and establish early warning systems for frost affecting producers (Ministry of Digital Economy and Entrepreneurship, 2023). This does not settle all governance questions, but it does mean agricultural AI is already legible within Jordan's national strategy environment.

### 4.8 Synthesis

Taken together, the documentary record supports six conclusions: the Ministry has a clear digital trajectory; food-security governance already depends on data and prediction; early-warning logic is already present; Jordan has experience with digital monitoring in plant-health management; ecological scarcity increases the value of predictive governance; and national AI policy legitimizes movement in this direction. These findings do not prove that the Ministry is ready for full-scale AI deployment today, but they do show that the institutional case for AI-enabled agricultural risk governance is both plausible and urgent.

# Chapter Five: The Proposed AI-Enabled Agricultural Risk Governance Framework

## 5.1 Introduction

This chapter presents the dissertation's core contribution: the AI-Enabled Agricultural Risk Governance Framework (AI-ARGF) for the Jordanian Ministry of Agriculture in Amman. The framework is derived from the literature reviewed in Chapter Two and the documentary findings synthesized in Chapter Four. It is designed to answer a specifically public-sector problem: how to convert distributed administrative and sectoral information into explainable and governable risk intelligence.

## 5.2 Core Premise

The framework begins from a simple but important institutional premise: the Ministry's problem is not lack of information alone, but lack of integrated and governable risk intelligence. Data exists or is emerging across food-security systems, field reports, inspections, digital applications, climate signals, and directorate-specific records. However, unless those data streams are organized, interpreted, and tied to clear governance procedures, they do not reliably produce anticipatory decision support.

## 5.3 Layer One: Integrated Risk Data

The first layer of AI-ARGF is a governed data foundation. This includes structured and unstructured data relevant to field inspections, pest surveillance, food-security indicators, weather and climate conditions, hydrological and irrigation signals, extension records, laboratory results, and selected licensing or compliance data. The objective is not unlimited data accumulation. The objective is interoperability, quality management, and role-appropriate accessibility. For a public ministry, data governance is inseparable from administrative trustworthiness.

## 5.4 Layer Two: Predictive Analytics

The second layer applies analytical models to detect patterns, forecast escalation, classify vulnerability, and rank cases requiring intervention. In the Jordanian context, the strongest near-term use cases are pest and disease surveillance, food-security anomaly detection, frost or climate

stress alerts, and risk-based inspection prioritization. These use cases are realistic because they align with documented national priorities rather than speculative automation narratives.

### 5.5 Layer Three: Explainable Decision Support

The third layer translates model outputs into forms that Ministry officials can understand and challenge. This includes dashboards, confidence ranges, interpretable risk scores, feature summaries, and scenario comparisons. In public administration, predictions cannot be treated as self-justifying. They must be communicable to human decision-makers. This layer therefore operationalizes the explainability and accountability requirements emphasized by NIST (2023), OECD (2024), and Laato et al. (2022).

### 5.6 Layer Four: Operational Response and Human Oversight

The fourth layer links intelligence to action. Depending on the risk domain, this may involve targeted inspections, escalated field visits, extension alerts, lab testing priorities, or coordination with food-security or emergency actors. Human oversight is indispensable at this stage. Ministry staff remain responsible for judgment, authorization, exception handling, and review. AI informs action; it does not replace institutional accountability.

### 5.7 Layer Five: Governance Assurance

The final layer provides the institutional safeguards necessary for legitimate AI use. These include risk classification, approval procedures, model documentation, monitoring of model performance, incident logging, review of false positives and false negatives, human override rules, and periodic revalidation. This layer operationalizes the insight that public-sector AI is not mainly a software deployment problem; it is a governance design problem.

### 5.8 Strategic Fit for Jordan

AI-ARGF fits Jordan for three reasons. First, it is tailored to a high-scarcity, high-vulnerability agricultural system where prediction and prioritization have significant administrative value. Second, it extends rather than contradicts the Ministry's existing digital direction. Third, it aligns with Jordan's national AI policy architecture, which already recognizes agriculture and digital government as legitimate domains of application.

Table 3. The AI-Enabled Agricultural Risk Governance Framework (AI-ARGF)

| Framework layer | Primary function | Illustrative Ministry application | Governance requirement |
|---|---|---|---|
| Integrated risk data | Combine and structure relevant data streams | Link food-security, pest, climate, inspection, and advisory data | Data stewardship, quality checks, role-based access |
| Predictive analytics | Forecast escalation and prioritize attention | Risk scoring, hotspot detection, anomaly alerts | Model validation, performance tracking, documented assumptions |
| Explainable decision support | Translate analytics into usable insights | Dashboards, interpretable scores, scenario views | Transparency, explainability, user training |
| Operational response | Connect intelligence to action | Targeted inspection, extension alerts, response escalation | Human review, escalation rules, recorded decisions |
| Governance assurance | Maintain institutional trust and legality | Audit trail, incident review, periodic model revalidation | Accountability, contestability, oversight body |

# Chapter Six: Implementation Roadmap and Policy Recommendations

## 6.1 Introduction

This chapter translates the proposed framework into a phased implementation roadmap. The central proposition is that large-scale AI deployment in the Ministry should not begin with full automation. It should begin with narrowly scoped, high-value, explainable, and reviewable use cases aligned with existing strategic priorities and data realities.

## 6.2 Phase One: Institutional Readiness and Governance Setup

The first phase should establish governance before scale. The Ministry should create an internal AI and Risk Governance Steering Committee with representation from planning, IT, plant protection, food security, extension, laboratories, legal affairs, and senior leadership. This body should define approval pathways, risk thresholds, documentation requirements, accountability arrangements, and pilot-selection criteria. The Ministry should also conduct a data-mapping exercise to identify where relevant datasets sit, what quality issues exist, and which systems are sufficiently mature for pilot use.

## 6.3 Phase Two: Pilot Use Cases

The second phase should focus on a small number of pilots with high administrative value and relatively low ambiguity. The strongest candidates are pest and disease surveillance, food-security alert support, frost or climate stress warning, and risk-based inspection prioritization. These areas are already echoed in Jordan's policy and operational record and therefore offer the best chance of institutional acceptance.

## 6.4 Phase Three: Evaluation, Audit, and Institutional Learning

The third phase should evaluate pilots not only for prediction quality but also for workflow usability, explainability, governance compliance, and organizational learning. A public-sector pilot that is technically accurate but not understandable or usable by Ministry staff should not be judged successful. Post-pilot reviews should examine false positives, false negatives, model drift, user comprehension, and whether documented governance procedures were actually followed.

### 6.5 Phase Four: Scaling to Ministry-Wide Predictive Governance

Only after pilots are evaluated and governance procedures prove workable should the Ministry consider scaling. Scaling should remain modular rather than monolithic. Jordan does not need a single all-encompassing platform on day one. It needs interoperable capabilities connected through a governance architecture that can expand carefully over time.

### 6.6 Policy Recommendations

The Ministry should formally redefine agricultural risk management as a predictive governance capability; develop an internal AI governance protocol aligned with national strategy and international trustworthy-AI standards; prioritize explainable and high-value pilot domains; invest in training and explanation as core infrastructure; and avoid a vendor-led model in which technology choices precede governance design.

Table 4. Proposed phased implementation roadmap for the Ministry of Agriculture

| Phase | Primary objective | Illustrative actions | Expected output |
|---|---|---|---|
| Phase 1 | Readiness and governance setup | Create steering committee; map data; classify use cases; define documentation rules | Institutional governance baseline |
| Phase 2 | Pilot deployment | Run small explainable pilots in pest, food-security, frost, or inspection domains | Tested use cases with human review |
| Phase 3 | Evaluation and audit | Assess accuracy, usability, explainability, and compliance; review incidents | Evidence for continuation or redesign |
| Phase 4 | Controlled scale-up | Extend successful components to wider directorates through modular integration | Ministry-wide predictive governance capability |

# Chapter Seven: Discussion, Conclusions, and Future Research

## 7.1 Discussion

The dissertation shows that the strongest case for AI in Jordanian agricultural governance is not technological novelty but institutional need under scarcity. Jordan's Ministry of Agriculture operates in a context where ecological stress, food-security vulnerability, and administrative fragmentation make reactive governance increasingly inadequate. The documentary record suggests that the Ministry and its partners have already moved some distance toward digitalization, but not yet toward an integrated model of predictive governance. The proposed framework addresses that gap by reframing AI as a governable administrative capability rather than as a stand-alone technical product.

## 7.2 Theoretical Contribution

The study contributes to scholarship by connecting three bodies of literature that are usually treated separately: agricultural risk management, AI in agriculture, and public-sector AI governance. In doing so, it extends the meaning of agricultural AI beyond precision farming and production analytics toward ministry-level risk governance. It also localizes the governance literature by applying trustworthy-AI principles to a concrete institutional case in Jordan.

## 7.3 Policy Implications for Jordan

The policy implications are direct. First, digital agricultural transformation in Jordan should be governed as an institutional capability-building project, not as a collection of disconnected apps. Second, food-security monitoring, pest surveillance, climate warning, and smart services should be understood as pieces of a broader predictive governance architecture. Third, the Ministry should not attempt scale without explanation, oversight, and a documented governance protocol. Jordan's national AI strategy provides policy support, but Ministry-level operational governance still needs to be built.

## 7.4 Limitations

This dissertation remains limited by its documentary and conceptual character. It does not present original interview findings, administrative data analysis, or model-performance testing. It is therefore strongest as a thesis-grade framework and research foundation rather than as a

completed empirical dissertation. A further limitation is that public documents do not always reveal the full state of internal data quality, interoperability, or organizational readiness.

### 7.5 Future Research

A full doctoral study should build on this manuscript through four empirical stages: semi-structured interviews with Ministry officials and partner institutions; documentary mapping of existing information systems and workflows; expert validation of the AI-ARGF model through a Delphi process; and pilot evaluation of one or two explainable AI use cases using historical administrative data. Comparative work with other MENA ministries of agriculture would also be valuable.

### 7.6 Conclusion

The central conclusion of this dissertation is that Jordan's Ministry of Agriculture has both a credible need and a realistic policy window for AI-enabled agricultural risk governance. The country's ecological constraints increase the value of predictive decision support, while its current digital and AI strategies reduce the institutional distance between present systems and a more integrated governance model. The decisive issue is therefore not whether AI should enter agricultural governance in Jordan, but whether it can be designed and governed in a way that is trustworthy, explainable, accountable, and operationally useful. This dissertation argues that it can —provided the Ministry treats AI as a supervised public capability rather than as a technical shortcut.

## Appendix A. Indicative Semi-Structured Interview Guide

The following guide is proposed for a future empirical phase of the dissertation. It is designed to elicit institutional knowledge about data practices, workflow bottlenecks, governance concerns, and feasible AI use cases inside the Ministry of Agriculture and among its partner organizations.

Appendix Table A1. Indicative interview domains and sample prompts

| Domain | Illustrative prompt | Purpose |
|---|---|---|
| Current risk workflow | How are high-priority agricultural risks currently identified, escalated, and | Maps the baseline administrative process |

| | | |
|---|---|---|
| | acted upon? | |
| Data environment | Which datasets are routinely used, and where do fragmentation or quality problems arise? | Assesses data readiness and interoperability |
| Decision authority | Who can validate, override, or escalate a model-assisted recommendation? | Clarifies accountability structure |
| Explainability needs | What kind of explanation would officials need before acting on an AI-based alert? | Identifies operational requirements for trust |

## Appendix B. Proposed Pilot Evaluation Scorecard

The scorecard below is designed for early pilots in pest surveillance, food-security alerts, or risk-based inspection prioritization. It evaluates performance as an administrative capability, not merely as a technical model.

Appendix Table B1. Suggested evaluation dimensions for pilot AI systems

| Dimension | Illustrative indicators | Evidence source |
|---|---|---|
| Predictive utility | Precision/recall trends, timeliness of alerts, practical relevance of outputs | Model logs; pilot reports |
| Explainability | Officials can interpret drivers, confidence, and exceptions | User testing; structured feedback |
| Workflow fit | Outputs arrive at the right time and in a usable format | Process mapping; observation |
| Governance compliance | Documentation, review, override, and incident logging are complete | Audit checklist |
| Public-value alignment | System supports fairness, responsiveness, and resilient prioritization | Managerial review; policy assessment |

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