CHAPTER 16

Adaptive and Evidence-based Policymaking

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Abstract

The escalating complexities of global agrifood systems, exacerbated by climate change, demographic shifts, and geopolitical instability, demand a critical departure from static, reactive public policy paradigms. This chapter explores the imperative transition toward adaptive and evidence-based policymaking in developing economies, advocating for robust data driven governance, systematic policy experimentation, and the institutionalization of deep feedback loops. By synthesizing empirical research, theoretical models, and diverse regional case studies, the analysis elucidates how continuous learning mechanisms enhance policy durability amidst sociopolitical and environmental volatility. The chapter critically reviews foundational frameworks, specifically the International Food Policy Research Institute's (IFPRI) Kaleidoscope Model of policy change and Swanson and Bhadwal's principles for adaptive policymaking. Methodologically, it evaluates the integration of Randomized Controlled Trials (RCTs) and digital public infrastructures in shaping and scaling agricultural interventions. Through detailed empirical analyses including the Kissan Card Subsidy Program in Pakistan's Punjab province, the institutionalization and subsequent dismantling of the National Council for Food and Nutritional Security (CONSEA) in Brazil, the political economy of policy experimentation in China, and the data-driven initiatives of Ethiopia's Agricultural Transformation Agency (ATA) the chapter identifies the precise mechanisms that enable successful policy scaling, resilience, and double loop learning. Ultimately, the findings emphasize that autonomous learning institutions, broad stakeholder consensus, and transparent science-policy interfaces are indispensable for developing durable, equitable, and sustainable food security frameworks in the Anthropocene.

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1. Introduction

1.1. The Anthropocene and the Crisis of Global Food Security

Global food insecurity has unequivocally emerged as one of the most pressing and intractable crises of the twenty-first century, currently affecting an estimated 691 to 783 million people worldwide (Iannotti *et al*., 2024). This escalating vulnerability is disproportionately concentrated across developing economies in Africa, Asia, and Latin America, where structural poverty, protracted armed conflicts, and the accelerating, non-linear impacts of climate change converge to destabilize agricultural livelihoods and disrupt food supply chains (Iannotti *et al*., 2024). The traditional paradigms of agricultural administration are often characterized by rigid, top-down directives, highly centralized bureaucracies, and static five-year planning cycles have proven increasingly inadequate in navigating the compounding and cascading shocks of extreme weather events, global pandemics, and shifting macroeconomic pressures. Consequently, the global development community is recognizing that ensuring long-term food availability, affordability, and nutritional quality requires a fundamental paradigm shift from prescriptive government mandates to dynamic, adaptive governance frameworks (Folke *et al*., 2005).

In contemporary agrifood systems, the profound interdependencies between human socio-economic activity and ecological constraints dictate that isolated policy interventions inevitably generate profound, and often unintended, systemic ripple effects. For instance, agricultural policies in many developing nations have historically prioritized the production and subsidization of staple cereals (such as wheat, maize, and rice) to

achieve baseline caloric sufficiency. While successful in mitigating acute famine, these policies inadvertently stifled agricultural diversification, degraded soil health through chemical intensification, and marginalized smallholder and female food producers who cultivate indigenous, nutrient-dense crops (Iannotti *et al*., 2024). As nations attempt to pivot from merely maximizing caloric output to fostering holistic, sustainable, and nutrition-sensitive food systems, the underlying policy architectures must become exceptionally agile. Modern policymakers are tasked with continuously negotiating the "triple challenge" of ensuring food and nutritional security, supporting equitable rural livelihoods, and maintaining environmental sustainability (Organisation for Economic Co-operation and Development, 2020). This complex, multifaceted mandate necessitates continuous learning, rapid institutional course correction, and the rigorous application of scientific evidence to mitigate risks and capitalize on emerging agricultural technologies. To truly address the scale of this crisis, global institutions must rethink how food security paradigms interact with ecological boundaries, shifting the focus toward decentralized systems that prioritize resilience and equity over mere aggregate volume.

1.2. The Paradigm Shift: From Static Administration to Adaptive Governance

The Organisation for Economic Co-operation and Development (OECD) defines evidence-informed policymaking as a systematic process whereby multiple sources of information including real-time data, official statistics, and rigorous impact evaluations are deliberately consulted before planning, implementing, or altering public policies and programs (OECD, 2020). While the medical and public health fields have long embraced evidence-based protocols through clinical trials, the deep integration of these principles into agricultural and food security policy in developing economies is a relatively recent phenomenon (Rocha & Harris, 2019). This ongoing shift is driven by the stark realization that an effective food security policy cannot rely solely on historical precedent, received wisdom, or political ideology; it must be continuously tested, evaluated, and refined against empirical realities on the ground.

Furthermore, the concept of "adaptive policymaking" has emerged specifically to address the profound uncertainties inherent in climate-stressed agricultural systems. Under this paradigm, policies are increasingly defined not merely as static, immutable rules, but as broad statements of purpose operationalized through flexible instruments that anticipate and respond to changing conditions (Swanson & Bhadwal, 2009). Adaptive policies are structurally designed to perform well under a wide range of anticipated future scenarios while retaining built-in triggers for immediate adjustment when contextual factors shift significantly (Swanson & Bhadwal, 2009). This adaptability relies heavily on the presence of durable "learning institutions" specialized entities, universities, and multi-stakeholder councils that manage knowledge, track longitudinal data, and foster an institutional memory that effectively outlasts short-term political and electoral cycles. By integrating these feedback mechanisms into the legislative foundation, governments can establish a more robust buffer against both anticipated climate volatility and unanticipated socio-economic crises.

1.3. Objectives and Chapter Organization

The primary objective of this chapter is to rigorously analyze the structural mechanisms through which adaptive and evidence-based policymaking enhances food security and agrifood system resilience in developing economies. It seeks to unpack the theoretical and practical underpinnings of policy durability, demonstrating how data-driven governance, rigorous policy experimentation, and structured feedback loops transform rigid bureaucratic systems into responsive, learning-oriented networks.

This chapter is structured to systematically bridge theory and practice. Section 2 provides a critical literature review of the agrifood systems framework, contrasting traditional public administration with adaptive governance, and exploring the digital turn toward data-driven governance. Section 3 outlines the conceptual and theoretical frameworks guiding the analysis, specifically focusing on the IFPRI Kaleidoscope Model of policy change, Swanson and Bhadwal's adaptive policy principles, and the organizational theory of single, double, and triple-loop learning. Section 4 examines the methodology of evidence generation, critically evaluating the role of Randomized Controlled Trials (RCTs) and the necessity of digital data infrastructures. Section 5 presents a detailed discussion of empirical results through four distinct national case studies:

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Pakistan, Brazil, China, and Ethiopia. Section 6 translates these findings into actionable policy implications for governments and development practitioners. Finally, Section 7 offers a comprehensive conclusion synthesizing the chapter's contributions to the broader discourse on sustainable development and food sovereignty.

2. Literature Review: Navigating the Agrifood Policy Landscape

2.1. The Agrifood Systems Framework and the Evidence Gap

The academic discourse surrounding food security policy has evolved significantly over the past three decades. Historically, agricultural economics and development policy prioritized interventions aimed at maximizing the aggregate supply of staple crops through input subsidies and technological transfers, heavily mirroring the productivist ethos of the Green Revolution. However, since the 1990s, interdisciplinary scholarships have advocated for a more holistic, systems-level understanding of food security that transcends mere agricultural production. The contemporary agrifood systems framework encompasses five distinct but interconnected elements: food availability, food affordability, nutritional quality, promotion (social behavior change and marketing), and long-term sustainability (Iannotti *et al*., 2024).

A critical review of the existing literature reveals significant asymmetries and gaps in how these five elements are governed and researched. While there is a robust and mature evidence base supporting the efficacy of affordability interventions such as conditional and unconditional cash transfers, as well as school feeding programs that deliver multiple educational and nutritional benefits interventions targeting the newer elements of the food environment remain drastically under-researched (Iannotti *et al*., 2024). For instance, evidence regarding the long-term impacts of sustainability practices (such as agroecological transitions and biodiversity conservation) or the regulation of food promotion (such as restricting the marketing of ultra-processed foods to children) is currently minimal in developing contexts (Iannotti *et al*., 2024). Furthermore, systematic reviews indicate that existing Food-Based Dietary Guidelines (FBDGs) in many developing nations frequently fail to reflect the latest epidemiological evidence or the actual realities of the local food supply, highlighting a critical breakdown at the science-policy interface (Iannotti *et al*., 2024). To bridge this gap, contemporary literature overwhelmingly advocates for multisectoral approaches that scale evidence-based interventions across all domains of the food environment, emphasizing the need for translational implementation science to convert raw agricultural data into actionable, holistic governance (Iannotti *et al*., 2024). Bridging this gap also entails actively rethinking how scientific guidelines are communicated to marginalized populations to ensure high adoption rates and long-term behavioral transformation.

2.2. Traditional Public Administration vs. Adaptive Governance

The theoretical transition from traditional government administration to adaptive governance represents a major focal point in recent environmental, public policy, and agricultural literature. Traditional public administration typically relies on hierarchical command-and-control structures, linear planning processes, compartmentalized ministries (e.g., separating agriculture, water, and health), and rigid regulatory enforcement. While highly effective in stable, predictable environments, this model routinely falters when confronted with the "wicked problems" of climate change and systemic food insecurity, where linear causal models are elusive and policy environments are highly volatile.

Adaptive Governance (AG) has emerged as an alternative paradigm specifically designed to manage complex socio-ecological systems (SES) characterized by rapid, unpredictable change and high degrees of uncertainty (Chaffin *et al*., 2014; Folke *et al*., 2005). Grounded deeply in ecological resilience theory, adaptive governance integrates science, policy, and decision-making to manage *for* change rather than attempting to insulate systems against it (Folke *et al*., 2005). Implementing adaptive governance requires a structural shift from hierarchical dictation to horizontal coordination, enticement, and broad multi-stakeholder participation (Jordan & Moore, 2023). This decentralized, networked approach facilitates the rapid processing of local, indigenous, and scientific knowledge, enabling institutions to detect early warning signals of crop failures or resource constraints, and empowering them to initiate immediate, context-specific responses before localized shocks escalate into national crises. Consequently, AG shifts the focus away from

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singular efficiency and toward deliberate, calculated redundancy that protects systems from catastrophic failure.

2.3. The Digital Turn: Data-Driven Governance and Its Discontents

The advent of digital technologies has revolutionized the capacity for evidence-based policymaking, giving rise to the paradigm of "data-driven governance." In the context of global food security, data-driven governance leverages big data analytics, the Internet of Things (IoT), artificial intelligence (AI), and high-resolution satellite remote sensing to replace intuition-based decision-making with empirical precision (Kamilaris *et al*., 2017). In developing economies, digital platforms are increasingly utilized to provide smallholder farmers with personalized agronomic guidance, early weather alerts, and real-time market pricing, which studies indicate can lower resource consumption and boost crop yields by 10% to 30% (Kamilaris *et al*., 2017). Beyond farm-level productivity, national monitoring systems utilize spatial data and algorithmic modeling to target social protection mechanisms, optimize the distribution of subsidized inputs, and monitor environmental compliance with unprecedented granularity.

However, critical literature also strongly cautions against the uncritical adoption of data-driven models, warning against techno-solutionism. Scholars warn of "algorithmic bias" which can manifest as allocative harm (withholding resources or credit based on prejudiced, automated assumptions) or representational harm (reinforcing the subordination of marginalized groups within data sets) (UNESCAP, 2019). The literature emphasizes that data infrastructures must be coupled with inclusive, participatory governance to prevent the exacerbation of existing rural inequalities, particularly the digital divide between large agribusinesses and resource-poor smallholders (UNESCAP, 2019). Furthermore, a lack of integration between computational models and sociological realities can lead to poorly structured feedback loops, where automated policies optimize for isolated, easily measurable metrics (e.g., aggregate yield) at the severe expense of broader systemic resilience and social equity. Ensuring that algorithms are audited for fairness and that human-in-the-loop oversight remains active is critical for maintaining public trust in digital governance systems.

2.4. Institutional Memory and Policy Durability

A central concern within the literature on policy reform is the concept of "policy durability." Policy durability refers to the capacity of a regulatory framework or public program to withstand political transitions, economic shocks, administrative turnover, and shifting electoral landscapes while maintaining its core objectives and operational efficacy (Hochman & Zilberman, 2023). Research on environmental and agricultural regulations highlights a dialectical relationship between durability and flexibility; a policy must be rigid enough to prevent regulatory capture by vested commercial interests, yet flexible enough to undergo iterative improvement based on new scientific evidence (Jordan & Moore, 2023). Durable policies must anchor sustainable forms of production without becoming obsolete rigidities that block deeper structural transformations over time (Folke *et al*., 2005).

The durability of food security interventions is intimately linked to the strength of "learning institutions". Higher education facilities, agricultural research boards, independent statistical agencies, and institutionalized civil society councils serve as vital repositories of technical expertise and institutional memory (Pahl-Wostl, 2009). When governments actively partner with these learning institutions to co-produce knowledge and manage data, they create structural anchors that buffer policies against the volatility of election cycles. The literature consistently demonstrates that policies crafted through broad, multi-stakeholder dialogues incorporating both Western scientific data and local indigenous knowledge systems secure greater community buy-in, thereby reducing the likelihood of abrupt policy reversals and ensuring long-term, sustainable systemic transformation (Leão & Maluf, 2012).

3. Conceptual and Theoretical Frameworks

To systematically analyze how empirical evidence and continuous learning mechanisms shape food security outcomes, this chapter relies on three intersecting theoretical frameworks: the Kaleidoscope Model of policy change, Swanson and Bhadwal's Adaptive Policy Principles, and the organizational taxonomy of learning

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loops. Together, these frameworks provide a comprehensive lens for evaluating how policies are born, how they survive uncertainty, and how they evolve.

3.1. The IFPRI Kaleidoscope Model of Policy Change

Developed by the International Food Policy Research Institute (IFPRI) with support from the United States Agency for International Development (USAID), the Kaleidoscope Model (KM) provides a robust, applied analytical framework for understanding the complex drivers of policy change within the agriculture and nutrition sectors of developing economies (Resnick *et al*., 2018). Recognizing that policymaking is rarely a linear, rational process, the model derives its name from the idea that, much like a kaleidoscope, shifting the analytical focus to different stages of the policy cycle reveals a constantly changing constellation of critical variables, veto players, and actor networks.

The KM maps the trajectory of policy reform across five distinct stages agenda setting, design, adoption, implementation, and evaluation and reform identifying 16 inductively derived, testable hypotheses regarding the proximate causes of policy change (Resnick *et al*., 2018). These primary causal variables are continuously shaped by a broader outer circle of contextual conditions, including macroeconomic shocks, changing demographics, and environmental crises (Resnick *et al*., 2018).

Table 16.1 illustrates the structural components of the Kaleidoscope Model, synthesizing the key variables and hypotheses at each stage of the policy continuum (Resnick *et al*., 2018).

Table 16.1: The Kaleidoscope Model of Policy Change

Policy Stage	Key Variables / Hypotheses Driving Change	Core Mechanism of Action
1. Agenda Setting	1. Relevant Problem 2. Focusing Events 3. Powerful Advocates	Issues gain governmental traction only when recognized as urgent (often triggered by focusing events like famines or market crashes) and championed by influential domestic or international actors.
2. Policy Design	4. Knowledge & Research 5. Norms, Biases, & Ideology 6. Cost-Benefit Calculations	Potential solutions are formulated based on available empirical evidence, heavily filtered through the ideological lens and cognitive biases of decision-makers, and weighed against political and financial feasibility.
3. Adoption	7. Proponents vs. Opponents 8. Government Veto Players 9. Propitious Timing	Formal legislative enactment depends on overcoming opposition from vested interests, navigating institutional veto points (e.g., ministries of finance), and acting during politically favorable windows.
4. Implementation	10. Requisite Budget 11. Institutional Capacity 12. Implementing Veto Players 13. Policy Champions	Successful execution requires sustained budgetary funding, bureaucratic administrative competence, and the continued, active commitment of champions to overcome bureaucratic inertia at the local level.
5. Evaluation & Reform	14. Changing Information 15. Changing Material Conditions 16. Institutional Shifts	Policies are revised, expanded, or terminated based on new monitoring data, shifts in underlying ecological/economic realities, or significant changes in government architecture.

By utilizing KM, researchers and policymakers can pinpoint exactly where an agricultural intervention is succeeding or failing. For instance, a policy might possess strong empirical backing and ideal cost-benefit ratios during the Design phase, but fail entirely during Implementation due to inadequate institutional capacity, lack of sustained funding, or the active resistance of local-level veto players. Incorporating these variables enables stakeholders to map political economy pathways carefully, moving away from purely technocratic views of policy failure.

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3.2. Swanson and Bhadwal's Principles of Adaptive Policymaking

While the Kaleidoscope Model outlines the political mechanics of how policies change, Swanson and Bhadwal's framework prescribes how policies *should be designed* from the outset to manage profound uncertainty. Based on extensive, multi-year empirical studies of water and agriculture policies in regions like Canada and India, the framework posits that static policies actively hinder a society's ability to cope with climate volatility and economic shocks (Swanson & Bhadwal, 2009).

Swanson and Bhadwal propose seven core principles for creating adaptive policies that remain robust in an unpredictable world (Swanson & Bhadwal, 2009):

1. **Integrated and Forward-Looking Analysis:** Utilizing advanced scenario planning, predictive modelling, and foresight exercises to anticipate a broad spectrum of potential future economic, demographic, and climatic conditions rather than planning for a single expected outcome.
2. **Multi-Stakeholder Deliberation:** Engaging diverse groups including marginalized smallholder farmers, agribusinesses, indigenous communities, and civil society to ensure the policy accounts for diverse practical realities and secures long-term sociopolitical consensus.
3. **Automatic Policy Adjustment:** Establishing predefined performance indicators and thresholds that trigger automatic recalibrations in policy parameters. For example, automatically scaling up emergency social safety nets or crop insurance payouts when satellite data indicates severe drought conditions, bypassing lengthy legislative debates (Swanson & Bhadwal, 2009).
4. **Enabling Self-Organization and Social Networking:** Empowering local communities, cooperatives, and farmer networks to adapt autonomously within a broad, permissive regulatory framework, fostering grassroots resilience (Swanson & Bhadwal, 2009).
5. **Decentralization of Decision-Making:** Pushing administrative authority to the lowest effective and capable administrative level (e.g., municipal or district governments) to ensure interventions are locally appropriate and highly responsive to micro-climates (Swanson & Bhadwal, 2009).
6. **Promoting Variation:** Treating diverse regional policies as a portfolio of experiments, allowing the overall system to learn which approaches yield the best results under varying conditions, thereby reducing systemic risk (Swanson & Bhadwal, 2009).
7. **Formal Policy Review and Continuous Learning:** Embedding mandatory, rigorous, and independent evaluation cycles into the legislation itself to capture lessons learned and systematically correct systemic failures, even when the policy appears to be functioning well (Swanson & Bhadwal, 2009).

3.3. Organizational Learning: Single, Double, and Triple-Loop Feedback Mechanisms

The ultimate efficacy of both data-driven governance and adaptive frameworks rests on the quality of their "feedback loops" the cyclical processes where the output of an agricultural system (e.g., crop yields, soil degradation, poverty rates) is fed back into the governance system to inform future inputs, budgets, and policy decisions (Pahl-Wostl, 2009).

Public administration and organizational theory categorize these feedback mechanisms into three distinct levels of learning depth:

- **Single-Loop Learning ("Are we doing things, right?"):** This involves routine, corrective adjustments to improve the efficiency of an existing policy without questioning its fundamental objectives or underlying logic. For example, digitizing a fertilizer subsidy program to reduce bureaucratic delays, combat corruption, and speed up delivery constitutes single-loop learning. The goal remains the same; the execution simply becomes more efficient.

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- **Double-Loop Learning ("Are we doing the right things?"):** This deeper, more transformative level of learning occurs when performance data reveals that the existing policy framework is fundamentally flawed, prompting a critical reassessment of underlying goals and assumptions. If empirical evidence shows that a fertilizer subsidy is severely degrading long-term soil health and failing to improve nutritional outcomes, shifting the entire policy focus from maximizing cereal yields to subsidizing agroecological practices and dietary diversity represents double-loop learning. This depth of learning actively changes the primary strategic aims of a governance framework.

- **Triple-Loop Learning ("Are we learning right?"):** The deepest level involves transforming the institutional architecture and epistemological foundations of learning itself. This might involve a government realizing its data collection methods are inherently biased against women farmers, leading to the establishment of new, participatory data-sharing consortiums between universities, farmers, and the state to continuously rethink how evidence is gathered, validated, and utilized (Pahl-Wostl, 2009).

Policies that achieve true durability are those institutionalized within environments capable of sustained double and triple-loop learning, ensuring they evolve intelligently rather than rigidly persisting in the face of continuous disruption. The transition from merely optimizing bad systems (single loop) to redefining structural purposes entirely (double/triple loop) remains the hardest challenge in public administration today.

4. Methodology of Evidence Generation in Policy Environments

To practice authentic evidence-based policymaking, governments, NGOs, and multilateral institutions require rigorous methodologies to ascertain the true causal impacts of agricultural interventions. This section details the primary methods used to generate actionable data, their inherent limitations in the context of developing economies, and the technological infrastructure required to support them.

4.1. The Role and Limits of Randomized Controlled Trials (RCTs)

In the aggressive push for evidence-based policymaking over the past two decades, the application of Randomized Controlled Trials (RCTs) has become a gold standard within development economics and agricultural policy (Weigel *et al*., 2021). Pioneered in the social sciences by organizations such as the Abdul Latif Jameel Poverty Action Lab (J-PAL) and the Agricultural Technology Adoption Initiative (ATAI), RCTs involve randomly assigning individuals, villages, or regional markets to a "treatment" group (which receives the intervention) or a "control" group (which does not). Because the assignment is strictly random, any statistically significant difference in outcomes between the two groups can be causally attributed to the policy intervention, eliminating selection bias. The growing volume of RCTs in this area is substantial, expanding ten-fold to over 1000 studies annually across the globe, documented systematically by the American Economic Association (AEA) RCT Registry (David *et al*., 2024).

RCTs have been instrumental in isolating the specific variables that drive agricultural technology adoption among smallholder farmers. For example, extensive field experiments and meta-analyses have empirically demonstrated that providing information or credit alone is rarely sufficient to boost farmer profits or technology uptake. Instead, evidence shows that bundling credit with weather-index insurance and tailored digital extension services significantly increases the adoption of climate-resilient seeds. Furthermore, RCTs allow policymakers to test precise variations of a policy such as comparing the effectiveness of flexible versus inflexible in-kind agricultural grants, or different behavioral "nudges" for reducing food waste before committing to a costly national rollout (McIntosh, 2024). By embracing policy experimentation, governments move beyond passive observation. Experimentation puts the manipulability of a policy to the test, uncovering behavioral nuances, unexpected cultural barriers, and implementation frictions that ex-post observational analyses frequently miss (Wang & Yang, 2021).

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4.2. Capturing General Equilibrium Effects in Scaling Interventions

Despite their unparalleled methodological rigor in establishing localized causality, RCTs present specific, highly consequential challenges when applied to macroeconomic food security policy. Small-scale experiments are notoriously resource-intensive, time-consuming, and often raise profound ethical concerns regarding the deliberate exclusion of control groups from potentially life-saving interventions in complex humanitarian emergencies.

More critically, RCTs frequently struggle to capture General Equilibrium (GE) effects the systemic, economy-wide economic shifts that occur when a program is scaled up from a pilot village to an entire region or nation. For instance, a well-designed RCT evaluating a modern seed and fertilizer subsidy might show a dramatic, highly significant increase in crop yields for the treated farmers. However, if that exact policy is rolled out nationally, the sudden, massive surge in aggregate crop production could drastically depress local market prices. This GE price effect could potentially leave farmers with lower net incomes despite their higher yields, completely undermining the policy's poverty-reduction goals. Simultaneously, a national rollout might increase the local demand for agricultural labor, driving up rural wages and altering the broader economy in ways the initial RCT could not detect.

To address these inherent limitations, modern evidence-based policymaking increasingly relies on hybrid, multifaceted methodologies. Researchers and state planners are pioneering approaches that combine the localized causal identification of experimental data with spatial and computable general equilibrium models. This synthesis allows governments to accurately forecast the distributional and systemic impacts of scaling up interventions, ensuring that policies remain effective outside the vacuum of a controlled experiment (Bergquist *et al*., 2022).

4.3. Digital Public Infrastructure (DPI) and Real-Time Data Architectures

While RCTs provide discrete, episodic evidence of what works, adaptive governance requires a continuous, unbroken flow of high-quality data to fuel automatic policy adjustments. Consequently, developing economies are heavily investing in digital infrastructures designed to capture systemic performance in real-time. The deployment of the Internet of Things (IoT) in agriculture such as soil moisture sensors, connected weather stations, and automated guided vehicles (AGVs) allows for the generation of massive, granular datasets that map resource utilization at the micro-level (Iannotti *et al*., 2024; Kamilaris *et al*., 2017). At the macro-level, Geographic Information Systems (GIS) and satellite remote sensing are routinely utilized to monitor crop health, predict localized drought conditions, map salinity intrusion, and verify environmental compliance (Badmus & Olamide, 2025).

Establishing a functional data-driven governance framework requires three foundational pillars of Digital Public Infrastructure (DPI):

1. **Interoperable Data Registries:** Moving away from siloed, paper-based bureaucratic data toward integrated national digital registries. This involves linking a national farmer identity database with real-time market pricing, mobile money payment systems (similar to Rwanda's Mojaloop integration for financial inclusion), and meteorological data (Digital Public Goods Alliance, 2023). Interoperability prevents single-point failures and ensures comprehensive analytics across previously disconnected ministries.

2. **Predictive Analytics and Decision-Support Tools:** Utilizing machine learning algorithms and multi-criteria decision analysis (MCDA) to process vast data streams, enabling proactive interventions such as dispatching early warnings or pre-positioning food aid rather than relying on reactive disaster relief (Badmus & Olamide, 2025).

3. **Institutional Capacity and Literacy:** Investing heavily in the digital literacy of civil servants, agricultural extension workers, and farmers to ensure that data insights are correctly interpreted and utilized to refine policy feedback loops without succumbing to algorithmic bias (UNESCAP,

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2019). Digital transformation must be coupled with organizational culture change to realize actual productivity gains.

5. Results and Discussion: Empirical Case Studies in Adaptive Policymaking

The theoretical imperatives of adaptive and evidence-based policymaking are best understood through their application in diverse socio-economic contexts. The following four case studies illustrate how developing economies navigate the complexities of data-driven governance, policy experimentation, and the institutionalization of learning to enhance food security.

5.1. Pakistan: Digitizing Agricultural Subsidies through the Punjab Kissan Card

Agriculture is the foundational backbone of Pakistan's economy, contributing approximately 19.2% to the national GDP and employing nearly 40% of the labor force (GoP, 2024). The province of Punjab, universally recognized as the nation's breadbasket, has historically struggled with stagnant agricultural growth. This stagnation was largely driven by outdated, blanket subsidy regimes established in the 1960s that encouraged the overproduction of water-intensive staple cereals (to achieve basic food security) at the severe expense of high-value horticulture, livestock development, and ecological sustainability (Government of Punjab, 2018).

To modernize the sector and break this path dependency, the Government of Punjab initiated the Agriculture Policy 2018, pivoting aggressively toward data-driven governance, market expansion, and direct-to-farmer support mechanisms (Government of Punjab, 2018). A cornerstone of this reform is the Kissan Card Subsidy Program (KCSP), an intervention designed to digitize the distribution of agricultural subsidies, streamline e-credit access, and eliminate corrupt intermediaries and commission agents (Yifei *et al*., 2026).

A rigorous impact evaluation of the KCSP, utilizing primary survey data from 440 farming households across highly vulnerable districts in Southern Punjab (Lodhran, Rahim Yar Khan, Layyah, and Muzaffargarh), demonstrated the profound efficacy of targeted, digitized interventions. Employing a double robust econometric approach specifically Propensity Score Matching (PSM) and Inverse Probability Weighted Regression Adjustment (IPWRA) to strictly control for selection bias the analysis revealed significant, causal improvements in household food security (Yifei *et al*., 2026).

Table 16.2 summarizes the statistical impact of the KCSP on key food security metrics, notably the Food Consumption Score (FCS) and the Household Food Insecurity Access Scale (HFIAS).

Table 16.2: Impact of the Kissan Card Subsidy Program (KCSP) on Food Security Metrics in Punjab, Pakistan

Variable	Description	Mean	Std. Dev.	T-test (Difference)
KCSP Participation	1 = if farmers participate in government subsidy program (Kissan Card), 0 = otherwise	0.404	0.483	N/A
FCS	Household Food Consumption Score (FCS)	37.824	16.069	-37.703***
HFIAS	Household Food Insecurity Access Scale (HFIAS) score	2.842	1.011	40.718
Age	Number of years	44.013	14.975	-0.339

Note: *** indicates high statistical significance. A higher FCS indicates improved dietary diversity, while a lower HFIAS indicates reduced vulnerability to food insecurity

The empirical data unequivocally indicates that households participating in the KCSP exhibited heightened dietary diversity (a higher FCS) and a statistically significant reduction in food insecurity (Yifei *et al*., 2026). Crucially, the evaluation highlighted the mediating role of digital inclusion; the program's positive impact on income and food security was highly correlated with a farmer's prior access to ICT tools and digital extension assistance (Yifei *et al*., 2026).

However, the program also revealed critical constraints characteristic of single-loop learning. While the KCSP effectively alleviated liquidity constraints for land-owning farmers, structural barriers in the digital registry systematically excluded tenant farmers who lacked formal land titles (Yifei *et al*., 2026). Furthermore, while the subsidies increased overall yields, they inadvertently incentivized the adoption of

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input-intensive, stress-tolerant crop varieties (STVs) while simultaneously reducing the uptake of ecologically sustainable practices like integrated pest management (IPM) and organic manuring (Yifei *et al*., 2026).

To facilitate the double-loop learning necessary to correct these distortions, the Punjab government leverages institutions like the Punjab Agricultural Research Board (PARB). Established to coordinate research and manage competitive grants, PARB serves as the vital institutional memory required to evaluate such empirical findings, pushing the policy agenda toward complementary nutrition interventions, expanded digital literacy, and conditional subsidies that mandate ecological sustainability (Government of Punjab, 2018). Concurrently, digital initiatives like the Groundwater Management Information System (GMIS) are a collaborative, web-based tool that aggregates groundwater-related data into a single platform to support monitoring and planning, developed using a CGIAR Scaling Readiness approach (Stifel, 2024). The collaborative framework used to build GMIS illustrates that technical conditions must be deeply intertwined with social and institutional mandates for these platforms to genuinely aid local communities.

5.2. Brazil: Policy Durability and the Institutionalization of CONSEA

Brazil's historical experience provides a profound and sobering lesson in the political economy of food security, highlighting the vital role of institutionalizing multi-stakeholder participation to achieve true policy durability. In 2003, the Brazilian government launched the *Fome Zero* (Zero Hunger) initiative, a massive, integrated social strategy that fundamentally shifted the national approach from fragmented agricultural supply management to a comprehensive, human rights-based framework for food and nutritional security.

A critical element in the architecture of Brazil's success was the re-establishment and empowerment of the National Council for Food and Nutritional Security (CONSEA) (Chmielewska & Souza, 2011). Acting as the primary science-policy interface and apex advisory body, CONSEA was uniquely structured to prevent bureaucratic echo chambers: two-thirds of its members were representatives from diverse civil society organizations (including indigenous groups, family farmers, and nutritionists), while one-third were government officials. This structure deeply embedded the principles of adaptive governance by democratizing the policy process. CONSEA facilitated continuous, structured dialogue, allowing local knowledge regarding agroecological farming, regional diets, and the lived experiences of marginalized communities to directly inform federal policy design (Chmielewska & Souza, 2011).

Under this robust, participatory governance model, transformative programs such as the National School Feeding Program (PNAE) and the Food Acquisition Program (PAA) were implemented. These programs generated a virtuous cycle of feedback by mandating that a minimum of 30% of all public-school food purchases be sourced directly from local family farms, thereby simultaneously addressing childhood malnutrition and rural poverty while circumventing massive agribusiness monopolies (Gueneau & Niederle, 2020). Through CONSEA's relentless advocacy and evidence-based lobbying, the right to adequate food was formally inscribed into the Brazilian Constitution in 2010, theoretically cementing the legal durability of the National Policy for Food and Nutritional Security (PNSAN) (Leão & Maluf, 2012).

However, the resilience of these frameworks was severely tested by extreme political shocks. Following administrative changes in 2019, the incoming government immediately abolished CONSEA and began dismantling the public food storage capacities of the National Supply Company (Conab) (Gueneau & Niederle, 2020). The sudden disruption of these key learning and coordination institutions significantly impaired the state's capacity to respond to subsequent crises, such as the COVID-19 pandemic. Without the feedback loops provided by CONSEA, emergency responses faltered, resulting in the rapid and tragic re-emergence of severe food insecurity and hunger among millions of vulnerable populations (Gueneau & Niederle, 2020).

Applying the IFPRI Kaleidoscope Model to the Brazilian context underscores a critical vulnerability: while the *Policy Design* and *Adoption* stages can achieve remarkable consensus and impact, the *Evaluation and Reform* stages remain highly vulnerable to ideological shifts in supreme *Veto Players*. The eventual, hard-fought reinstatement of CONSEA in 2023 highlights that while political discontinuity can severely fracture

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policy implementation, the deep institutional memory, empirical evidence base, and mobilization capacity residing within civil society networks are essential mechanisms for resurrecting and defending durable food policies.

5.3. China: The Political Economy of Policy Experimentation

China presents a compelling, large-scale case study of how policy experimentation is systematically utilized to resolve uncertainty and facilitate evidence-based learning. Since 1980, the Chinese government has engaged in some of the most extensive agricultural and economic policy experimentations in recent history (Wang & Yang, 2021). By actively piloting interventions such as decentralized rural governance models, agricultural tax reforms, and ecological compensation schemes before a nationwide rollout, the state embodies the principles of adaptive, sequential experimentation.

However, empirical evaluations of these experimental frameworks reveal critical nuances that complicate the direct translation of localized data into national policy. Recent comprehensive analyses of China's policy experimentation demonstrate significant political economy challenges that can distort single and double-loop learning mechanisms (Wang & Yang, 2021).

Table 16.3 illustrates the primary characteristics and structural limitations identified within these experimental policy frameworks.

Table 16.3: Characteristics and Limitations of Policy Experimentation in China (Wang & Yang, 2021)

Experimental Characteristic	Empirical Finding	Impact on Policy Learning and Durability
Positive Sample Selection	Approximately 90% of policy experiments are conducted in localities with higher-than-average economic development.	Results in severe selection bias; successful outcomes in affluent regions frequently fail to replicate in poorer, resource-constrained areas.
Resource Allocation Bias	Career-driven local politicians allocate disproportionate administrative and financial resources to ensure the pilot's success.	Creates an artificial 'greenhouse' effect; the high effort level is not sustainable or replicable when the policy is rolled out nationwide.
Interpretation Bias	The central government often interprets localized, highly subsidized successes as universally applicable mandates.	Distorts national policy directives, leading to widespread implementation failures when external validity is assumed without critical adjustment.

Note: Data synthesized from comprehensive assessments of policy experiments conducted over four decades

This case study fundamentally challenges the assumption that localized policy experimentation automatically leads to robust, durable national governance. While the active intervention and manipulation of policy treatments provide deeper engaged learning than passive observation, the political incentives of local officials actively skew the generated evidence (Wang & Yang, 2021). When career advancement is tethered to the success of an agricultural pilot, local authorities over-invest resources, generating an artificial success rate. Consequently, when the central government scales these policies without accounting for this resource bias, the resulting national frameworks often lack durability and fail to achieve their intended food security or economic objectives. This highlights a crucial double-loop learning imperative: for adaptive governance to succeed, the institutional structures evaluating the evidence must rigorously account for the political economy of how that evidence was produced (Wang & Yang, 2021).

5.4. Ethiopia: Catalyzing Transformation through the ATA

Ethiopia provides a compelling, world-class case study on the creation of specialized "learning institutions" designed specifically to catalyze evidence-based policy implementation and overcome bureaucratic inertia. Despite sustaining high macroeconomic growth rates over the past two decades, Ethiopia's agricultural sector which employs over 75% of the population, primarily on small, fragmented, rain-fed plots has historically struggled with low productivity, land degradation, and severe structural bottlenecks.

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Recognizing that traditional ministerial structures lacked the agility, cross-sectoral coordination, and advanced analytical capacity required to rapidly modernize the sector, the Ethiopian government established the Agricultural Transformation Agency (ATA) (subsequently renamed the Agricultural Transformation Institute, ATI). Functioning as a highly strategic, data-driven learning institution, the ATA was mandated to identify systemic constraints, design innovative, evidence-based solutions, and coordinate execution across various ministries and regional governments. By actively partnering with global research entities such as IFPRI to build internal capacity and utilizing robust diagnostic tools, the ATA embedded evidence-based decision-making directly into the state's bureaucratic apparatus.

A rigorous, large-scale evaluation of the ATA's interventions implemented between 2011 and 2016, utilizing high-resolution remote-sensing data combined with extensive household panel surveys, demonstrates the profound impact of scaling data-informed practices. The empirical strategy revealed that the ATA's multifaceted agricultural interventions successfully increased crop yields and significantly improved aggregate food security outcomes across the targeted regions (FAO, 2020). Furthermore, an evaluation by the UN Food and Agriculture Organization (FAO) underscored the broad macroeconomic dividends, observing that these interventions not only bolstered household-level food availability but actively sustained broader GDP growth against potential shocks by catalyzing agro-industry and transportation developments.

Interestingly, the application of causal mediation analysis uncovered critical, highly nuanced heterogeneity in the impact pathways. For the most vulnerable, resource-poor households, the agricultural interventions translated directly into enhanced food security via increased domestic food production and caloric availability. Conversely, for better-endowed, relatively wealthier households, the increased agricultural productivity allowed them to fundamentally adjust their livelihood strategies; they utilized the surplus to pursue higher-income off-farm economic opportunities without sacrificing their household nutrition or food security.

This nuanced, empirically derived understanding of differential, heterogeneous impacts is a hallmark of triple-loop learning. By maintaining a sophisticated, continuous data architecture, the ATA systematically avoids blanket, one-size-fits-all policy prescriptions. Instead, it utilizes targeted analytics to refine its operational strategies, demonstrating that centralized, highly capable, data-driven institutions can effectively bridge the massive gap between high-level agricultural policy aspirations and the complex, highly variable socio-economic realities of rural smallholders.

6. Policy Implications for Developing Economies

The synthesis of theoretical frameworks and empirical evidence presented in this chapter underscores several critical, actionable implications for policymakers, multilateral donors, and development practitioners aiming to fortify food security in developing economies. Transitioning toward adaptive, evidence-based governance requires deliberate, sustained investments in institutional design, technological infrastructure, and inclusive democratic processes.

6.1. Institutionalizing Science-Policy Interfaces (SPIs)

To transition beyond the myopia of short-term political and electoral cycles, governments must structurally embed continuous learning and rigorous evaluation into the policymaking apparatus. Developing economies should establish, fund, and legally protect independent, multidisciplinary bodies such as agricultural research boards (e.g., PARB in Pakistan), transformation agencies (e.g., ATA in Ethiopia), or participatory food policy councils (e.g., CONSEA in Brazil) that serve as permanent Science-Policy Interfaces (SPIs).

These institutions act as the vital custodians of institutional memory, conducting continuous scoping exercises, commissioning independent RCTs, and managing longitudinal evaluations to safeguard policy durability (FAO, 2020; Gueneau & Niederle, 2020). Furthermore, governments should actively partner with higher education institutions and universities. By integrating sustainable food systems research into academic curricula and funding localized pilot programs, the state can leverage universities not only to generate context-specific agricultural data but also to train a vanguard of technologically literate extension

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workers and agile policymakers (Pahl-Wostl, 2009). This creates sustainable intellectual reservoirs immune to the shifting winds of temporary political leadership.

6.2. Fostering Adaptive Sequential Experimentation

Governments and international donors must fundamentally shift their mindset to treat policy implementation not as a finalized endpoint, but as an ongoing, iterative experiment (Wang & Yang, 2021). Scaling agricultural interventions should systematically incorporate phased rollouts and Randomized Controlled Trials (RCTs) to rigorously evaluate effectiveness, behavioral responses, and cost-efficiency before committing to a national deployment.

However, explicitly recognizing the limitations of localized RCTs in capturing macroeconomic distortions and general equilibrium effects, policymakers should adopt "adaptive sequential experimentation" (Bergquist *et al*., 2022). This involves creating regulatory sandboxes or innovation policy labs where novel interventions such as digital subsidies, localized food procurement mandates, or climate-index insurance are carefully piloted in specific ecological zones (OECD, 2025). By combining experimental field data with predictive computable general equilibrium models, authorities can accurately anticipate how an intervention will affect regional commodity prices, labor wages, and environmental thresholds, allowing them to proactively mitigate adverse ripple effects before a full-scale, irreversible launch.

6.3. Mitigating Algorithmic Bias in Data-Driven Governance

The effective, rapid administration of modern agricultural policy is intrinsically linked to the quality and equity of its underlying data infrastructure. Developing nations must invest heavily in the digitalization of rural economies, ensuring that extension services, market intelligence, and subsidy delivery are supported by robust, interoperable Digital Public Infrastructure (DPI) and data registries.

Crucially, however, data-driven governance must be managed ethically and transparently to prevent the exacerbation of rural inequalities. Policymakers must be hyper-vigilant against algorithmic biases that could result in allocative harm, ensuring that historically marginalized populations such as tenant farmers without formal land titles, women producers, or ethnic minorities are not systematically excluded from digital platforms, credit algorithms, or subsidy registries (UNESCAP, 2019). To achieve this, technological deployment must be accompanied by community-based participatory design models, ensuring that data architectures are transparent, highly accountable, and that local farmers have a definitive voice in how their information is collected, utilized, and governed (Leão & Maluf, 2012).

6.4. Designing for Durability Through Multi-Stakeholder Consensus

Finally, the longevity, resilience, and ultimate success of any food security policy depend heavily on the breadth and depth of its political and social foundation. Applying the core principles of adaptive policy, governments should consistently engage in broad, formalized multi-stakeholder deliberations during the earliest phases of policy design (Swanson & Bhadwal, 2009).

Actively including civil society organizations, private agribusinesses, marginalized indigenous producers, and technical experts in the drafting and continuous monitoring process as powerfully demonstrated by the early successes of Brazil's CONSEA ensures that the policy addresses actual ground-level realities and secures widespread sociopolitical legitimacy (Gueneau & Niederle, 2020). When a policy represents a negotiated, deeply rooted consensus rather than a unilateral, top-down mandate, it cultivates a protective, highly mobilized network of advocates. These networks serve as the ultimate guarantor of policy durability, capable of defending the framework and its learning institutions against arbitrary reversal during periods of severe political turbulence or administrative turnover (Chmielewska & Souza, 2011).

7. Conclusion

As developing economies confront an unprecedented era characterized by systemic macroeconomic volatility, demographic shifts, and rapidly escalating climate pressures, the traditional, rigid architectures of agricultural administration are no longer sufficient to guarantee national food security. The transition to

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adaptive and evidence-based policymaking represents a vital, non-negotiable evolutionary step, moving away from ideologically driven, static mandates toward highly dynamic governance systems capable of continuous learning, rapid recalibration, and proactive crisis management.

By deeply grounding policy design in robust empirical methodologies ranging from randomized field experiments to real-time digital monitoring and predictive analytics governments can accurately identify and scale the specific interventions that demonstrate nutritional diversity, enhance rural livelihoods, and protect fragile ecological thresholds. Analytical frameworks such as IFPRI's Kaleidoscope Model and Swanson and Bhadwal's adaptive design principles offer actionable, evidence-backed blueprints for navigating the complex political economy of reform, ensuring that policies are not only successfully adopted but systematically evaluated and iteratively refined.

Ultimately, the durability and success of these frameworks rely absolutely on the cultivation and protection of strong, inclusive learning institutions. When states empower specialized agricultural transformation agencies, leverage the rigorous research capacity of higher education, and legally institutionalize the participation of civil society in the governance process, they create resilient, shock-proof networks. It is only through this deep synthesis of rigorous scientific evidence, decentralized administrative adaptability, and broad, democratic social consensus that developing economies can forge enduring agricultural policies capable of nourishing future generations in an increasingly uncertain world.

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