Julius J. Okello
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Behavioural Interventions and Agricultural Innovation

Evidence-Based Strategies to Drive Technology Adoption

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To the smallholder farmers, pastoralists, extension workers, and community leaders across Africa and Asia whose daily decisions inspired this work.

Your quiet wisdom, resilience, and lived realities taught us that agricultural innovation is not only about better technologies, but about better understanding people.

Foreword

Improving our understanding of human behaviour is one of the frontier challenges facing the agriculture and food research community, where we are all motivated by delivering impact for those most in need. Yet, our supply system for science, technology, and innovations is not well designed for foresight or feedback that allows tailoring of innovations that engage positively with human behaviour. The agriculture and food systems research communities that strive to improve the livelihoods of smallholder farmers have over decades experienced that apparently robust technologies or innovations failed to scale sufficiently to generate the needed impacts.

While human behaviour has been identified as a key bottleneck for successful scaling and adoption, the successful application of the behavioural sciences to understanding the interplay between innovations and smallholder farming households and communities has been limiting. This book is particularly exciting and timely, because it addresses this key knowledge gap, by bringing together the key thinkers and practitioners in behavioural sciences and economics in an integrated manner that advances our collective understanding of the challenge and opportunity of applying behavioural research to accelerate the adoption of livelihood-changing agricultural innovations.

Engaging with human psychology and behaviour that dictates the likelihood, speed, and nature of adoption of innovations requires moving beyond rational cost-benefit thinking, while realising that behaviour will always depend on the social, economic, and cultural contexts within which the person exists. When we present scientific advances or innovations as "solutions" how do we engage with the plethora of behavioural factors that dictate whether the solution delivers the necessary value for its intended end-users? Such factors are many, and include behavioural frictions, defaults, choice architecture, social norms, peer and identity effects, present bias, time inconsistency, trust, credibility, messenger effects, misperceptions, emotions, cognitive bandwidth, habit, persistence, and incentives, amongst others.

This book demonstrates that behavioural science and economics provides a powerful toolbox for co-development of agri-food innovations that have higher odds of impact. The consideration of (and experimentation with) concepts such as bounded rationality, heuristics, prospect theory, preference dynamics, social preferences, framing, dual-process thinking, and salience, along with nudge and choice architecture, has real potential to improve the effectiveness and impact of agri-food research for development.

To deliver the impact that is urgently needed in agriculture and food systems, behavioural science and economics has much to offer, particularly if we are to develop the types of innovations where the easiest option becomes the most powerful intervention. We must not forget that the most effective innovations will succeed by fitting into lives, not by demanding new ones.

I would encourage all within the agriculture and agri-food communities of practice to engage with this book, as it provides a much-needed opportunity and impetus for accelerating more effective adoption of agri-food innovations.

Charles Spillane
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Preface

Agriculture is again at a moment of global anxiety—an anxiety reminiscent of the 1960s, when fears of mass hunger helped to trigger the Green Revolution. Today's concern is not simply about producing more food, but about producing it under harder conditions: shrinking natural resources, increasing climate shocks, growing conflict-driven disruptions, and persistent malnutrition and hunger. At the same time, the global aspiration to end poverty and hunger by 2030 is quickly slipping away with every passing day, and the Sustainable Development Goal 2, Zero Hunger, is unlikely to be met. Against this daunting backdrop, demand for food is projected to rise sharply by mid-century, while many food systems—especially in low- and middle-income countries—remain fragile and unequal.

Yet the most puzzling feature of this moment is not the lack of innovation. Agricultural research organisations, national programmes, private firms, and development partners have generated vast pipelines of improved seed varieties, disease-control tools, agricultural practices, and digital services. Indeed, for decades, the dominant challenge has been understood as one of supply: develop agricultural innovations and deliver them efficiently to farmers. But a stubborn reality continues to confront researchers and development practitioners alike: adoption of innovations remains disappointingly low. For many innovations, uptake levels plateau far below what would be required to shift productivity, resilience, nutrition, higher incomes, and poverty at scale. In some cases—particularly for specific crops or varieties—adoption is extremely low, less than 40%, even after substantial investment in promotion, input distribution, and extension.

This book begins from that tension: transformative innovations emerge daily, yet the majority languish unused while the problems they could solve persist. What's breaking down between invention and impact?

Our starting point is a simple observation that is now increasingly difficult to ignore: adoption is not only a technical or economic process; it is also one deeply rooted in human behaviour. Farmers and consumers do not make decisions in the ways that standard "perfect rational utility maximising" models often assume. Decisions are, instead, shaped by habits, emotions, trust, social norms, culture, identity, time preferences, and perceptions of risk—especially in environments marked by risk and uncertainty, market constraints, and resource scarcity. These human dimensions are not "noise", as they tend to be treated; they are often decisive.

The idea that behavioural science could strengthen efforts to stimulate adoption of agricultural innovations did not originate for us in a theoretical debate, but in a practical struggle—one rooted in food, culture, and lived experiences.

Julius Okello vividly recalls listening to presentation that focused on the application of nudge theory to influence consumer behaviour at the American Applied Economics Association meeting in San Francisco, USA, in 2015. David R. Just from Cornell University was giving a Keynote talk titled "Why Choice Matters and Why It Doesn't: An Application to Food Policy" in a Post Conference Workshop named "Applying Behavioural and Experimental Economics to Food and Agri-Environmental Issues." David presented very compelling findings on the use of nudge theory to influence children's food choices in American public schools with the aim of combating obesity. His talk drew from Cornell University's Smarter Lunchrooms Programme which he co-directed. At the very same time, our teams in the global South were grappling with a different but related problem: how to jump-start the adoption of Orange-fleshed sweet potato (OFSP) varieties by encouraging the consumption of OFSP-based foods—a proven strategy for combating Vitamin A deficiency. The scientific case was clear; the nutritional promise was real. But consumers, who doubled up as producers/farmers, resisted.

In Osun State, Nigeria, OFSP was introduced through school feeding programme, partly on the logic that children can act as change agents in shaping household preferences towards increased consumption of this novel innovation and thereby increase the adoption of OFSP. OFSP was served in mashed form alongside a popular staple, fufu. The reality in the lunchroom was revealing. Many children filled up on fufu first. Then—perhaps not wanting to appear disrespectful or to "disappoint the visitors"—some would dispose of the mashed OFSP rather than eat it. In one memorable account, the OFSP was said to be tossed out of the lunchroom window, a small act of resistance that captured a bigger truth: an innovation can be nutritionally superior and still be socially unaccepted. Texture and taste mattered. Norms and what other kids eat mattered. Expectations mattered. The barrier was not the ignorance of nutrition advantage of OFSP; it was behaviour.

I asked David R. Just a direct question after his presentation: could we test nudges in a low-income setting, such as Nigeria, to see whether behavioural interventions could reduce resistance and waste and encourage consumption? He agreed, and was joined by Carl-Johan Lagerkvist, of Swedish University of Agricultural Sciences, who examined whether positive eating experiences versus eating for health benefits/nutrition outcomes mattered. Delays meant that our first tests were conducted in Ethiopia before later work in Nigeria. In Ethiopia's school feeding context, OFSP was served alongside injera, a popular food, and our design focused on whether nudges could reduce food waste linked to OFSP being left uneaten. The point was not to "force" children to eat, but to examine whether small changes in choice architecture—simple, ethical, low-cost behavioural cues—could produce measurable improvements in consumption of OFSP.

Those early studies were pioneering in African agricultural context: they brought behavioural tools that had proven influential in other sectors (education) and regions

(developed-country) into the highly contextual, resource-constrained realities of low- and middle-income countries.

Then the question evolved.

A few years later, in Uganda, a donor-supported initiative faced a related challenge, but now on the production side: adoption of improved sweetpotato varieties by farmers was poor, and OFSP varieties were among the most affected as farmers preferred older landraces, despite they being less productive. The same sensory issues—softness when boiled and taste—were again impediments, but the problem was larger than taste and softness. It became clear that farmer adoption decisions were shaped by multiple behavioural factors: culture, social norms, risk perception, distrust of seed systems, reliance on landraces, and the powerful pull of "what we have always done".

Hugo Campos, then Director of Research and Innovation at the International Potato Center (CIP), pointed out the insight that helped shape this volume: if behavioural forces can hinder adoption of quality seed of improved sweetpotato varieties, can behavioural interventions be designed to address them—at the farmer level, across a major sweetpotato growing districts, and with an eye towards scalability?

That challenge led to a rigorous district-wide study focusing on Amuria, in Uganda's Teso region—one of the country's most important sweetpotato-producing areas, where we designed behavioural studies targeting farmers rather than consumers. David R. Just joined the CIP team led by Julius Okello. Later, in neighbouring Katakwi District, additional behavioural interventions were tested in collaboration with Carl-Johan Lagerkvist from Swedish University of Agricultural Sciences, this time focusing on social incentive nudges.

"The results defied easy summary. Indeed, nudges showed promise—but they also revealed a more nuanced truth about behavioural intervention. Effects were rarely clean: positive in one setting, null in another, occasionally harmful in a third. We watched nudges fail to boost adoption yet still alter diffusion networks in unexpected, positive ways. Each study underscored the same uncomfortable reality: without rigorous design and deep contextual understanding, even well-intentioned interventions can misfire.

That tension gave birth to this book.

Behavioural interventions in agriculture are still nascent in many developing country settings, even though they have transformed thinking in health, education, public finance, environmental management, and other policy domains. There is now a growing body of evidence showing that farmers respond to salient behavioural cues. Yet much of the influential behavioural work—particularly at scale—has occurred in high-income/developed country settings or has focused heavily on consumers. The adoption challenge in smallholder agriculture, however, is shaped by conditions that demand special attention: social norms, risk and uncertainty, thin markets, weak extension systems, gendered constraints, and deeply ingrained cultural embeddedness. These conditions do not reduce the relevance of behavioural tools; indeed, they heighten it, while also making design more delicate and context-dependent.

This volume therefore offers perspectives from low- and middle-income countries, focusing largely on farm-level decisions and smallholder contexts. The book is organised to move from foundations of behavioural science to application, and from single-study insights to synthesis. Part I provides conceptual grounding and frameworks for understanding nudges in agriculture. Part II explores behavioural drivers such as procrastination, psychosocial constraints, cultural norms, and social learning in adoption and diffusion. Part III examines extension, communication, and digital nudges—including mobile phone-based text message reminders, promoter farmer models, and participatory digital platforms. Part IV then synthesises what has been learned and considers how to design and evaluate behavioural interventions, and generalise evidence responsibly.

Three commitments guide this book.

First, we aim to treat farmers and other agricultural actors not as passive recipients of technology, but instead as decision-makers navigating complex lives. Adoption choices sit alongside many other demands, risks, and social obligations. Behavioural design must be grounded on context and reality.

Second, we aim to contribute evidence that is rigorous yet useful. The book reflects the view that behavioural interventions, when ethically deployed, can be low-cost complements to conventional instruments such as subsidies, infrastructure, and extension. Yet we also recognise that nudges are not a silver-bullet. They do not substitute for functioning markets, stable institutions, adequate supply systems, or supportive national policies. Their value lies in resolving behavioural bottlenecks that prevent existing investments from translating into real uptake.

Third, we aim to be honest about context, limits, and ethics. Nudges must respect autonomy and avoid manipulation. They must be tested with stringent statistical power, transparently reported, and evaluated with a view towards scaling. This includes recognising that average effects may be modest, but still policy-relevant when cost-effective and scalable.

Ultimately, the purpose of this book is to help close the long-standing gap between innovation development and widespread use/adoption. If agricultural development is to succeed in improving the quality-of-life of millions of people that depend on agriculture—especially under climate pressure, global uncertainty, and rising food demand—it will need not only better technologies, but better strategies for encouraging adoption. Behavioural insights are not a replacement for agronomy, plant breeding, economics, or institutions; they are an essential complement.

We offer this volume for three audiences grappling with the same question—how to turn knowledge into action. For policymakers: tools that work within budgets and political realities. For practitioners: designs that hold up when they meet real farmers in real villages. For scholars and students: a foundation for research that refuses to dissociate behavioural insight from agricultural context.

We are grateful and indebted to all chapter authors for their scholarship and collaboration, and to the many farmers, extension agents, enumerators, community leaders, local government staff, and institutions across Africa and Asia whose engagement made this work possible. We hope the ideas and evidence assembled

here will inform better design of agricultural interventions in general, smarter evaluation, and more human-centred innovation pathways—so that agricultural technologies can deliver on their promise of increasing productivity, resilience, nutrition, equity, social inclusions, and ultimately better quality of life to agricultural populations.

Our aspirations have been realised with this volume: The tools are here. The issues have been framed and the evidence assembled. Design interventions with rigor. Evaluate them honestly. Put farmers—their contexts, their constraints, their wisdom—at the heart of every innovation pathway. Because when we get this right, the payoff isn't incremental. It's transformative: farms that feed families and communities, food systems that withstand shocks, lives marked by dignity and opportunity rather than precarity, human-centred innovation pathways achieving impact on a large scale. That future is within reach. Go claim it.

Kampala, Uganda — Julius J. Okello
Ithaca, NY, USA — David R. Just
Lima, Peru — Hugo Campos
Uppsala, Sweden — Carl-Johan Lagerkvist
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I owe profound appreciation to my family—my wife, Ruth Mutuli, and my children, Dr. Shaddi Achieng, Imane Juma, and Engineer Shalord Tito—for their patience, understanding, and resilience throughout the demanding process of research and writing. Their ability to thrive despite my absences during fieldwork, late-night meetings across time zones, and weekends devoted to writing was a source of strength and inspiration.

Finally, I acknowledge with reverence the grace of God, to whom belongs all the glory. This book is a testament to His gift of life, good health, and providence.

Hugo Campos I'm grateful to the International Potato Center for creating space where curiosity becomes research, questions become impact. To Julius, David, and Carl-Johan: despite being scattered across continents and thousands of miles, editing this book felt less like work and more like a journey of discovery—thank you for your patience with my missteps and delays. To the Gates Foundation: its support has enabled my contribution to improving the livelihoods of farmers growing root, tuber, and banana crops across Africa and beyond.

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About the Editors

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Hugo Campos serves as Deputy General Director—Science & Innovation at the International Potato Center in Lima, Peru. With a PhD in Plant Genetics from the John Innes Centre (England), an MBA from Universidad del Desarrollo (Chile), and a Professional Certificate in Innovation & Entrepreneurship from Stanford

University (USA), he bridges science and business with fluency and has earned the World Food Prize Organization's Top Agri-Food Pioneer Award (2025), a Lifetime Achievement Award from the International Society for Root and Tuber Crops (2025), and recognition as a Foreign Fellow of India's National Academy of Agricultural Sciences. Over 1,000,000 copies of his books have been downloaded or sold. He started his career as plant breeder, serving diverse markets in private companies and in international development, and over the years his interests have pivoted to a wicked problem: the adoption gap that keeps Global South farmers from embracing innovations and the role of behavioural sciences in reducing such gap.

Carl-Johan Lagerkvist is Professor of Business Economics at the Swedish University of Agricultural Sciences (SLU) in Uppsala, Sweden. He has a PhD in Economics from the Swedish University of Agricultural Sciences. He was Head of Department of Economics at SLU during 2008–2022. He served as editor of the *European Review of Agricultural Economics* during 2017–2022 and is on the editorial board of *Food Quality and Preference*. His research deals with behavioural decision-making, often from a consumer or farmer perspective. His research is directed towards theoretical or methodological aspects and often in relation to preference elicitation, choice analysis, issues of risk and uncertainty, as well as financial and investment aspects. He has a long-standing cooperation with different CGIAR centres, i.e. WorldFish, CIP, and ICRISAT.

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Part I

Foundations of Behavioural Interventions in Agriculture

1 Behavioural Interventions and Adoption of Agricultural Innovations: Perspectives from Low- and Middle-Income Countries—An Introduction to the Book

Julius J. Okello, Hugo Campos, David R. Just, and Carl-Johan Lagerkvist

Abstract

There is growing anxiety over global food security, akin to that of the 1960s, driven by predictions that food demand will rise 35%–50% by 2050. Despite the CGIAR investing an estimated $60 billion into agricultural research between 1970 and 2020, adoption rates for high-yield innovations—like improved seeds and vaccines—remain stubbornly low, often below 40%. This dismal performance is attributed to the failure of the traditional "rational" economic models to account for the human element that dictate farmer behaviour hence innovation uptake such as the psychological biases, social norms, and cultural contexts. In this book, we demonstrate the role that behavioural science interventions can play in stimulating adoption of best-bet agricultural innovations. This book argues that the application of nudge theory—a behavioural science approach that uses low-cost, subtle cues to influence decision-making without restricting choice—can contribute to increased innovation use among smallholder farmers in low- and middle-income countries. While successfully applied in health and finance and developed countries, its use in developing-country agriculture is nascent but promising. By shifting focus from purely technical solutions to behavioural "nudges" like text message reminders or social signalling, this book aims to provide a framework for jumpstarting productivity. Its main premise is

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that understanding the cognitive and social processes of smallholder farmers is essential to achieving inclusive, sustainable, and equitable global agrifood systems.

Keywords

Global food security · Adoption of agricultural innovations · Behavioural science · Nudge theory · Smallholder farmers · Low- and middle-income countries

1 Introduction

There is growing anxiety over whether agriculture and the global agrifood systems can supply food needs of future populations. This anxiety is like that of the 1960s, which is credited with inspiring the green revolution. It relates to the prediction that demand for food will grow by 35% to 50% between 2010 and 2050, which is just less than one-quarter century away (van Dijk et al., 2021). Evidence points to the failure of the world to meet global aspirations, including eradication of poverty and hunger by 2030. Malekpour et al. (2023) for instance indicate that 575 million people are living in extreme poverty, while 600 million others will be facing hunger. Ishtiaque et al. (2024) argue that by 2050, South Asia, where the green revolution started, will become one of the most food-deficient regions globally.

The concerns about the capacity of the global agrifood systems to meet the increased food demands stem from the recent and ongoing negative global trends. First, the increase in food production is expected to exert heightened pressure on the natural resource base, especially land, thus undermining productivity (Araújo et al., 2023). Second, global insecurity resulting from armed, violent conflicts affects food distribution and trade and is likely to continue undermining food security through, among others, destruction of agricultural land and infrastructure, and the conflict-induced displacement of people (Kemmerling et al., 2022). Third, climate change is expected to deepen food insecurity by raising temperatures, aiding the outbreak and rapid spread of pests and diseases and exacerbating extreme weather events leading to productivity decline (Abdullahi et al., 2024). Fourth, and most relevant to this chapter, is the disappointingly low rate of adoption of agricultural innovations among smallholder farmers (Perosa et al., 2021; Reich et al., 2021; Suri & Udry, 2022; Habtewold & Heshmati, 2023; Ayalew & Girma, 2025).

Agricultural innovations are embodied technologies that are incorporated in agricultural inputs such as seeds, breeding stocks, livestock management practices, chemical inputs such as fertiliser and pesticides, agronomic practices such as seed rate, plant spacing, and crop rotation, and equipment like irrigation pumps (Lau & Yotopoulos, 1989; Ruttan & Hayami, 2015). They are therefore designed to boost productivity by increasing output per unit of land area or per cattle. Technological change resulting from the use of such innovations has been associated with productivity growth in agriculture (Ruttan & Hayami, 2015; Pellegrino et al., 2019). However, long-term productivity growth has slowed down as agricultural land declines due to population pressure and conversion to other land uses (Fuglie, 2018; Sadigov, 2022). More broadly, Fan

and Cho (2021) and Fan and Otsuka (2020) report that pressure on land has resulted in very low total factor productivity in all developing-country regions, with Sub-Saharan Africa recording the slowest growth. The decline and slow growth are attributed to the low use of improved crop varieties, in the case of crop production, and land fragmentation resulting from continuous subdivision of land parcels.

Focusing specifically on adoption of seed of improved varieties, studies document an adoption ceiling of 40% for the majority of the farmers in developing countries. For instance, McEwan et al. (2021) find an adoption rate of less than 40% for vegetatively propagated crops, small grains and legumes in Africa. Rahman et al. (2022) report a 12% adoption rate for flood-tolerant rice varieties developed by the International Rice Research Institute in Bangladesh. Ilukor et al. (2025) find that only 3.1% of smallholder farmers grow orange-fleshed sweetpotato in Uganda and that the share of farmers growing improved sweetpotato varieties in general is 10%. Mishra et al. (2022), using a small sample survey of 304 households, however, report that only 24% of the respondents were planting WITA 9, a rice variety bred by AfricaRice to tackle rice yellow mottle virus (RYMV) disease. Clearly, the use of productivity-enhancing crop innovations has been disappointingly low.

The low use of agricultural technologies by farmers occurs against the backdrop of years of effort (financial, programming, and development) aimed at improving the delivery of innovations to smallholder farmers. It is, for example, estimated that the CGIAR spent USD 60 billion between 1970 and 2020 in generating new elite fit-for-purpose agricultural innovations (Alston et al., 2020). In 2017 alone, the CGIAR[1] reported that it produced 616 innovations, about one-half of them in genetic innovation (CGIAR, 2018). In 2020, the CGIAR programme on Root Tubers and Bananas, one of the several collaborative research programmes implemented between 2011 and 2019, reported 34 new innovations. These innovations do not include those generated by the national research programmes/institutes in developing countries. Hence, the low use of agricultural technology by farmers is not due to lack of innovations. Indeed, since the 1960s' green revolution, agricultural research centres have continuously added to the volume of innovations available to farmers, and significant scientific progress has been made in most crop and livestock subsectors of developing countries. The question then is: why is adoption of agricultural innovations so low among smallholder farmers? What strategy can be used to promote their adoption? What can be learned from areas other than agriculture to increase the rate of innovations adoption? That is, what is it that the current strategy of putting innovations into the hands of the main users lacks?

2 Historical/Theoretical Perspective

Suri and Udry (2022) argue that progress in agriculture that is necessary to improve the quality of life of farmers and other value chain actors who rely on it cannot be achieved without increased use of agricultural technology. Indeed, Esther Boserup's[2]

[1] https://www.cgiar.org/cgiar-system-annual-performance-report-2017/

[2] Boserup, E. (2014). The conditions of agricultural growth: The economics of agrarian change under population pressure. Routledge. See also (Robinson & Schutjer, 1984; Boserup, 1991, 1996).

theory posits that tackling the problem of food insecurity requires intensification of agricultural production, which in turn requires using improved technologies. Boserup's theory was developed at a time of intense anxiety over the rapid increase in human population, with food production and supply not rising at a commensurate rate, just as in the current case. It was a response to Thomas Malthus' prediction that mass starvation would occur because of agriculture's inability to sustain continued population growth, famously referred to as limits of growth. The theory argued that "limits to growth" can be overcome by unleashing the power of agricultural innovations in food production (Lipton, 1989; Soby, 2017).

In the 1970s and 1980s, Yujiro Hayami and Vernon Ruttan developed the theory of induced innovation to demonstrate how limitations/constraints to agricultural production because of scarcity of one or more of the factors of production induce innovation that fosters intensification using the more relatively abundant factors (see Ruttan & Hayami, 1984, 2015). Their theory anticipated that population growth would exert pressure on agricultural land thus making it relatively scarce, hence more expensive than other factors of production. In this case, agricultural development would shift towards using the less scarce factors of production that "substitute" for land by increasing production per unit of given land. They referred to this process as "induced technical innovation", in which inputs that embody technological improvements such as improved seed variety, pesticide, or fertiliser would be used by countries that face land scarcity to increase production per given unit of land.

The induced innovation theory was later extended to cover instances where constraints to productivity increases were not necessarily caused by technical matters, thus explicitly recognising social dimensions of innovation use (Ruttan & Hayami, 1984; Ruttan, 2006, 2010, 2016). The extension focused on the role of institutions and gave rise to the theory of induced institutional innovation (Ruttan & Hayami, 1984). Kikuchi and Hayami (1980), for instance, argue that human behaviour-driven institutions—such as land tenure system and labour contracting—are induced endogenously by the desire of farmers/agricultural actors to increase production and "establish claims to larger income shares" (pg 21).

The linking of innovation use with human behavioural aspects marked a significant departure from the hitherto mainstream thinking that was driven by the neoclassical economics paradigm. The paradigm framed use/adoption of innovations in terms of profit maximisation (Mulder et al., 2001; Sredojević et al., 2016; Khanna and Miao, 2022). Farmers would therefore adopt an innovation if it generates higher benefits/returns (in terms of revenues) than the existing technologies. It is a paradigm that is now widely viewed as falling short in explaining innovation use behaviour by farmers (Lynne, 1995; Weersink & Fulton, 2020; Naeher, 2022; Wuepper et al., 2023).

Everett Rogers, in his seminal work on technology diffusion and adoption, argues that human behaviour plays a key role in innovation use (Rogers, 1962). He posits that the adoption of innovations is a cognitive process that spans several stages, from awareness of the innovation to the decision to test it out. He argues that this process is affected by the information available to the user (Rogers, 2004). Okello et al. (2018

and 2019) argue that the adoption process is influenced by psychological, cultural, and social factors in which personal motivations in the form of life goals play a key role. They argue that neoclassical economic theory's profit maximisation is only a means to an end, and the end goal of the decision to adopt new innovations is influenced by mental processes. In tandem with Rogers (2004) and Okello et al. (2018, 2019), Leeuwis and Aarts (2020) treat the adoption of innovations as a social process that is influenced by human personality traits, including conscientiousness, neuroticism, attitude, human values, and normative beliefs. Leeuwis (2004) further argues that the adoption of innovations cannot be understood in isolation from the plurality of behaviours and decisions a person has to make and the environment in which one operates.

The recognition of the role human behaviour plays in the adoption process therefore shifts focus from the traditional extension approach, which relies on public extension provision, to non-traditional strategies of demonstrated success in economic beyond agriculture. One such approach with much promise is the use of nudge theory and behavioural economics to encourage (i.e. nudge) farmers to use new innovations. Nudges use simple changes in the framing of choices to direct decision-making in predictable ways, without limiting the choice set. Often, nudges can be extremely inexpensive and thus scalable even in a resource-poor environment. Can nudges and similar behavioural interventions be used to accelerate innovation adoption? Recent studies conducted in developing countries in family farm environments seem to suggest so.

The use of nudges and behavioural interventions in agriculture is nascent. However, nudge theory has been successfully applied in other sectors of the economy following the seminal work by Thaler and Sunstein (2009). The theory has been successfully used to influence behaviour in health, education, public finance, environmental management, and food industry, among others. One of the latest examples of large-scale/national application of nudges was in the health sector in the United Kingdom when the British government used the theory to respond to the COVID-19 pandemic. In the education sector, in the USA and later in Europe, nudges have been used to address the problem of obesity among school children. A classic example of deployment of nudges in the education sector is the Smarter Lunchroom programme pioneered by Cornell University (Just & Gabrielyan, 2016). Nudges that promote health-promoting choices and lifestyle have also been adopted and are widely accepted by several countries in Europe (Reisch et al., 2017). Additionally, nudges have been successfully applied in public finance focusing on tax compliance; environment and resource management targeting water, pollution, and waste management; and energy sector to reduce electricity consumption. The widespread acknowledgement of the potential nudges have in influencing human behaviour at the national level has led to steady growth in nudge units/departments in developed countries (Tor, 2020; DellaVigna & Linos, 2022; De Ridder et al., 2024) and affirmation of its novelty by the award of the Nobel Prize in economics in 2017 to Richard Thaler, the originator of the theory. DellaVigna and Linos (ibid) indicate that by 2021, there were more than 200 nudge units established by governments globally.

In agriculture, nudge theory was first applied by Duflo et al. (2008) in a seminal experimental research on the effect of present bias nudges on fertiliser use by

smallholder farmers in Kenya. She was similarly awarded a Nobel prize in 2019 for her experimental approach to alleviating poverty, which included the use of nudges in agriculture. Since then, scholars—typically using experimental methods—have tested a wide array of nudges in many subsectors of agriculture in developed countries. Almost universally, the studies have shown that farmers respond to sufficiently salient nudges. A few key examples include: framing forgoing irrigation as a loss increased irrigation water use/management efficiency, disclosing neighbour use of water reduced water consumption by the heaviest users, a suite of simple nudges increased compliance with non-point source fertiliser-based pollution, picture-based and social comparison nudges promoted farmer land retirement, social norm and status signalling increased the use of ICT-based agricultural innovations, and insurance information nudges increased uptake of farm insurance. Most of these effective interventions involve simple disclosure of information at the point of decision. While responses to nudges have mostly been positive, there are several examples of nudges that have backfired or led to nuanced and varied responses. A good example is from the recent study by Okello et al. (2023), which found that social incentive nudges reduced the use of agricultural innovations in Uganda. Sunstein (2017), Tor (2020), and De Ridder et al. (2024) discuss the types of nudges that fail to achieve the intended goal and why. They indicate that failure in nudges can arise from several causes, among them the statistical power, the complexity of public policy implementation procedures, and the context in which the nudges are applied.

One question that has until recently remained untackled in the behavioural interventions literature is that of what happens when one moves from the often context-specific studies to applying nudges at scale. DellaVigna and Linos (2022) address this question in a unique collaboration between academia and two government nudge units, which provide them with access to a large dataset involving 165 trials testing 347 nudge treatments and affecting almost 37 million participants. The study compares the impact of nudges under the restricted academic studies and those deployed at scale (by the governments). The findings are promising. They indicate that though nudges generate a smaller impact at scale (by a factor of 1/6th), the impact is highly significant and results in nearly 9% increase in outcomes compared to the control group. This finding underscores the well-known phenomenon in nudge interventions, namely that the impacts tend to be small in size. El Benni et al. (2026) explain that the efficiency and effectiveness of nudges are greatly influenced by public policy. How a specific nudge performs depends on its interactions with existing policy instruments and farmers' reactions to a mix of existing policies. El Beni et al. (ibid) therefore recommend randomised controlled trials that specifically focus on the effects of nudges under real policy context.

3 Aims

This book explores the use of nudge theory/behavioural interventions to promote agricultural innovations to jumpstart productivity growth in developing-country agriculture. Its premise is that even when technology is right and the farm environment in which it is to be deployed is known, behavioural factors could still hinder

and slow down its adoption. The aims of this book are fivefold: (i) provide an updated framework for the use of nudge theory in stimulating innovation use in agriculture in the low and medium income countries of the global South (ii) bring together into one volume recent evidence of application of nudge theory under smallholder farmer conditions in the global South, (iii) synthesise the evidence to highlight major implications for practice and policy, (iv) guide scholarly design of studies gathering rigorous-based evidence about the efficacy of nudges, and (v) serve as reference material for policy makers, scientific leaders and scholars of applied behavioural research.

4 Scope

This volume brings together evidence from developing countries focusing on Africa and Asia, two regions that face the highest incidence of malnutrition and hunger, as well as rapidly growing populations in a context where anthropogenic climate change is dampening global agricultural productivity and continuous expansion of agricultural land (Ortiz-Bobea et al., 2021). It presents evidence from a wide range of contexts—crop and livestock farming, risk management instruments, information, urban and peri-urban farming. We limit ourselves to the farm level and smallholder farmers' aspects in which the application of nudges is relatively new. Interest in applying nudges at the consumer level is also growing in developing countries. While noteworthy, such studies and their evidence fall beyond the scope of this book.

5 Definitions

The concept of nudges is used and defined differently by different authors. Throughout this volume, we define nudges as an intervention that seeks to change behaviour without altering the choice set, and without applying incentives associated with available choices. This definition is consistent with the concept first proposed by Thaler and Sunstein (2009). One way to think about this definition is that it seeks to guide and engage the decision-maker on a behavioural level without actually changing the economic facts (from a neoclassical perspective) describing the decision.

Our definition, while clear, does give rather broad latitude for the use of informational nudges, which can be a source of debate among behavioural researchers. To see why this can be controversial, consider a couple of examples. The association of one choice with positive and motivational words or images is clearly in the spirit of nudging. This offers an identical choice but seeks to lead the individual to have a more positive association with the item. This clearly works solely on a behavioural level and not a neoclassical economic level. Alternatively, an extension agent informing a farmer about the technical aspects of a new technology they are unfamiliar with would not be considered a nudge by most behavioural researchers. In this case, we are providing information that complements the good or service itself

and likely changes the perceived neoclassical economic benefits. We intentionally leave this boundary of the nudge definition fuzzy and flexible. This allows room for nudges that draw from the disciplines of marketing and communications as potentially fruitful avenues to drive adoption of innovations by smallholder farmers.

Despite using this consistent definition, it should be recognised that there is a continuum of behavioural interventions. While authors focus primarily on nudges, some compare this approach with other approaches that combine behavioural interventions with more traditional interventions. While the focus of this book is on the use of purely behavioural interventions, many will be introduced in the context of existing traditional incentive programmes. The interplay of these approaches is also a fruitful area for research and exploration but is largely left to future complementary work.

6 Chapter Organisation/Summary

This volume is comprised of 13 chapters.

This introductory chapter frames the urgency of the moment: global food demand is projected to rise by 50 per cent between 2020 and 2050 even as land, water, and ecosystems come under mounting stress. Most of the UN's Sustainable Development Goals are unlikely to meet their goals by 2030, and SDG2 will certainly not. Conflict and climate change further disrupt production and trade, amplifying volatility and risk. Despite decades of scientific progress and substantial investment—such as CGIAR's USD 60 billion over 1970–2020 (Alston et al., 2020)—adoption of improved varieties among smallholders seldom exceeds 40% and can be far lower for specific crops. The chapter poses the central puzzle that guides the volume: if inventions abound across seeds, livestock, inputs, and agronomic practices, why does farmer uptake lag—and which strategies can close the innovation–use gap?

In Chap. 2, David Zilberman, David R. Just, and Sadie Shoemaker introduce behavioural economics as a corrective to the limits of neoclassical assumptions about fully rational decision-makers. They show how real farmers decide under uncertainty, habit, social influence, and emotion, and why economic incentives alone often underperform. Nudges—popularised by Thaler and Sunstein (2021)—are presented as tools that steer choices without restricting options or changing prices, complementing subsidies, infrastructure, and education. Building on Wuepper et al. (2023), the authors argue for hybrid policy frameworks that combine behavioural and conventional levers tailored to local context.

Chapter 3, by David R. Just and Jie Jiao, turns from "why behaviour matters" to "how to design for it", proposing a structured framework for applying nudges in agriculture. They define nudges as subtle choice architectures that preserve autonomy while shifting decisions in predictable ways. Drawing lessons from governmental "nudge units" and other sectors, they highlight cost-effectiveness, scalability, and the need to anticipate ethical concerns and unintended effects. The framework is then adapted to agricultural priorities—technology adoption, climate adaptation,

and resource allocation—so practitioners can translate theory into field-ready designs.

Chapter 4, authored by Jaap Sok, Carolien de Lauwere, and David R. Just, addresses livestock disease as both an economic and public health threat, especially in low- and middle-income countries. The authors argue that epidemiological models and One Health strategies are stronger when they incorporate behavioural drivers such as incentives, trust, risk perception, and time preferences. They review literature linking these drivers to interventions and show how nudges can improve prevention and control. The chapter concludes that integrating behavioural insights into bio-economic and epidemiological modelling yields more realistic outcomes and more effective policy.

In Chap. 5, Janet M. Mutiso, Carl-Johan Lagerkvist, Julius J. Okello, and Penina N. Muoki examine how procrastination and psychosocial factors shape both planned and actual adoption of biofortified crops. Using data from 320 sweetpotato farmers in Kenya, they apply the theory of planned behaviour alongside recursive partitioning regression technique. They distinguish general from unintentional procrastination and show how tailored information nudges interact with agency, subjective norms, and past behaviour. Their findings highlight extension services toward targeted nudges, reminders, and community-based approaches that reduce behavioural frictions in adoption.

Chapter 6, by Julius J. Okello, David R. Just, Arjan Verschoor and Hugo Campos, brings culture and social norms to the foreground in decisions about purchasing quality seed. Focusing on Uganda's sweetpotato farming system, they demonstrate how culture and social norm nudges can stimulate sustained demand for agricultural innovations. The authors argue that culturally framed nudges—aligned with local identities and norms—can shift behaviour more credibly than purely economic appeals. The authors propose a new and novel strategy for strengthening seed systems and raising agricultural productivity by exploiting nudge theory to stimulate demand for quality seed of improved sweetpotato varieties.

In Chap. 7, Kelvin M. Shikuku and Erwin Bulte analyse social learning and incentives in the diffusion of improved crop varieties. They demonstrate that information rarely spreads "spontaneously"; hence, farmers must be motivated to share and champion innovations. Economic and social incentives, amplified by loss-framed messaging, reference dependence, and goal priming, can accelerate peer-to-peer transmission. The chapter links these mechanisms to practical programme design, showing how policy can target social networks to scale up adoption of agricultural innovations.

Chapter 8, by Reddy S. S. Jayanth, Srinivasulu Rajendran, and Julius J. Okello, turns to digital nudges delivered through mobile text reminders. Evidence from India and Kenya shows SMS can counteract forgetfulness, reinforce training effects, and complement under-resourced extension systems at low cost. The authors review literature on design choices—timing, frequency, and personalisation—and how literacy, gender, and inclusion interact with nudge to shape outcomes. While impacts are mixed, message cadence often matters more than content richness, underscoring the value of simple, well-timed prompts.

In Chap. 9, Janet M. Mutiso, Arjan Verschoor, and Julius J. Okello investigate promoter farmers and extension agents as carriers of information nudges where formal services are limited. They find that effectiveness hinges on a triple interaction: who delivers the nudge, what the nudge is, and who receives it. They argue that gender frequently mediates results, suggesting the need for sensitivity to social and cultural structure in intervention design. The authors provide design principles for embedding behavioural nudges in local advisory ecosystems.

Chapter 10, by Kelvin M. Shikuku and colleagues, studies social nudges within an Ethiopian agricultural information crowdsourcing initiative. By varying expectations about continued payment and clearly communicating uncertainty, the programme found sustained effort even after rewards were withdrawn for a random subset. Their results show that anticipation management and salience of social value can offset disappointment and maintain participation. The chapter offers actionable guidelines for participatory platforms that depend on steady contributor engagement.

Chapter 11, by Julius J. Okello and co-authors, examines behavioural nudges within urban and peri-urban contexts where production dynamics and market proximity differ from rural areas. Contrary to expectations, they find that interventions that encouraged progressive farmers to share information with co-villagers, and eased access constraints, unexpectedly lowered immediate demand for quality seed. They explain null findings using the concept of overjustification. The interventions, however, activated information networks that improved diffusion and learning, revealing complex substitution and timing effects. The authors recommend pairing capacity-building and network activation with supply-side fixes so that diffusion translates into sustained demand.

Chapter 12, authored by Jens Rommel, synthesises evidence through a metascience lens focusing on designing nudge interventions to facilitate future impact evaluation. He notes that average nudge effects are often small but policy-relevant and argues for well-powered, adaptive experimental designs that utilise digital tools. The chapter warns of upward bias when working with idiosyncratic partners or samples and calls for transparent reporting and careful discussion of generalisability. It closes by insisting that cost-effectiveness under plausible scale-up scenarios be part of any serious plan to integrate behavioural interventions into agricultural policy.

Finally, Chap. 13 by Julius J. Okello, Hugo Campos, David R. Just and Carl-Johan Lagerkvist synthesises evidence from across this book to distil cross-cutting lessons on how behavioural insights can improve the adoption and diffusion of agricultural innovations in low- and middle-income countries. Moving beyond chapter-specific findings, it identifies overarching themes and translates them into practical guidance for policy, practice, and research. The central argument is that agricultural innovations, ranging from improved seed varieties and livestock vaccines to digital advisory services, are adopted not solely on the basis of technical merit or economic returns, but through complex human decision-making processes shaped by perceptions, biases, social networks, and cultural norms. Classical models of rational choice are therefore inadequate to explain the uneven or slow uptake of promising innovations. Integrating behavioural economics, psychology, and sociology offers a

more realistic lens for understanding farmer behaviour and for designing context-sensitive, equitable, and effective interventions.

Chapter 13 speaks to three primary audiences. For policymakers, it demonstrates how behavioural approaches can inform cost-effective and politically feasible agricultural strategies. For development practitioners, it offers evidence-based lessons for embedding behavioural insights into programme design, implementation, monitoring, and scaling. For academics, it highlights theoretical contributions, methodological considerations, and opportunities for interdisciplinary research at the intersection of behavioural and agricultural sciences.

The synthesis is organised around key lessons emerging from the foundational frameworks presented earlier in this book and illustrates how behavioural mechanisms operate differently across livestock systems, crop systems, and extension or digital platforms. By combining broad synthesis with domain-specific illustrations, the chapter provides both conceptual clarity and practical relevance. It concludes by reaffirming the importance of behavioural interventions in promoting inclusive adoption of innovations and advancing sustainable and equitable food systems.

Taken together, these chapters move from foundations to frameworks, from livestock health to seeds and mobile phone-based text messages, from rural to urban systems, and from single pilots to synthesis. They show that behavioural tools—deployed with cultural intelligence, statistical rigour, and institutional realism—can help bridge the long-standing gap between innovation development and widespread farmer use.

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Behavioural Consideration and Nudges in Agriculture

2

David Zilberman, David R. Just, and Sadie Shoemaker

Abstract

Behavioural economics has become increasingly influential in agricultural economics by providing tools to better understand decision-making that deviate from the assumptions of full rationality. We examine how behavioural considerations have been incorporated into agricultural production, technology adoption, risk management, and consumer behaviour. While neoclassical economic models remain effective for analysing aggregate outcomes and sectoral performance, they often perform poorly at explaining micro-level decisions made by farmers and consumers. Drawing on extensive literature and applied examples, this chapter demonstrates that agricultural economists have long relied on behavioural assumptions, even prior to their formalisation within behavioural economics. Nudges, broadly defined, are shown to be pervasive throughout the agricultural and food systems. They are used by extension services, policymakers, and private firms to influence input use, technology adoption, environmental stewardship, and food consumption. The chapter highlights that the effectiveness of nudges is highly context-dependent and often enhanced when combined with traditional economic incentives. By synthesising evidence across production, adoption, risk, and consumer domains, the chapter underscores the value of integrating behavioural

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insights with applied agricultural economics and suggests directions for future research and policy design.

Keywords

Behavioural agricultural economics · Nudges · Technology adoption · Risk and decision-making · Agricultural production · Consumer food choice

1 Introduction

Neoclassical economic models are based on the assumption of rationality, while behavioural economics incorporates psychological and emotional aspects of decision-making into economic frameworks. Such additions can be of critical importance in addressing long-term policy challenges where human behaviour appears to contradict incentives.

Economic analysis is based on assumptions regarding the structure of choices available to a decision-maker and the decision-maker's motivations. These assumptions are generally used to simplify complex human contexts, emotions, and motivations, allowing for the specification of models. Modelling requires simplifications that enable feasible calculations and the derivation of general relationships and results. Economists, starting with Adam Smith, have long realised that real life is more complex than a basic economic model could possibly represent. While often this abstraction from reality is inconsequential to the analysis, consequential work has focused on when greater realism is needed. Simon (1997) introduced the notion of "bounded rationality" and the first wave of behavioural economic models. Kahneman and Tversky's (1979) prospect theory ushered in a second wave of behavioural economic models emphasising identifying behavioural patterns that contradict the neoclassical model through experiments, empirical work, and using these to inform modelling. Behavioural economic concepts have long been part of agricultural economic analysis and have increasingly become a growing area of research and application, particularly in developing countries (Wuepper et al., 2023).

One of the major contributions of behavioural economics is the notion of nudging. Thaler and Sunstein (2008) defined nudges as "any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives" (pg. 6). Nudges are actions taken by economic agents to affect the behaviour of others. Traditional economics mostly emphasises the role of financial incentives, direct control, education, investment in infrastructure, and R&D as behaviour-altering interventions. Alternatively, nudges exclude rational antecedents and focus solely on social and psychological decision factors.

Nudges in the field can be implemented by extension specialists, farm advisers, agribusiness, or government agents who aim to enhance adoption or to change nutritional intakes. By considering social and psychological decision factors, nudges significantly expanded the range of tools considered by economists to affect human

behaviour. Nudges tend to be a gentle form of intervention (reminder, rearrangement of choices, hint), and are based on the recognition of human cognitive limitations, emotional, and other "irrational" factors that affect behaviour (Thaler & Sunstein, 2008).

Nudges, like any economic tool, can enhance or reduce welfare, and one of the challenges of economic analysis is analysing their impact in different circumstances (Just, 2017). Given the heterogeneity of economic systems, and especially agricultural systems, nudges may perform differently in different contexts (Wuepper et al., 2023). Given the diversity of nudges and their varying performance in different environments, it is less meaningful to assess the aggregate impact of nudges, but rather to assess the performance of individual nudges in particular circumstances to determine where and how to use them. Loewenstein and Chater (2017) note the wide set of options that combine nudges with more traditional economic interventions, advocating for an approach that is not solely restricted to one or the other. In many cases, adding nudges to an existing incentive structure could enhance effectiveness. Such hybrid cases are worthy of study.

Applied economists have gained an understanding of a wide range of nudges, both through experimentation and observing behaviour in the field, how they operate, and how to design them better. Different forms of nudges have existed for a long time—for example, they have been used by marketers in agriculture and natural resources (Heiman & Hildebrandt, 2018)—and only recently have been incorporated into economic literature. This is a wide area for continuous research and application. This chapter aims to investigate three related questions, expanding the findings of Wuepper et al. (2023). To what extent has behavioural economics, especially nudging, been incorporated into agricultural production economics? To what extent are nudging and other related behavioural interventions prevalent in agriculture? And, what are the potential uses of nudges in agriculture, and what does it imply for research?

2 Behavioural Economics in Agricultural Economics

Agricultural Economics is a hybrid discipline that aims to integrate economic principles with the reality of agriculture to develop practical methods for analysing agricultural policy and farm and resource management. We use the term "Agricultural Economics" to designate the discipline that now covers the analysis of natural resource economics, environmental economics and development economics (Dorfman et al., 2024). Agricultural economists have developed applied theories that address many aspects unique to agriculture and have conducted empirical research on problems related to the management of agriculture and natural resources. Often, these applied theories have led to major contributions to economic theory.

Neoclassical economists developed functional relationships and theories based on assumptions that make intuitive sense, such as decreasing marginal productivity. Theorists also simplified relationships to enable analytical manipulation. For example, using the Cobb-Douglas production function simplifies the derivation of supply

curves and their interpretation. Behavioural economists tend to identify behavioural patterns, document them, and then introduce them as a key element of a theory to predict behaviour. Agricultural economists have used neoclassical theory as their starting point, but being closer to the field and interacting with farmers and agricultural policymakers, agricultural economists realised early on that people's choices do not coincide with the basic assumption of neoclassical economic theory. This is especially true when it comes to micro-level analysis. As a result, agricultural economists have relied on ad hoc rules or behavioural simplification to analyse behaviour (Zilberman, 2019).

In this chapter, we identify several behavioural approaches that are incorporated into agricultural economic practices and modelling. We rely on published papers in major journals and the procedures used by agricultural and resource extension personnel. We demonstrate that behavioural economics was dominant in both analysing and influencing behaviour at the micro level. In contrast, neoclassical economics was more important in developing a perspective to analyse performance at the sectoral level. We will also demonstrate the important role of nudges in agricultural economics research and policy.

There is a growing literature on behavioural economics in agriculture. Wuepper et al. (2023) suggest that this body of literature can be referred to as behavioural agricultural economics and provide a survey of this literature. They argue that behavioural economics served to introduce tools and mechanisms from psychology to economics, and they have significant value in agriculture. Čop and Njavro (2024) provide a detailed survey of the agricultural economic literature on nudges, covering 53 studies in this area. To avoid reinventing the wheel, we rely on some of these studies to illustrate what type of nudges are suggested in agriculture.

First, we argue that applied field studies in agriculture frequently assume that farmers use rules of thumb in their decision-making. Then we identify different categories of nudges that were proposed and partially implemented in agricultural production. Finally, we analyse specific behaviour considerations in several fields, including the adoption of technology and risk.

3 Farmers' Production Choices Follow Behavioural Rules

Much of the economic literature on agricultural production assumes a neoclassical production function as foundational, and provides prescriptions based on this perspective (Ray et al., 2022). However, agricultural economists, especially in extension, who work with agricultural scientists and farmers, have recognised that farmers use rules of thumb extensively in their decision-making. This is consistent with Aumann's (2019) notion of rule-rationality. Individuals follow rules that are modified over time based on learned experience. Just et al. (1990) demonstrated econometrically that assuming a fixed proportion production function, which is modified over time, does a much better job explaining water allocation and chemical use by individual farmers than using a neoclassical production function and exploiting duality theory. The widespread use of a crop budget illustrates the

importance and relevance of assuming that farmers' behaviour is fixed proportion. Crop budgets are provided by extension workers to farmers and the public to guide production. As can be seen from the Cost and Return studies of the University of California, Davis[1](UC Davis), these crop budgets assume fixed proportion production functions, denoting how much input, such as water or fertiliser, is applied per acre with different technologies and locations. These crop budgets resemble food recipes and are among the most widely used operational tools for implementing production functions in practice. The coefficients used in crop budgets change over time, reflecting changes in technology and economic conditions. Agronomists assume a fixed ratio between input and output ("von Liebig" production), and farm advisers and farmers are interested in the most appropriate fixed proportion for a situation.

Agricultural economists working in the field use fixed proportion relationships.[2] This allows linear programming or more advanced programming forms to be the basis for advice on allocation of resources in the farm sector. For example, land allocation by farmers and regional water allocation (Pannell, 1996; Howitt et al., 2010; McCarl & Spreen, 1997). The use of crop budgets and similar tools by farmers when allocating resources is consistent with the emphasis on the use of heuristics in behavioural economics (Thaler, 2016), as they abstract away from non-linear relationships and potentially complicated complementary relationships.

The agricultural economic literature suggests that farmers in developed countries tend to overapply fertilisers, and farmers in developing countries tend to underapply fertilisers.

4 The Use of Nudges in Agricultural Production

Based on Čop and Njavro (2024), and with the assistance of ChatGPT (used to locate relevant literature and structure the table), we identify several categories of nudges applied in agriculture. Representative studies for each category are listed in Table 2.1.

Some of the mechanisms appearing in the table are clearly not pure nudges. For example, there are many cases where nudges are used to complement incentives. This builds on the observations of Loewenstein and Chater (2017) that nudges are much more effective, practical, and predictable in combination with traditional incentives. Policymakers who aim to change behaviour will not often select pure strategies of nudging but rather combine multiple tools. Provision of targeted and relevant information to individuals is another "impure" nudge that is quite effective. In many cases, adding a nudge to an existing incentive-based policy can make a dramatic difference.

[1] https://coststudies.ucdavis.edu

[2] Personal communication with the late Karen Klonski, who was in charge of extension at the University of California.

Table 2.1 Alternative nudging patterns in agriculture

Nudge	Definition	Examples
Information	Provide targeted information to influence farmers' decisions	Increase in farmers using weather forecasts for decision-making (Fafchamps & Minten, 2012) Farmers received personalised soil reports (Bernard et al., 2019)
Social norms and peer comparisons	Inform farmers of peers' behaviour	Drip irrigation adoption increases when farmers are told most of their neighbours had already switched (Grafton et al., 2018) Adoption of high-yield seeds increased based on peer adoption (Beaman et al., 2021) Social comparison led farmers to save water but reduce the proportion that does not consume water at all (Chabé-Ferret et al., 2019)
Default options	Set sustainable choices as the default in decision-making processes	Enrolment in agriculture insurance increased when it became the default option (Cai, 2016) Long-term adoption of technologies is more likely when opting out of subsidies is the default option (Jack et al., 2015)
Environmental framing	Encourage eco-friendly behaviour by framing choices with an environmental perspective	Traffic light labelling of pesticide toxicity reduced pesticide application (Buchholz & Musshoff, 2021) Farmers who received green nudges (information on pollution and environmental damage) were less likely to burn crop residues (Lopes et al., 2023)
Financial incentives with nudging	Combine financial incentives with behavioural nudges to drive change	Time-limited discounts on fertiliser after harvest serve as nudges to encourage fertiliser use among Kenyan farmers (Duflo et al., 2011) Short-term subsidies change expectations and enhance learning and adoption of integrated pest management (Balew et al., 2024)
Framing and anchoring	Present information in a way that influences decisions	Adoption of conservation tillage was higher when framed as a profitability strategy instead of an environmental one (Dessart et al., 2019) Setting clear reduction targets led to a drop in pesticide use (Rosenberg & Perry, 2021)
Labelling and certification nudges	Use labels and certifications to guide decision-making	Fairtrade certification benefits farmers economically (Sellare et al., 2020) Farmers were more likely to seek certification when shown price benefits (Dragusanu et al., 2014)
Social incentives and public recognition	Use social prestige to encourage behaviour change	Farmers selected to use advanced variety adopted it but did not share much of the knowledge with others (Okello, Shikuku, et al., 2023b) Social signalling (publicly showcasing farmers who embraced innovation) increased adoption (Howley & Ocean, 2022)

It is important to assess the effectiveness of different nudges in different situations. The studies we cited in Table 2.1 provide some quantification of the impact of the nudges they introduce. Most of the examples we cite in the chapter are investigated with randomised control trials. For example, Fafchamps and Minten (2012) found modest increases in the use of weather information for decision-making, while Bernard et al. (2019) found a 25% greater increase in the adoption of fertiliser recommendations based on personalised soil tests. Social norms seem to work very well in the case studies we have considered. There was a 44% higher rate of adoption of high-yield seeds based on social learning (Beaman et al., 2021). Adoption of drip irrigation was 22% higher among individuals who were told that their neighbours adopted it (Grafton et al., 2018). Similarly, group comparisons led to a significant reduction in groundwater pumping, and the impact did not decline for 5 years (Hrozencik et al., 2024). Similarly, group comparisons led to reductions in waste by regional utilities that received comparison data compared to regions that did not (Earnhart & Ferraro, 2021).

Changing default options is a very effective nudge in a variety of choice contexts. Take-up of insurance increased from 5 to 33% (Cai, 2016), and an opt-out option for subsidies led to a 40% increase in adoption rate after the subsidy period ended (Jack et al., 2015). Environmental framing has limited impact but works well when paired with other incentives. On the other end of the spectrum, combining incentives with nudges leads to an increased application of fertilisers at the desired time (Duflo et al., 2011) and doubled the adoption of IPM compared to the case without a payment. Framing and anchoring have high impacts. Adoption of conservation tillage was 30% higher when framed as a profitability strategy instead of an environmental one (Dessart et al., 2019). Setting clear reduction targets led to a 21% drop in pesticide use (Rosenberg & Perry, 2021). Farmers will adhere to labelling and certification requirements when they yield increases in profitability. Similarly, farmers valued social status and recognition, making this an effective motivator to introduce change (Howley & Ocean, 2022). But progressive farmers may not allocate effort to share the knowledge (Okello, Shikuku, et al., 2023b).

Nudges have been suggested as a means to address under- or over-application of important inputs such as fertilisers or pesticides. Farmers in developed countries tend to overapply fertilisers. Peth et al. (2018) suggest (based on an empirical experiment) a pair of nudges aimed at reducing application rates. The first nudge shows the environmental and health damage from excessive fertiliser application, while the second provides comparative information on fertiliser use by farmers. Surprisingly, the nudge with pictures of damage from fertilisers works better than the comparative nudge, and in some cases, the comparative nudge actually increases fertiliser application.

Farmers in developing countries tend to underapply fertiliser. Duflo et al. (2011) suggested that the lack of investment in fertiliser may be due to a lack of cash. They suggest a combination of a behavioural intervention and an incentive—encouraging fertiliser use through timely discounts. In particular, they observed that smallholder farmers delayed purchasing fertilisers and suggested a limited-time fertiliser discount immediately after harvest when farmers have cash. Mukherjee et al. (2024)

argue that farmers under-invest in fertiliser because they face challenges in physically saving money. Without the ability to save, they cannot arbitrage and sell their output at the best time but must sell when expenses are due. They conducted an experiment where they provided a simple tool—a safe that protects their cash savings—which led some farmers to delay selling crops to obtain a higher price.

5 Adoption of Technologies

One of agricultural economics' most important contributions to economics was the study of adoption (choice of technologies or practices by individuals) and diffusion of a technology (aggregate adoption). The seminal studies of Griliches (1957, 1958) documented that farmers do not adopt a technology immediately it becomes available. Rather, the process is gradual, reflecting heterogeneity and relying on social learning mechanisms like imitation. Zilberman et al. (2012) argued that diffusion is a multi-stage process. It consists of individual choices that depend on information and capacity and vary by individuals according to various sources of heterogeneity, which may include size, age, education, etc. It advances over time due to dynamic processes of learning by doing (reducing the cost of technology), learning by using, and increased value of adoption resulting from positive network externalities. There are multiple studies on the role of nudges in inducing adoption. For example, Chabé-Ferret et al. (2023) showed that informational letters, social comparison nudges, and testimonials led farmers to adopt payment for ecosystem services (PES) in France. Howley and Ocean (2022) found that combinations of two nudges, information about social norms, and the prestige associated with adopting new technologies complemented one another and enhanced the willingness to adopt worker safety and environmental quality strategies in England. On the other hand, Okello, Akite, et al. (2023a) found that enhanced recognition of their adoption of modern seeds is not an effective incentive to enhance the adoption of certified seeds in Uganda.

Wuepper et al. (2023) emphasised the importance of social norms and historical experience. For example, historical variation in returns and investment explains variation in time preference. Studies show that farmers from regions with higher returns on investment tend to be more selective before adopting new technologies. Similarly, farmers who lived in regions with higher rates of climate variability and less control over outcomes may be less willing to accept new technologies. They also find that individual backgrounds matter. For example, farmers with more internal locus of control (stronger belief that they have control over their lives) are more likely to engage in change, and farmers with a greater sense of self-efficacy (stronger beliefs in their ability to execute plans) and more skills as farmers and decision-makers are more likely to engage in new ventures. Thus, while it is challenging, if we can design programmes that enhance self-confidence and skills, we are more likely to strengthen the likelihood of adopting new technologies.

Homann-Kee Tui et al. (2018) suggest that one plausible reason for the under-adoption of modern greener systems in developing countries is status quo bias by individual farmers, leading to hesitancy. Many agricultural choices are

intertemporal. Adopting new technologies generally requires initial investments that yield later payment. Neoclassical economics assumes that people maximise expected profits or utility with a constant discount rate. Behavioural economists cite hyperbolic discounting, a cognitive bias causing people to favour immediate rewards over long-term returns. Decisions that fail to take advantage of such delayed returns are often assumed to be due to credit or liquidity constraints by neoclassical economists and hyperbolic discounting by behavioural economists. Agricultural economists were among the first to identify behaviour consistent with this hesitancy. Significant evidence from water economics and the pesticide literature shows that some farmers tend to be myopic and continue to use inferior technologies rather than invest in water conservation technologies or integrated pest management (Carlson et al., 1993). Kusunose and Mahmood (2016) argue that farmers do not engage in long-term planning or rely on climate and weather forecasts in agriculture because of uncertainty and the difficulty of access to information. They suggest providing more user-friendly access to the data that would be more frequently updated to increase reliability. Barnes et al. (2013) demonstrated that nudges provide information that improves the physical environment and provides better default options, leading farmers in India to use water quality management technologies.

"Empathy" nudges are small, low-cost prompts that encourage farmers to be empathetic to others. In the case of agriculture, farmers are made aware of some of the environmental damage their activities may cause and are encouraged to join environmental stewardship programmes. These programmes have been found to work very well in the United States and have led to a doubling of applications to the Conservation Stewardship Program (Czap et al., 2019). Reduction in pesticide use with significant environmental effects requires significant overall participation in a conservation programme. For example, Kuhfuss et al. (2016) suggest that sufficient farmers will participate in an environmental services programme to reduce herbicide use when they get a bonus for participation once participation exceeds a threshold level.

6 Risk

The literature on adoption in economics emphasises the role of risk as a reason to avoid adoption. Agricultural economists have used safety rules (e.g. safety-first and safety-fixed) to explain why farmers avoid adopting Green Revolution technology (Feder et al., 1985). The simplest of these rules, safety first (also called "Roy's Safety-First Rule"), presumes that the decision-maker will minimise the probability that monetary outcomes will fall below some disaster threshold. For example, Roumasset (1976) extensively documented that the safety-first model can explain very well the adoption pattern of new Green Revolution rice varieties. Alem and Broussard (2018) demonstrated that participation in safety net programmes that insure farmers against shocks lead to increased investment in fertiliser and intensification, perhaps because these programs reduce the probability of falling below a low-income threshold.

A major behavioural economics concept is loss aversion, a cognitive bias where people feel the pain of a loss more than the pleasure of a gain (Kahneman & Tversky, 1979). This is consistent with the emphasis on risk of loss relative to benefits in adoption studies. Some studies confirm these results. For example, Tanaka et al. (2010), Bocquého et al. (2014), and Rommel et al. (2023) found that low-income villagers in Vietnam and France tend to be both risk-averse and acutely loss-averse. Liu and Huang (2013) make the same finding for farmers in China, though behaviour among farmers was not uniformly loss-averse. They find managerial differences between loss-averse and risk-averse farmers. Loss-averse farmers use more pesticides because they put a high weight on reducing loss, and risk-averse farmers use fewer pesticides because they weigh the loss of income associated with payment for more pesticides more heavily.

A key component of behavioural economics is prospect theory, originally proposed by Kahneman and Tversky (1979). Prospect theory employs a value function (like a utility function) that reflects loss aversion and framing relative to a reference point. Prospect theory additionally employs probability weighting in risky decisions. Framing allows the prospect theory model to represent sensitivity to the presentation of information and choices before making a decision. Probability weighting models an empirical observation that decision-makers give disproportionately high importance to rare events. Probability weighting leads to overvaluing very small risks. Anand et al. (2019) suggest that loss aversion explains farmers' preference for adopting switchgrass as a biofuel over miscanthus, which has higher profitability potential but higher likelihood of failure.

Chai et al. (2023) argue that farmers may overapply fertiliser because they followed the advice of agronomists and consultants who aim to maximise yield, rather than maximising profit. Alternatively, over-application may result from farmers' overestimation of yield risk. They suggest that nudges emphasising evidence from practical experience applying less fertiliser because of shortages or higher prices without losing yield could induce farmers to reduce their applications. Another strategy is identifying the farmers who overapply because they assume that fertiliser is a risk-reducing input and providing them with evidence of past experiences where applying less fertiliser did not increase risk. This latter nudge strategy is perhaps difficult because risk is not directly observable, requiring multiple observations—perhaps over time or across multiple plots.

7 Actually, Nudge-Like Activities Are Ubiquitous in Agriculture

In the previous section, we had multiple examples of nudges and combinations of nudges with traditional incentives, such as providing new information, manipulating the order of choice, improving the convenience of choice, etc. Important research in agricultural economics emphasises the importance of information networks and the importance of decision-makers using different sources of information to make their choices. Just et al. (1990) emphasise that farmers utilise formal and informal

sources before making decisions, and Just et al. (2002) and Wolf et al. (2001) identify the major sources of information that farmers use to make certain decisions. For example, the USDA and extension are the most important sources of information about demand and supply predictions. At the same time, commodity associations are the most important sources of information on regulatory changes, and agricultural media are the most important for information about production innovation.

Cooperative Extension was established to educate farmers about new technologies and encourage them to adopt them. Extension personnel may use different nudges, including reminding farmers on the radio when to apply chemicals or start irrigating, providing leaflets with directions about decision-making, and directly interacting with farmers. The main job of salespeople is to encourage adoption by approaching farmers and speaking with them about the technology, identifying obstacles to adoption, and negotiating about price—all in order to increase adoption. Salespeople will aim to help farmers obtain credit, sometimes helping them use and operate new technology effectively. Some of these activities are nudges.

Commercial vendors are a significant source of information for price forecasts, production innovation, and regulatory changes. Vendors and suppliers are aware of the need for this type of information for decision-making and, therefore, provide it. One major objective of marketing activities is to modify farmers' behaviour by providing information and reducing decision-making difficulties (Heiman et al., 2022). The stages of adoption include awareness of the product, assessment, choice, and re-evaluation. Marketers may contribute to awareness through product advertisements or some other promotion. For example, major pesticide firms typically use marketing rewards programmes to induce distributors to allocate greater than 90% of their shelf space to their branded products when facing generic competition. This prevalence signals social norms and induces salience and convenience. Sellers can affect consumer assessments by providing timely information about the product through advertisements. Potential buyers are concerned about product reliability, performance, and especially the fit for their own needs. Marketers provide demonstrations and sampling to help assess performance and fit, providing pre-purchase trial (e.g. test-drives). Offering money-back guarantees also reduces worry about fit. All these marketing activities are not straight incentives but are used like nudges to enhance the likelihood of adoption. They provide a different choice architecture than a direct purchase for a given price with no extra conditions. For example, "money-back guarantees" are a mechanism to reduce fit risk (the risk that the product does not fit the buyer), which increases the price of a product compared to direct purchase; its value reflects loss aversion of buyers concerned about making a mistake (Heiman et al., 2015). Similarly, the impact of different marketing tools in agriculture, from money-back guarantees to sampling, has been documented as being substantial for a long time. As new opportunities for marketing tools arise, agricultural vendors utilise them.

Once we recognise that many marketing activities play similar roles to nudges and enhance adoption, we may assess their effectiveness to see what types of marketing activities serve as useful nudges. Furthermore, nudge designers may look at existing marketing strategies and see if those that have been tried and tested by marketers fit the role of a nudge they are seeking to implement. This suggests that

marketing choices should be better incorporated into the research on technology adoption and the context of designing nudges and other elements emphasised by behavioural economics (Heiman et al., 2020). The main flaw of some traditional models, such as farmers' behavioural choices or adoption (see, for example, models for adoption under uncertainty in Feder et al. (1985)), was not that they excluded nudges but that they did not explicitly incorporate or assess different marketing strategies. While we know that sellers may use marketing strategies we do not have much evidence of the impact. There is a significant literature on the impact of different nudging strategies. Most of the impacts are evaluated through randomised controlled trials or different experiments. Perhaps the impact of the nudges may be overstated because of publication bias, as demonstrated by Bartoš et al. (2023) and Nemati and Penn (2020). Actually, Chabé-Ferret et al. (2024) have shown that nudges can backfire. In their case, a comparative nudge tends to decrease adoption compared to chemical control. Nudges generally result in modest modification of behavior. In order to induce significant changes required for ambitious policy goals (e.g., decarbonization) requires the use of additional policy tools (Huebner et al., 2023).

In development economics, there is a significant effort to identify new nudges and to spend significant amounts of money to assess whether, and, to what extent, they work (Banerjee et al., 2021). It may be better to understand the behaviour of marketers in developing countries to assess what does and does not work. Some may be uneasy with marketing activities because they serve the purpose of the seller rather than society. For example, advertisements may promote sugary foods in children's diets. However, the fact that this advertisement works shows the worth of advertising as a nudge. Marketers and policymakers can develop advertisement nudges to promote the public good as well.

8 Conclusions

In this chapter, we demonstrated the important role of behavioural economic assumptions in everyday life and the agricultural and food sectors. We argued that the neoclassical theory presents simplification and relationships that may not work very well at the individual level but are useful for analysing the performance of agriculture in the aggregate. To affect behaviour, it is not sufficient to use prices and direct control, but it is important to develop nudges that will direct people towards desirable behaviour modification based on understanding of human limitations and constraints. We identified multiple types of nudges, and research will identify many more. Once nudges are introduced, it is important to assess their impact in a rigorous and effective way (Palm-Forster et al., 2019).

We also find that nudges are used throughout the agriculture and food system at all stages. A better understanding of agricultural marketing efforts can help improve behavioural economic research and its usefulness since both marketing and behavioural economics integrate economics and psychology (DellaVigna, 2009). Assessing the relationship between different types of mechanisms, incentives, regulations, marketing tools, and nudges is an important topic for future research.

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A Framework for Understanding the Role of Nudges in Agriculture

3

David R. Just and Jie Jiao

Abstract

Nudges use subtle changes in the framing of choices in order to influence choice outcomes. While there is significant work examining behavioural economic phenomena in agriculture and the general use of behavioural field experiments (or randomised controlled trials (RCTs)), few have explored the potential use of nudges to achieve agricultural policy goals. Taking lessons from other field contexts, this chapter outlines the factors that contribute to a powerful nudge intervention. Using these factors, we develop a framework for formulating nudge interventions. Using the framework, the chapter discusses the potential for using nudges to address several persistent policy problems with wide application in the developing world context, including problems such as technology adoption, investment in soil health, savings decisions, conservation practices, and inequitable intra-household allocation. In each case, we identify the decision points that are most open to influence and the likelihood of measurable policy impact.

Keywords

Behavioural nudges · Analytical framework · Technology adoption · Agricultural development and policy · Developing countries

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1 Introduction

Nudges are subtle changes in the framing of choices that influence decision outcomes without restricting options or significantly altering economic incentives. Rooted in behavioural economic principles of libertarian paternalism, nudges have gained attention since the early 2000s and have been successfully applied in various fields (Just, 2022; Thaler & Sunstein, 2003, 2008). Nudge interventions, informed by behavioural economics and psychology, aim to guide decision-making towards preferred outcomes and enhance policy effectiveness. Because they are very easy to avoid, many have suggested that nudges are less susceptible to reactance (Sunstein, 2014a, b) and face less political opposition (Just, 2022).

Governments and organisations worldwide have established specialised teams to explore and implement nudges, demonstrating their potential to improve public welfare and government efficiency. This includes the Behavioural Insights Team (BIT) established by the UK in 2010 and the Social and Behavioural Sciences Team (SBST) established by the USA in 2014. Some field experiments conducted by these government "nudge units" have shown promising results (BIT, 2012; John, 2014; Ball & Head, 2021). Compared to alternative interventions such as incentives, which may have a larger impact but are more costly, nudges offer advantages like cost-effectiveness, scalability, and minimal disruption to decision-making processes. This makes nudges an important policy tool, whether implemented independently or as part of policy bundles. However, they also present challenges, including potential unintended consequences (Lin et al., 2017), varying effectiveness across contexts and populations (Sunstein, 2017), and ethical considerations surrounding manipulation and individual autonomy (Sunstein, 2015; Just, 2017; Jung & Mellers, 2016).

While behavioural economics has contributed significantly to agricultural research (Palm-Forster & Messer, 2021), the application of nudges in this domain remains limited. Most studies focus on incentives rather than nudges, highlighting the need to explore the potential of nudging in agriculture, particularly in developing countries. This chapter outlines the factors contributing to effective nudge interventions, proposes a framework for applying nudges in agricultural production, and discusses their potential to address policy challenges in technology adoption, climate change adaptation, household savings, and intra-household allocation.

2 Nudges

Nudges offer behavioural solutions to problems often attributed to limitations in human cognitive resources, whereas other behavioural factors such as hope and aspirations provide motivation for economic development (Loewenstein & Chater, 2017; Lybbert & Wydick, 2018). Nudges have shown promise in various contexts, making them a viable policy tool. Compared to incentive-based initiatives, nudges are subtle, cost-effective, and scalable while maintaining efficacy.

Examples of nudges include automatic enrolment in retirement savings plans (Thaler & Sunstein, 2008; Camilleri et al., 2019) and strategic placement of healthier foods in cafeterias (Just & Gabrielyan, 2018). These interventions demonstrate how subtle changes can significantly influence decision-making and promote desired behaviours.

Nudge interventions are characterised by their subtlety and non-intrusiveness. They avoid limiting choices, which can reduce political resistance. Nudging tools like defaults, simplifications, and social norms are often more cost-effective than traditional economic incentives (Sunstein, 2014a, b), often requiring only subtle changes in the wording of forms or signs. Because many nudge experiments involve only minor adjustments to existing programmes, nudges are generally easy to incorporate and scale. The digital age has further amplified the potential of nudges, as digital interfaces offer numerous opportunities for subtle yet impactful interventions (Weinmann et al., 2016). Digital tools, such as SMS reminders, mobile apps, and digital platforms, can play a pivotal role in resource-constrained farming environments by reducing the cost of implementing nudges while enhancing their impact. With the increasing availability of mobile devices and internet connectivity in rural areas, digital technologies can seamlessly integrate nudges into the daily routines of farmers.

A meta-analysis of nudge interventions shows that many different types of nudges succeed in changing behaviour in a wide range of domains (Hummel & Maedche, 2019; Beshears & Kosowsky, 2020; Mertens et al., 2021). Median effect sizes fall between 20% and 30%, and mean Cohen's d (standardised difference between two means) falls in the range 0.2–0.5 in these meta-analyses. Though in many instances nudges have failed or led to mixed results, the literature contains many robust examples of successful nudges. The empirical evidence indicates that applying behavioural science in the form of nudges can indeed change behaviour. Despite the relative strength of nudges in the literature, it is important to acknowledge the potential for novelty effects in randomised trials, the potential for publication bias in this literature, and the "voltage effect" that can occur when nudge interventions are scaled (List, 2022). While it is not always easy to separate the signal from the noise, the weight of evidence suggests there is indeed a robust signal at least for a critical mass of nudges.

The effects of nudges are especially significant in domains such as promoting healthy behaviours, encouraging pro-environmental behaviours, retirement saving plans, and public procurement. A review of the theory and practice of nudging in changing health behaviours (Vlaev et al., 2016) applied the "MINDSPACE" framework (Dolan et al., 2012), concluding that insights from behavioural economics offer powerful policy tools for influencing behaviours such as food choice. A comprehensive search strategy identifying research published since 2009 showed that nudge applications in food purchasing settings, particularly priming, offer a promising public health strategy to encourage healthier food choices among adults (Lindstrom et al., 2023). Many lab and field experiments in the area also showed similar results (Kroese et al., 2016; Just & Gabrielyan, 2018; Hanks et al., 2016). Environmental policies are increasingly informed by behavioural economics

insights. "Green nudges" encourage consumers to act in an environmentally benign way, such as by choosing renewable energy sources or conserving energy (Schubert, 2017; Carlsson et al., 2021). In addition to the canonical success story of "automatic enrolment" increasing participation in retirement saving plans (Thaler & Benartzi, 2004) Ferraro et al. (2024) conducted field experiments with commercial farmers in the USA examining the effect of framing on bidding in competitive conservation auctions, finding that a simple change in framing of solicited bids can lead to dramatically higher bids.

Thaler and Sunstein (2008) broadly classified nudges into several categories, including defaults, simplification and framing, social norms, priming, salience, affect, commitment, ego, etc., among which defaults (involving automaticity) are found to be the most effective and robust, while precommitment strategies are the least effective (Hummel & Maedche, 2019; Congiu & Moscati, 2022). Additionally, across various behavioural domains, interventions that target the structure of decisions consistently outperform those that focus solely on providing information or decision assistance (Mertens et al., 2021). The effectiveness of nudges could be enhanced by matching the type of nudge to the nature of the behaviour being targeted (Beshears & Kosowsky, 2020). For example, defaults are particularly effective for behaviours where inertia plays a significant role, such as enrolling in a retirement savings plan. In contrast, social norms can be powerful in contexts where peer behaviour influences individual decisions, such as in encouraging water conservation by informing households about their neighbours' water usage (Ferraro & Price, 2013).

Despite the advantages of nudges, their weaknesses also require careful consideration. Recent research highlights several areas of concern, including the overall effectiveness of nudges, heterogeneous treatment effects across different demographics, and ethical issues. Not all nudges are successful (Sunstein, 2017). While nudges can be effective, their impact may not always be as substantial or consistent as desired (Johnson & Goldstein, 2003; Allcott & Rogers, 2014; D'Adda et al., 2017). Some might backfire and lead to unintended consequences, particularly if participants are already motivated to perform the intended behaviour (Banerjee et al., 2023). For instance, a nudge designed to increase energy conservation by highlighting social norms might backfire if the target is already highly motivated. In such cases, the nudge might come across as redundant or even patronising, potentially leading to a decrease in the desired behaviour. Some treatment effects might appear only due to experimenters' inferred preferences (so-called experimenter demand effects) or because of the novelty effects experienced by the participants, leading to temporary behaviour changes that might not persist over time (Sunstein, 2017; Finkelstein et al., 2016; Allcott & Rogers, 2014). For instance, when a new recycling initiative is introduced, such as providing colourful and more accessible recycling bins, participation rates might spike initially. Over time, as the novelty wears off and the measures become routine, engagement might diminish. An intervention aimed at influencing behaviour in one context might unintentionally spill over into another context, either confounding or jeopardising the intended nudge effects (Greening et al., 2000). Suppose a nudge encourages

households to reduce electricity use by providing real-time feedback on energy consumption. This nudge might effectively reduce electricity usage. However, households might feel that their conservation efforts in electricity grant them a "licence" to be less environmentally conscious in other areas, such as water usage or waste recycling, thus leading to an overall neutral or even negative environmental impact.

In many nudge-based experiments, the impacts of interventions vary across different demographic groups. For example, a randomised experiment by Chabé-Ferret et al. (2019) was conducted in South-West France to test the nudging effect of social norms on water saving. While intense users reduced their usage, the opposite was true for those who used the least prior to intervention. Peth et al. (2018) found an overall positive effect of a nudge, including a social comparison component, on reducing illicit fertiliser application in proximity to water resources. However, they also observed an increase in non-compliant behaviour for a significant subpopulation. Understanding heterogeneity is crucial as interventions that work for one group may not work for another, leading to uneven outcomes. Nudges may not be a one-size-fits-all solution.

Finally, ethical issues related to nudges are widely debated (Sunstein, 2015). Concerns include transparency and individual autonomy. For instance, while opt-out policies for retirement plans or organ donation status increase participation, they may bypass genuine informed consent. Additionally, there is scepticism about paternalism, with some believing that policymakers do not necessarily know better than individuals what is best for them (Bovens, 2009). Fairness and equity concerns also arise due to varying treatment effects across different demographic groups (Sunstein et al., 2017). Finally, growing evidence suggests that reactance may result from seemingly benign nudges (Hagman et al., 2015).

In the agricultural domain, the applications of nudges offer promising opportunities to improve agricultural decision-making in developing country contexts but require both innovation and careful thought. Using nudges in agricultural decisions can help overcome behavioural barriers such as procrastination, loss aversion, and status quo bias that prevent farmers from adopting best practices (Duflo et al., 2011). The cost-effectiveness of nudge interventions means implementation requires minimal resources, making them an ideal policy instrument in a resource-poor environment. For example, sustainable farming practices could be encouraged through adjusting default options or by establishing social norms (Allcott, 2011).

The design and implementation of nudges face unique challenges due to varying social, cultural, economic, and agricultural conditions. Wuepper et al. (2023) highlight the importance of incorporating behavioural insights, including cultural influences, social norms, and even personalities, in shaping agricultural decision-making. Nudges must be carefully tailored to the local context to address specific circumstances and ethical concerns (Palm-Forster & Messer, 2021; Sunstein, 2017). Moreover, we must consider the specifics of decision-making processes in agriculture.

3 A Model of Decision-Making

In creating a framework for understanding how nudges could be used in an agricultural setting, it is first important to outline how decisions are made. An accurate model of decision-making can highlight the various points at which a nudge could play a role and how those nudges are likely to shape decisions. Once formed, the model can be used to identify not only the entry point for a nudge but also the types of nudges that may be most effective and how these may be shaped by the behavioural target of the nudge.

We outline our model of agricultural decision-making in Fig. 3.1.[1] The figure depicts time as one proceeds from left to right, for a decision-maker regarding some generic production decision. The first branching of our model is a determination of whether a decision is made actively or passively. The notion of a passive decision is related to Kahneman's concept of "thinking fast" (Kahneman, 2011) in which actions can become so routine that they elicit a decision without any deep consideration of the tradeoffs. However, in this context, passive decisions may encompass a much broader set of disengaged decision-making. Farmers who fall into routines for timing, input purchases, or other productive activities can be thought of as making passive decisions when they opt not to re-evaluate their routines. In this case, decisions regarding what crops to plant when, how to plant them, the technology to use, etc. may all be the product of passive decisions. However, if one is engaged in considering weather data or liquidity and budgets as they determine the timing or materials to use, then these would fall under active decisions.

In this nomenclature, non-adoption of improved technology may often be the result of simply not considering new options, and would thus be passive. Active decision-making requires effort and time, which likely leads to a bias toward passive decision-making. Such a bias is consistent with the observed phenomenon of status quo bias (Samuelson & Zeckhauser, 1988; Johnson & Goldstein, 2003). In general, active decisions that are made repeatedly (such as cropping decisions) are likely to eventually become passive as the farmer develops routines and habits. Several factors can contribute to the shifting of a decision from a passive to an active

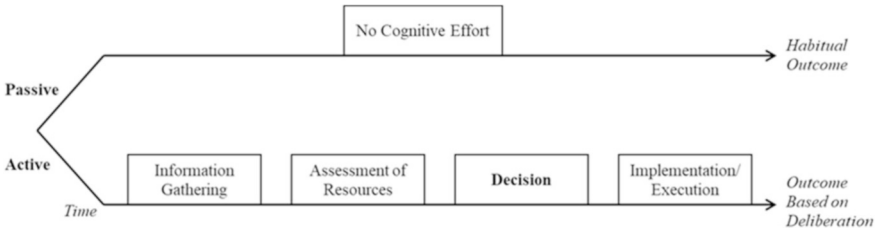


Fig. 3.1 A model of agricultural decision-making.

[1] The nudging strategies and their contexts for use, based on this decision-making model, are illustrated in Fig. 3.2.

decision. This might occur, for example, if input products that were used previously are no longer available, or if extreme weather eliminates the ability to plant on a normal schedule. Such events may force an active decision either by making a routine impossible to execute or by making potential losses from following a routine salient.

When a decision is made actively, several factors may be considered. A standard economic approach to modelling decisions is to consider how profits will be affected by the decision. Our behavioural approach considers several other factors, including the effort-cost of determining the most profitable decision. If this effort-cost looms large, a decision-maker may rely on other shortcuts to determine the best option. These shortcuts may include contextual clues as to what the optimal decision is likely to be. For example, a farmer visiting an input supplier may notice that much of the retail space is devoted to a particular input, with little space devoted to an alternative (Dreze et al., 1994). This may suggest to them that the more prominent product is more in demand, more normal, or perhaps of superior effectiveness, relative to other inputs. Similarly, a farmer may observe or consult other successful farmers to determine the best choice, opting to follow perceived social norms (Rogers et al., 2014**;** Just et al., 2002). In some contexts, a default option may play a role in signalling the perceived optimum (Johnson et al., 2012).

While many recurring decisions will eventually become passive, one-time decisions are unlikely to be passive, and some regularly recurring decisions may persist as active decisions. One-time decisions may include decisions regarding the purchase or sale of land or major equipment. Such decisions are rare but may have a substantial impact on the viability of a farm venture. There may be specific factors that determine which recurring decisions will be made actively. This may include decisions that allow the ability to adapt to weather or market conditions, or those that respond to specific family needs or available resources. In each case, active decisions generally involve a series of decision points that may present opportunities to impact the final decision outcome. Decision points may include stages such as information gathering, assessment of resources, and implementation or execution. At each decision point, the decision-maker may make a series of intermediate decisions, such as where to search for credible market information and what types of information to search for. At each of these points, the decision-maker is likely to display to some degree the same bias towards a simplified decision process and routinisation. Thus, convenience and accessibility may oftentimes trump credibility or accuracy (Wolf et al., 2001).

Three key factors play a significant role in determining how decisions are processed: salience, complexity, and compensation. Salience refers to the prominence of a potential choice among the set of available choices. Salience can often be driven by visibility. Attractive signage placed at eye level, for example, can highlight a particular input choice, making it more salient than other options. Salience may also be driven by other factors, such as a prominently known feature or a well-known brand name. When a particular option or set of options is more salient than others, it may lead the decision-maker to artificially reduce the choice set in order to

simplify the decision-making process (Bordalo et al., 2013). Thus, salience is often tied to behavioural choices.

Decision-makers tend to avoid complexity and detail (Reyna, 2012). This leads to two distinct behaviours. First, complex information is often encoded into more gist-like summary statements. In this way, tradeoffs and nuance can be glossed over or lost in the decision-making process. Thus, instead of considering tradeoffs in the cost, effectiveness, environmental impacts, and personal health impacts of a pesticide, the decision-maker may simply classify the pesticide as "dangerous" or "effective". This coding of information can gloss over important tradeoffs, leading to suboptimal decisions as well as censored searches for relevant information. Secondly, complex information itself can induce a cognitive load which will interfere with the ability to make goal-oriented decisions. A growing literature demonstrates that individuals make substantively different decisions when under cognitive load relative to when they do not face such a load (Deck & Jahedi, 2015; Oechssler et al., 2009). In food choice, this often leads people to more indulgent choices when they are under cognitive load (Shiv & Fedorikhin, 1999). In other contexts, it can lead to decisions that focus on simplified goals (e.g. increased yields) that may have non-monotonic relationships with profitability. In this way, complexity can interfere with both the characterisation of choices and the overall aims of the decision-making process.

Finally, decision-makers generally use reference points in making decisions. Thus, they may benchmark their yields relative to an especially salient year. The literature on loss aversion (Kahneman & Tversky, 1979; Tversky and Kahneman 1992) suggests that falling below such a reference po Deck, C., & Jahedi, S. (2015 int will lead to risk loving behaviour as one seeks to regain the reference point, while exceeding the reference point will lead to risk averse behaviour. This will also play a role in the way decision tradeoffs are considered. When considering multiple outputs (e.g. several crops), or multiple objectives (e.g. profit and leisure), a reduction in one outcome will need to be compensated for by a more significant gain within the other outcomes. Similarly, compensating behaviours for production or price shocks may be exaggerated relative to the optimal choice. Through a process of anchoring and adjusting (Tversky & Kahneman, 1974; Epley & Gilovich, 2006), the decision-maker may make changes in the direction of the optimum, but with a magnitude that exceeds the optimal adjustment. This results from a desire to avoid losses due to the shocks endured.

4 A Framework for Nudges in Agriculture

The potential to use a nudge to impact behaviour will depend critically on the type of decision being made, as well as the context and considerations going into the particular decision. Similar frameworks have been developed for more general decision contexts (see MINDSPACE, Dolan et al., 2012). In our framework, we will consider two primary divisions based upon the type of decision process: passive versus active.

4.1 Passive Decision Nudges

When seeking to influence decisions that are currently being made in a passive manner, there are two broad strategies available. Perhaps most effective in changing behaviour would be a nudge that is incorporated into the passive behaviour. We will refer to this as a passive nudge. For example, consider a farmer who always purchases the same input mix of seed, fertiliser, and pesticide, and a policy goal of improving soil health. Adjustments to the formulation of the inputs may go unnoticed, or, if noticed, may be considered a minor enough change so as not to induce changes in behaviour. If such formulations can be induced that encourage better soil health, the individual may continue to apply the inputs as usual and unwittingly improve the soil. If the original formulation is still available, it may be disadvantaged in the marketplace either by being labelled with a different name or designation, or by only being available by special request. Passive nudges clearly can only be implemented in specific circumstances but have the power of making passive decisions work in favour of the policy outcome, making them quite robust.

Alternatively, one way to approach a passive decision is to encourage a more active decision process. This is achieved using what has been termed a "behavioural interrupt" (Just & Gabrielyan, 2016). A behavioural interrupt can take several forms but acts to force an explicit decision instead of a passive one. The classic example of a behavioural interrupt can be found in Schwartz et al. (2012), where diners at a quick-service Chinese restaurant who have purchased a meal are explicitly asked whether they would like to forgo one of the side dishes they already paid for to reduce the calories in the meal. About a third of those who were given the question decided to forgo the side dish, whereas none would have avoided the side dish otherwise. Similarly, a behavioural interrupt could arise in the context of many of the passive decisions in the agricultural production context through input suppliers or through the action of agricultural extension or policy implementation. This may include requiring explicit reporting of policy-relevant choices accompanied by information or other behavioural influences that may impact the decision. In general, a behavioural interrupt will be accompanied by other nudges intended to influence the active decision that ensues.

No current literature examines the effectiveness of passive nudges versus behavioural interrupts in the context of agricultural decisions. However, there are other contexts in which it appears that passive nudges are generally more effective and longer lasting if available. In the context of agricultural decisions, such nudges may require the cooperation or incentivisation of input suppliers or retailers or may be entirely infeasible.

4.2 Active Decisions

When dealing with active decisions, the object of the nudge is to frame the decision to encourage the policy target. Each decision point presents an opportunity to introduce a nudge that could influence the decision. When the individual is engaged in

an active decision, we consider two general strategies. The first of these, and most common in the literature, is to present information that encourages the target behaviour. This may be accomplished using loss/gain framing or using induced social norms.

Loss/gain framing generally involves using rhetoric to frame the desired choice as one that will produce a gain relative to some reference point and other choices as a loss relative to the same reference point. To achieve this framing it may be necessary for the intervention to focus only on certain aspects of the outcomes or to emphasise one favourable aspect of the tradeoff.

The use of social norms generally attempts to paint some behaviours as common and acceptable while others as less common. This can often be achieved through the presentation of options (such as a menu of options in which one choice is labelled as more common, or presented more prominently), or through the explicit appeal to the popularity of a particular option (e.g. 70% of your neighbours engage in this option). Sometimes the offer of accompanying services can signal the normality of a particular action (e.g. including tools or materials that allow for low tillage when purchasing some quantity of inputs).

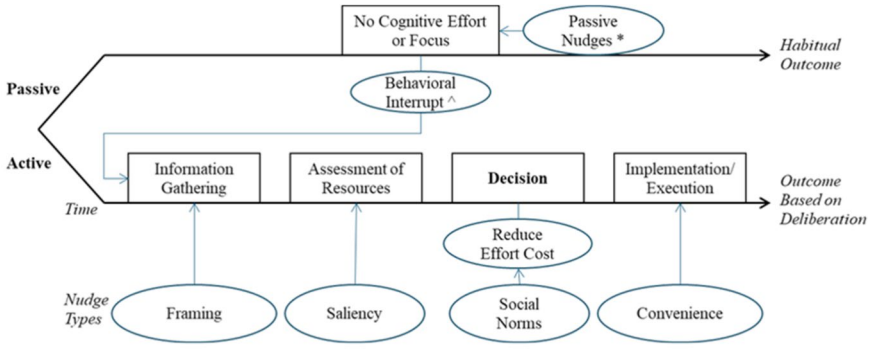
An alternative approach to nudging an active decision is to attempt to make a particular choice more convenient or less cognitively taxing. This can be done through making one option more salient in the decision context or by emphasising a simple gist-related message. By offering a narrative that reduces the effort-cost of the decision, a farmer may be led to take the shortcut and not fully engage in the decision cognitively.

4.3 Nudging Framework

Recall that Fig. 3.1 illustrates the model of agricultural decision-making. Figure 3.2 displays our classification of nudging strategies and their proper context for use. We propose that when formulating a potential nudge in an agricultural context, the researcher first considers the type of decision and then the decision points available. Once these are identified, the list of nudge types can be considered in developing a specific strategy. This process leaves sufficient room for creative applications and approaches, while providing some structure to that creative process. Indeed, it may be useful to consider some of the more general frameworks for behavioural interventions once the basic decision type and decision points are identified.

5 Examples

In this section, we present several examples of how nudges could be applied to address prominent policy issues raised in the development economics literature. The goal is to consider how actionable hypotheses could be formed and effective interventions developed.



*Passive Nudge: a nudge that is incorporated into the passive behavior.

^ Behavioral Interrupt: a way to encourage a more active decision process.

Fig. 3.2 Classification of nudging strategies and context for use

5.1 Technology Adoption

For much of the history of development economics, work has focused on the diffusion of more efficient agricultural technologies (Feder & Slade, 1985; Feder et al., 1985). Low or no fertiliser use is often cited as a key impediment to African agriculture. Duflo et al. (2011) find that small incentives (free delivery) encouraged adoption among Kenyan farmers. The study identifies present biased preferences as a key barrier to fertiliser adoption. The study also demonstrates that a behavioral interupt using time-limited micro-incentives can significantly increase adoption rates.

Adoption of more efficient technologies can improve yields and profitability for the farmer, perhaps contributing to a reduction in poverty. The technology in question has ranged from farm equipment, to particular crops, to specific breeds (such as GMOs). Because adoption scenarios involve such a wide variety of technologies, the challenges of technology adoption are also diverse. In general, there has been a persistent finding in the literature that farmers in low- and middle-income countries may be slow to adopt technologies that are demonstrably superior to the status quo (Takahashi et al., 2020). In the case of large equipment or irrigation, farmers may be slow to adopt due to the large upfront costs (Turral et al., 2010; Maertens et al., 2014). In the case of improved seed, farmers may face a higher input cost for the improved seed, while the yield improvement may eventually lead to greater profitability (Kolady & Lesser, 2008; Lybbert, 2004). In both cases, there is a need for an upfront investment that will eventually pay off.

Some technologies requiring higher upfront costs may be out of reach due to liquidity or credit constraints, which would decidedly place them out of reach of a nudge. Alternatively, some are available and affordable, but not adopted (very often the case with improved varieties or simple changes in cropping practices like integrated pest management). In these cases, barriers may include a perception of

additional risk (Feder et al., 1985), lack of awareness of the technology itself, or lack of knowledge required to implement (Wolf et al., 2001). Misperceptions and negative myths about technology have also played a major role (Oladipo et al., 2020).

In considering decision points within the framework, we will operate under the assumption that most cases of technology non-adoption are passive decisions. In other words, a farmer who could benefit from adopting an improved practice or variety simply does not consider changing their current practice, perhaps due to the cognitive load of managing agricultural activities in general. Following the framework, this presents two options. A *passive nudge* approach could be to change the default option. For example, if seed is purchased commercially, working with sales points, improved seed could be sold by default unless a buyer gives a specific request for the conventional seed. Other approaches may be to increase the shelf space allotted to the target inputs in the hopes that individuals will take the improved input out of convenience. Both of these options may be unlikely in a developing country setting where many inputs may be produced on the farm (e.g. sweet potato vines (Okello et al., 2024)) or exchanged through informal means.

Alternatively, adoption could be encouraged through a *behavioural interrupt*. Such an approach could seek to confront the decision-maker with an explicit decision of whether to adopt the new technology. This could be done at the point of sale, in a community meeting or through agricultural extension educators.

To be effective, a behavioural interrupt would need to use some technique to make the new technology seem either more attractive, convenient, or normal. This could be achieved through several different means. For example, extension agents could frame the technology with testimony from a respected community member, or by reporting on the number of neighbours who have adopted it and their results. A convenience nudge could simply make an improved seed available by delivery to the household prior to the time when seed would normally be procured. Making the seed more attractive would involve emphasising the yield advantage or profit result. Such should be communicated in a simple and almost visceral way in order to have an impact. For example, yield differences could be depicted graphically on posters placed prominently. Alternatively, selecting a name or branding for the improved seed that makes it synonymous with aspirational attributes of success, abundance, wealth, or resilience could have an impact.

While this example considers low-cost input decisions, nudges could be used to consider more substantial investments. Drawing upon the literature on retirement investments (Thaler & Benartzi, 2004), it is clear that framing can be key even in cases that involve substantial wealth and what appear to be deliberately calculated decisions.

5.2 Climate Change Adaptation and Conservation

Climate change is anticipated to pose a significant challenge to reducing food insecurity (Wheeler & Von Braun, 2013). Variations in climate affect the global food production landscape by altering the distribution of regional water resources and

soil moisture levels (Calzadilla et al., 2013). The stability of entire food systems may be further compromised by fluctuations in trade patterns and food prices stemming from unstable food production. As a result, food insecurity in regions already vulnerable to hunger and malnutrition could worsen. Beyond agricultural disruptions, climate change contributes to a wide range of other challenges, including water scarcity, extreme weather events, biodiversity loss, rising sea levels, and ocean acidification. Addressing food insecurity and poverty will require farmers to adapt to a changing climate by modifying crops, cropping patterns, management practices, and technologies. Conservation practices are somewhat similar in that they provide for a sustainable return at the cost of some upfront investment. Both prospects may present some risk in the mind of the farmer.

Developing countries often face a range of pressing challenges, including poverty, public health crises, trade disruptions, limited access to clean water, and political instability. In the context of frequent catastrophes, advocating for long-term investment can be particularly challenging. Consequently, many developing nations address climate change reactively rather than proactively (Chambwera, 2010). This reactive approach risks deferring climate change adaptation until a future crisis, when investments may be far less effective, and the resulting damage to lives and property could be severe. A more practical strategy is to integrate climate change adaptation into farm planning, which involves systematically identifying and prioritising problems and corresponding adaptation measures.

When considering decision points as shown in the framework, we assume that most climate change adaptations function similarly to general technology adoption, where non-adaptation often results from passive decision-making. In other words, a farmer who could benefit from adopting alternative cropping patterns or practices may resist change due to a lack of awareness, understanding of the benefits, or recognition of the risks associated with maintaining the status quo. Within this framework, two approaches can be employed: a passive nudge or a behavioural interrupt. A practical *passive nudge* could involve bundling seeds for alternative crops with traditional crops by default, thereby subtly encouraging their adoption. A *behavioural interrupt* might involve an extension programme explicitly visiting farms at key moments when adaptive practices should be implemented. These visits could include presenting relevant information, sharing testimonials, and offering services to trial or adopt new practices. Framing current yields or returns as a loss compared to alternative practices could leverage loss aversion, encouraging farmers to take calculated risks to improve returns. Efforts could also be made to enhance the social acceptability and desirability of adaptation, such as publicising the success stories of farmers who have adopted adaptive practices or distributing signage and merchandise that identify and celebrate these farmers' achievements.

To promote adoption, new adaptations should be made more economically attractive, practically convenient, or suggested as the social norm. Raising awareness of the long-term benefits that may result from short-term investments or transitions to new practices is crucial. The advantages of climate change adaptations and conservation should be communicated clearly and in plain language to ensure accessibility. Credibility in these communications can be strengthened by involving

respected community members and credible extension educators. Additionally, adopting environmentally friendly equipment or fixtures can be facilitated through convenient in-home delivery and installation services. Such initiatives could be aligned with green energy subsidy and rebate programmes, making it easier and more appealing for individuals to transition to sustainable practices.

5.3 Household Savings and Consumption

Savings play a crucial role in the financial health and stability of households. Saving rates in developing countries are significantly influenced by household income and wealth levels (Schmidt-Hebbel et al., 1992) as well as perceived social norms. For households facing financial difficulties, policy interventions generally prioritise increasing income. Nudge interventions aimed at influencing saving decisions are more applicable to families with more favourable economic conditions. Saving is essential to household well-being, as it not only provides a hedge against income fluctuations but also serves as a means to achieve long-term familial goals such as the purchase or repair of a home or equipment. Factors such as income and wealth levels, family size and structure, cultural norms, financial literacy, and access to financial services all significantly influence household saving and consumption decisions.

Household saving rates vary both across countries and over time. In developing countries, where disposable income is lower, saving rates tend to be lower, as a significant portion of income is allocated to essential expenditures. Low disposable income contributes to food insecurity and a host of other challenges. When households do have the capacity to save, they often lack the self-restraint or the management skills to do so. Surveys conducted in Pakistan suggest that people are ill-equipped to make complex financial decisions, do not plan sufficiently, and have a poor understanding of investment concepts (Bhabha et al., 2014). Additionally, limited access to financial institutions and services further hinders their ability to save effectively. In rural areas of sub-Saharan Africa, many households have limited access to banks and financial services, which impedes their ability to save securely and systematically (Collins et al., 2009).

Assuming that saving decisions in developing countries are passive in nature, where households do not automatically save due to a lack of awareness or habitual behaviours despite the significant benefits of saving, this framework presents two options. One *passive nudge* approach could be to automatically enrol households in saving plans when they receive their pay cheques. The accumulated savings, along with the accrued interest income, could then be used for purposes such as making a down payment on a home or funding education. Account holders would have the option to opt out upon request. Such an approach has shown some success previously (Sherraden, 2017). This approach may not be realistic in the regions where financial services are not widely accessible.

Alternatively, a *behavioural interrupt* could be used to encourage saving behaviours. One prominent example of a behavioral interrupt primed individuals to

consider their spending in the recent past, helping them to identify how they could have made better use of their resources (Garbinsky et al., 2021). In a similar way, decision-makers could be confronted with an explicit decision of whether to save or to consume. Approaches more specific to agricultural households could be implemented through financial institutions when farmers sell their crops. For example, a portion of the sale proceeds could be automatically directed into savings accounts. To enhance the accessibility and acceptance of these financial services, extension professionals and community leaders could play a pivotal role. They could provide the necessary financial education and support, thereby making these services more approachable and trusted within the community. Furthermore, financial institutions and community services could enhance savings behaviour by sending regular reminders through messages or broadcast notifications. These communications should emphasise savings goals and progress, and clearly outline the benefits of saving, using simplified and easily understandable language.

5.4 Intra-Household Allocation

In the case of intra-household allocation, gender and age-based bias are common in individual financial, nutritional, and healthcare allocations in developing countries. Cultural, economic, and biological factors all contribute to such discrimination or neglect (Messer, 1997; Kaul, 2018). Policy goals generally include nutritional security in the broader sense, which incorporates "food, health, and care" (International Conference on Nutrition, World Declaration and Plan of Action for Nutrition, FAO/WHO, Rome, 1992).

In the intra-household allocation process, allocation only happens because of cash inflows. Whether the income is from routine economic activities or from a one-time windfall would likely determine whether the decision process is passive or active. Resources of a routine nature such as salaries or proceeds from crops may induce passive decision-making, while a one-time income shock such as an inheritance, sale of assets, a government payment or winnings from gambling likely triggers an active decision-making process.

Key in this process is who receives the money, who is engaged in the decision and who eventually benefits from the resource. In a development context, decisions are often made by the family member who earns the preponderance of income, who, in many cultures, is the male household head. In some circumstances, the decisions are made through collective consultations. Some studies find that female household members usually make familial nutritional decisions that lead to better health outcomes (Doss, 2013), arguing for putting more resources in the hands of wives and mothers. Culture and economic conditions play an essential role in forming a strong social norm that is unlikely to change with a simple intervention.

In considering potential nudges, the intervention will need to depend on context and target. For example, a government direct payment programme could serve as a *passive nudge* by associating the payment with a uniquely female action (e.g. breastfeeding) or a socially female action (e.g. producing non-cash crops or tending

young children) creating a separate social norm around this particular resource. Alternatively, a policy goal could employ a *behavioural interrupt* to encourage male heads of households to invest in their families. For instance, government payments could be made accessible only after filling out and signing a form that asks specific questions about how prior resources have been allocated, similar to the financial responsibility exercise of Garbinsky et al. (2021). A more direct approach may ask individuals to report the percentage of the income they intend to allocate to specific needs of children or spouse, as a soft commitment (Bryan et al., 2010). Any such mechanisms could promote the perception of a positive social norm and the positive outcomes of such. Finally, in cases where cards or certificates could be used to access resources, simple pictures or phrases reminding the decision-makers of family or family needs may help to associate their decisions more closely with children and spouse.

6 Conclusion

The use of behavioural decision tools to encourage development, increased welfare, and wealth creation is in its early days. We have much to learn about what is and is not effective, and which tools are appropriate to which circumstances. Nudges provide a fruitful ground for initial research as they present very little risk of harm—choice sets are not actually altered—and generally cost much less to implement than other interventions. The challenge to find promising applications depends upon the creative application of general behavioural principles. In this chapter, we have attempted to provide a framework that can help researchers to identify potential targets. This framework requires first identifying the decision points in the target process, classifying those decisions as passive or active, and then considering the ways to leverage known and existing behavioural effects appropriate to that process. While much work is needed to determine the eventual effectiveness of such nudges, there is substantial reason to believe that it will be worth the investment. Where developed economies have widely adopted such an approach to improving policy, the gains are potentially much larger in proportion in the developing country context.

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Part II

Behavioural Drivers and Targeted Applications

4 Behavioural-Economic Factors and Epidemiological Models for Improved Livestock Disease Interventions

Jaap Sok, Carolien de Lauwere, and David R. Just

Abstract

Livestock disease epidemics have major economic, environmental, and public health consequences, making farmers' adoption of prevention and control measures essential. This chapter reviews the behavioural-economic factors influencing farmers' adoption of livestock disease prevention and control measures and examines how these insights can improve intervention design and epidemiological modelling. Drawing on behavioural frameworks developed in the broader agricultural economics literature, we review the animal health economics and related literature according to four groups of behavioural factors: (i) risk and time preferences, (ii) risk perceptions, heuristics, and cognitive biases, (iii) culture, social capital, and personality, and (iv) motivations and perceived abilities. We then link these factors to intervention functions and assess how they have been incorporated into bio-economic and epidemiological models. The review shows that effective interventions require distinguishing between relatively stable behavioural characteristics and more dynamic factors that can be influenced during disease events. Farmers respond not only to objective disease risks but also to emotions, social networks, and behavioural biases. Important research gaps remain, particularly regarding empirical evidence on risk and time preferences and the use of experimental and longitudinal research designs. Current epidemiological models largely represent decision-making as rational cost–ben-

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efit analysis and underrepresent behavioural complexity. Integrating richer behavioural-economic insights into epidemiological and bio-economic models can improve intervention design, strengthen voluntary disease prevention strategies, and support more effective livestock disease policy.

Keywords

Animal health economics · Livestock disease prevention · Farmer decision making · Behavioural factors · Bio-economic modelling · Epidemiological modelling · Risk perception · Behaviour change interventions

1 Introduction

Livestock disease epidemics can have significant socio-economic impacts and pose risks to human health if not effectively managed. To address these challenges, public bodies at national and international levels often collaborate through supranational organisations like the World Organisation for Animal Health (WOAH). These collaborations aim to coordinate efforts and develop strategies to minimise the impacts and risks associated with livestock diseases. The European Union (EU), for example, has established a comprehensive legislative framework under the EU Animal Health Law (Regulation (EU) 2016/429), which outlines specific prevention and control measures for member states to implement during outbreaks[1] to limit disease transmission and mitigate consequences (European Parliament and Council of the European Union, 2016).

The One Health approach, emphasising the interconnectedness of human, animal, and environmental health, highlights the importance of prevention and preparedness. Beyond zoonotic disease control, this approach addresses broader challenges such as antimicrobial resistance, food safety, and food security. For example, reducing antibiotic resistance in low- and middle-income countries (LMICs) may require greater focus on animal and environmental reservoirs of resistance rather than solely targeting human antibiotic misuse (Nadimpalli et al., 2018).

Within these frameworks, both mandatory and voluntary approaches to livestock disease prevention and control are possible, depending on a disease's socio-economic and public health impact. When outbreaks pose severe socio-economic consequences of public health risks, mandatory measures such as disease reporting, quarantine, and movement restriction are often necessary. While these measures are effective in ensuring rapid and reliable epidemiological outcomes, they can be costly and may frustrate stakeholders, particularly if they perceive the regulations as excessive.

[1] The diseases mentioned in the main text include foot-and-mouth disease, classical swine fever, African swine fever, highly pathogenic avian influenza, and African horse sickness. Annex II of this regulation includes 39 other animal diseases.

In contrast, voluntary approaches can provide cost-effective, efficient, and less disruptive alternatives if they achieve comparable epidemiological outcomes (e.g. Segerson, 2013). Voluntary strategies can minimise transaction costs associated with lobbying and legislation (ex ante) and reduce costs related to surveillance and enforcement (ex post), making them a potentially preferable option (Furubotn & Richter, 1998). For example, voluntary adoption of biosecurity practices, participation in vaccination programmes, or reduction in antibiotic use can enhance disease prevention and control. In LMICs, where resources and enforcement capacities may be limited, voluntary approaches can be particularly valuable. These strategies empower local farmers and communities to adopt preventative measures that align with One Health principles, even in the absence of stringent regulatory frameworks.

Designing interventions requires collaboration among policy makers, veterinarians, epidemiologists, and animal health economists (hereafter referred to as animal health stakeholders). These stakeholders must carefully weigh the trade-offs between mandatory and voluntary approaches, considering factors such as disease severity, available resources, and the potential for long-term compliance. A key aspect of this process is understanding the behavioural factors influencing farmers' adoption of prevention and control measures. Social science and economics can offer valuable insights into these factors, enabling targeted and effective interventions. For example, financial incentives may suffice if research shows that farmers are primarily motivated by economic and risk considerations.

While the primary focus of this book is on LMICs, unfortunately little of the work on farmer behaviour and livestock disease prevention and control has focused on this target set of countries. LMICs face unique challenges in the availability of veterinary care and disease monitoring (Jilo, 2023), increasing the vulnerability of both markets and human populations. Veterinary services in Africa and Asia rely heavily on private provision of services with informal markets for veterinary drugs (Cheneau et al., 2004). This is a particular challenge where private incentives are insufficient to attract the necessary expertise and resources to monitor emerging zoonotic diseases. For example, in Kenya and Uganda, limited extension and government resources combined with low private incentives have led to (i) a lack of access to competent advice for pastoral farmers, and (ii) abuse and overuse of veterinary drugs (Ilukor, 2017). It is arguable that behavioural factors play an outsized role where formal advice may be absent, pointing to the critical need for more formal research in LMICs in this area. As a foundation for such efforts, we rely heavily on the emerging literature on behavioural factors in livestock disease management in the developed country context.

Over the past decade, several authors have reviewed the behavioural factors affecting the adoption of livestock disease prevention and control measures. Barnes et al. (2015) examined the effects of animal health compensation on disease reporting behaviour and adoption of biosecurity practices. They noticed, among other things, a division in literature between economic and socio-geographic literature and argued for a mix of choice- and non-choice-based interventions for successful outcomes. Garforth (2015) reviewed motivational, informational, and persuasive factors that influence the intention to implement these measures. Key lessons from

his review include the impact of previous experiences with diseases and control measures on intentions, as well as the importance of credible information sources. Gilbert and Rushton (2018) critiqued the reliance on rational economic models in contexts involving externalities and collective action, highlighting the limitations imposed by systematic biases in human reasoning and the importance of psychological constructs in understanding decision-making processes. Their findings underscore and expand upon Garforth's conclusions, particularly emphasising the role of risk perception, farmers' long-term goals, trust, and time preferences as mediating variables. For instance, trust in animal health stakeholders influences compliance, while time preferences affect willingness to invest in measures with delayed benefits, such as vaccination programmes. Ritter et al.'s (2017) extended findings from the motivational literature by assessing the usability of several extension tools to motivate farmers to improve endemic infectious disease prevention and control. They distinguish between extension tools targeting central routes of communication, which assume farmers make rational, science-based decisions, and peripheral tools that leverage behavioural cues, heuristics, or nudges, recognising that these may often be more effective than purely science-based argumentation.

From this body of work, several gaps in the animal health economics literature become apparent. First, much of the existing research focuses predominantly on motivational factors. Reviews in other sub-domains of agricultural economics suggest a broader categorisation of behavioural factors (Dessart et al., 2019; Wuepper et al., 2023; Finger et al., 2024), including risk preferences, personality traits, and individual differences, which remain underexplored in livestock disease management. To address this, we conducted a scoping review[2] to categorise the behavioural factors and mechanisms influencing the adoption of prevention and control measures. We selected up to three studies that were intentionally diverse, targeting different livestock diseases in various regions worldwide and employing both quantitative and qualitative research approaches. For each category, we identified potential gaps and open issues for future research. The factors we reviewed were identified a priori based on the framework provided by Finger et al. (2024), who recently constructed a comprehensive categorisation of behavioural factors influencing adoption in sustainable crop protection. While more established frameworks might exist, Finger et al. (2024) build upon them and integrate behavioural factors in an interdisciplinary perspective that aligns well with the scope of our research. Specifically, their framework incorporates also behavioural factors such as risk and time preferences, personality traits, and individual differences, which are underexplored in the context of livestock disease management.

[2] We used Scopus to conduct this scoping, narrative review using this search query: (TITLE-ABS-KEY (*behavioural factor of interest*) AND TITLE-ABS-KEY (farmer*) AND TITLE-ABS-KEY (disease AND (control OR outbreak OR epidemic)) AND TITLE-ABS-KEY (livestock OR herd* OR animal*)) AND PUBYEAR >2013.

Second, interventions must be better tailored to behavioural factors. Several frameworks,[3] across different research domains, propose taxonomies of policy instruments and interventions, with some also linking them to behavioural factors. These frameworks acknowledge that in voluntary approaches, a mix of tools is required to reach out to heterogeneous farmer profiles. Drawing on frameworks used in public health, we attempted to link the behavioural factors from the categorisation of Finger et al. (2024) with intervention functions. We thereby also evaluated the potential for nudging and other innovative tools from a temporal perspective to enhance voluntary approaches.

Third, integrating behavioural factors into bio-economic or epidemiological models is essential. These models, used to evaluate interventions and policies for livestock disease prevention and control, often assume that farmers are primarily motivated by goals such as profit or utility maximisation, or by minimising costs and risks. While these models are mathematically tractable, they offer a narrow perspective on the behavioural factors driving actions such as adopting biosecurity measures or participating in vaccination schemes. Furthermore, current models often underrepresent the interplay between disease dynamics and human behaviour (Ceddia et al., 2013). We reviewed[4] the studies that have explored this interaction and which and how behavioural factors and interventions have been incorporated into these models. Based on our findings, we offer suggestions for improving or rethinking modelling approaches to better account for the range in behavioural factors and related interventions.

The remainder of this chapter is organised as follows. Section 2 identifies key behavioural factors for livestock disease prevention and control. Section 3 links these factors to intervention functions and tools. Section 4 reviews epidemiological models incorporating behavioural factors. Section 5 concludes with recommendations for research and policy.

[3] Examples of such frameworks include the RESET model (Rules, Education, Social pressure, Economic incentives, and Tools; e. g. Lam et al., 2017), which is based on the "sorting scheme" introduced by Van Woerkum (1990). The Nuffield Health Ladder of Interventions (see e.g. Barnes et al., 2015) categorises actions by coercion level, from voluntary measures to mandatory ones. Additionally, the "stick, carrot, sermon" typology distinguished tools into regulations and penalties (sticks), incentives or rewards (carrots), and information and persuasion (sermons) (e.g. Andreoni et al., 2003; Bemelmans-Videc et al., 2011).

[4] We used Scopus and Web of Science to conduct this additional review using this search query: (TITLE-ABS-KEY (epidemio*) AND TITLE-ABS-KEY (behavio*) AND TITLE-ABS-KEY (farm*) AND TITLE-ABS-KEY (disease)). We included papers that incorporate one or more behavioural factors and related interventions in the livestock disease prevention and control domain. We excluded literature that focuses on game-theoretical and strategic interaction modelling and only considered livestock disease control applications.

2 Key Behavioural Factors for Livestock Disease Prevention and Control

We distinguish eight broad categories of key behavioural factors that were classified into four groups, originating from various social science fields, including economics, sociology, psychology, and interdisciplinary studies. Our review outcomes are presented in Table 4.A1 in "Appendix". For each behavioural factor, the table provides a definition, examples of how it was studied in a livestock disease context, and potential gaps and open issues for future research. Here, we summarise the main findings (Sects. 2.1–2.4) and discuss the temporal dynamics of behavioural factors in relation to prevention and control decision-making during livestock disease events (Sect. 2.5) before continuing with linking the behavioural factors to interventions (Sect. 3) and linking behavioural factors and interventions to epidemiological modelling (Sect. 4).

2.1 Risk and Time Preferences

Imagine a farmer must choose between two disease control strategies:

1. Immediate vaccination: Costs €1000 today but reduces outbreak risk from 40% to 10%.
2. Wait-and-see approach: No cost today, but if an outbreak occurs next year, the farmer faces a €5000 loss.

This decision reflects two fundamental behavioural concepts in economic theory: risk preferences and time preferences. Risk preferences influence how farmers evaluate and respond to uncertain outcomes, such as the probability of a disease outbreak. Many farmers tend to be risk-averse, preferring to reduce the mean outcome to minimise potential losses. Our review highlights the need to better understand how farmers assess probabilities and consequences in the context of livestock diseases (see the next section). Factors such as disease characteristics, epidemiological dynamics, and individual traits influence these preferences. While farmers may manage risk by considering probabilities, dealing with uncertainty, where probabilities are unknown, requires a different approach and remains less understood.

Time preferences shape how individuals balance immediate versus future outcomes, influencing their willingness to invest in measures with delayed benefits. Discounting refers to the tendency to value future benefits less than immediate ones, while patience describes the willingness to wait for those future benefits. Our review aligns with Gilbert and Rushton's (2018) observation that discounting and patience are understudied in research on farmer behaviour and livestock disease prevention. Insights into how farmers approach decisions involving time and uncertainty are crucial for designing effective policies, particularly those with long-term implications like disease eradication efforts.

Risk and time preferences are commonly used in behavioural-economic models to represent farmer behaviour. Bio-economic models combine biological factors,

such as how disease dynamics affect production levels, with economic factors like costs. Epidemiological models focus on disease spread and control. Incorporating risk and time preferences into these models helps assess how farmer behaviour can influence both economic and epidemiological outcomes.

2.2 Risk Perceptions, Heuristics, and Biases

The next group of behavioural factors centres on how individuals act in situations characterised by limited information and/or uncertainty. Risk perception, as a behavioural concept, is explored across multiple disciplines. In economic theory, it is analysed from both objectivist and subjectivist perspectives (e.g. Hardaker & Lien, 2010), where it is typically framed in terms of probabilities. An alternative view conceptualises risk perception as an intuitive judgement informed by limited and uncertain information (Slovic, 1987; Slovic et al., 2004). The former approach treats risk perception as a calculative exercise, while the latter acknowledges its experiential nature. For example, farmers often seek to avoid the recurrence of previous harmful experiences with livestock diseases, particularly those involving significant suffering of animals. Consequently, the literature on risk perception frequently intersects with research on heuristics and cognitive biases.

The most prominent theories of decision-making under risk are expected utility theory (EUT) and prospect theory (PT). EUT assumes that individuals evaluate all possible outcomes by weighing their probabilities and consequences, aiming to maximise the expected utility of values associated with those outcomes. In contrast, PT emphasises that people perceive probabilities subjectively, often assigning greater weight to potential losses than equivalent gains.

A notable observation from our review is the limited exploration of alternatives to EUT in research on livestock disease prevention and control. While EUT assumes constant probabilities, psychological research reveals that individuals tend to overweigh low probabilities and underweigh high probabilities, and they evaluate potential outcomes relative to a reference point (e.g. their income). These cognitive biases are explained by (cumulative) prospect theory, which has been widely used to explain and predict risk behaviour (Tversky & Kahneman, 1992). This theory is commonly applied in human health and medicine to describe how people handle probabilities and outcomes (e.g. Winter & Parker, 2007; Attema et al., 2013; Kairies-Schwarz et al., 2017). However, its application in animal health economics, particularly with farmers as decision makers, remains largely unexplored.

This gap in the literature also stresses the importance of distinguishing between different behavioural factors that influence decision-making under risk. For example, risk perception and risk preference are often conflated in empirical ex post studies (Just & Just, 2016). Similarly, risk and time preferences are frequently intertwined (Andersen et al., 2008). Clarifying these distinctions is critical for formulating strategies to effectively engage and motivate decision makers (Andreoni & Sprenger, 2012; Just & Cao, 2018).

Most studies in our review relied on ex ante survey methods combined with self-reported measures of risk perception. Experimental approaches in livestock disease decision contexts are rarely employed, possibly due to their expensiveness in farmer behaviour research settings. Nevertheless, these studies confirm earlier findings that risk perceptions encompass both calculative and experiential or affective components (risk as appraisal or as feeling).

2.3 Culture, Social Capital, and Personality

Culture, defined as the shared beliefs, values, norms, and practices that characterise a group or society, plays a key role in shaping social capital and personality traits. Cultural dimensions, such as power distance[5] and individualism versus collectivism (Hofstede, 1980), significantly influence livestock disease prevention and control strategies. For example, high power distance societies tend to rely on hierarchical structures and community leaders to enforce disease prevention measures, while collectivist cultures emphasise group cohesion in decision-making. These cultural values may help explain the divergent responses among European member states during the Bluetongue epidemic from 2008 to 2010, where some countries adopted voluntary approaches while others implemented mandatory measures (Sok et al., 2015).

Many interventions discussed in this research rely heavily on social capital elements such as norms, values, and trust. The effectiveness of information dissemination, for example, is largely determined by how well social networks and extension or advisory services function as mechanisms for cooperation and coordination. Although not specifically reviewed here, veterinarians play a crucial role in this process, yet their influence can vary depending on the type of livestock disease and may not always be effective in communication (e.g. Morgenstern et al., 2024). Moreover, studies indicate that social capital and cultural factors can sometimes work counterproductively—for instance, cultures of secrecy or practices that discourage reporting or preventive actions (Delabouglise et al., 2017). Depending on the cultural context, social capital and networks can either support or hinder disease prevention and control policies.

At the individual level, personality traits also affect farmers' willingness to adopt prevention and control measures. Studies often find that a higher conscientiousness correlates with better compliance with biosecurity measures and a more favourable attitude towards vaccination. The Big Five personality traits are frequently used to assess how cognitive and non-cognitive skills affect livestock disease prevention and control decisions (e.g. O'Kane et al., 2017; Sok, Hogeveen, et al., 2018a; Delpont et al., 2021).

[5] It refers to the extent to which less powerful members of a society, organisation, or institution accept and expect that power is distributed unequally.

2.4 Motivations and Abilities

To foster higher uptake or participation rates and enhance the effectiveness of disease prevention and control strategies, it is important to acknowledge that motivations extend beyond economic preferences and the conventional goal functions commonly used in epidemiological and bio-economic models. A broad range of intrinsic and extrinsic motivations influence decision-making. While some farmers may act based on financial incentives, social norms, or regulatory requirements (extrinsic motivation), others may be driven by personal values or a sense of duty (intrinsic motivation) (Frey & Jegen, 2001; Engelen, 2017). Additionally, different motivations can reinforce or undermine each other, influencing behavioural responses to interventions. Lastly, even when motivation is present, perceived ability to act can be a key limiting factor in actual implementation.

Most of the research on farmer motivations and abilities has relied on models from social psychology, which focus on intention as the central construct for empirically assessing the determinants of behaviour. The most widely adopted framework in this regard is the theory of planned behaviour (TPB), a reasoned action approach (Fishbein & Ajzen, 2010; Sok et al., 2021). Empirical applications of the TPB typically involve mapping the determinants of intention using correlational survey data. According to the TPB, these determinants include attitude towards the behaviour, injunctive and descriptive norms (referring to what others expect and how other behave, respectively), and perceived behavioural control. For example, if attitude is identified as the primary driver of intention, then it is recommended for behaviour change strategies and intervention design to focus on tools that target and influence beliefs via reasoned opinions. However, our review reveals that experimental and/or longitudinal designs that test the success of interventions in increasing participation and uptake rates are rarely employed. A recent study that used a longitudinal design in the realm of sustainable farming practices, for example, reported a significant intention-action gap when subsidisation was used as an intervention (Byfuglien et al., 2025).

2.5 Temporal Dynamics of Behavioural Factors

A critical challenge moving forward is the integration of behavioural-economic insights into mathematical bio-economic and epidemiological models. Achieving this would enable these models to better capture the nuanced motivations underlying farmer behaviour. As a starting point, it is essential to examine the temporal dynamics of the eight behavioural factors reviewed earlier.

Bio-economic and epidemiological models differ in how they represent time, either implicitly or explicitly. Epidemiological models typically simulate disease spread within and between populations over short intervals, such as days or weeks, using discrete time steps or continuous time dynamics. Conversely, traditional bio-economic models often span long time horizons, focusing on cumulative impacts of farmer decisions on production and economic outcomes, typically emphasising

equilibrium or long-term trends. Dynamic bio-economic models bridge this divide by incorporating temporal evolution, enabling assessments of how farmer behaviour and economic impacts respond to interventions or disease outbreaks over time.

To illustrate this, Liebenehm et al. (2016) developed a dynamic bio-economic model integrating an epidemiological susceptible-exposed-infectious-recovered (SEIR) framework with an economic component that employed a discounted utility function alongside observed risk and time preferences. Although the model utilised prospect theory, it conflated probability (risk perception) and impact (see Sect. 2.2). By adjusting parameters related to epidemiology, risk, or time preferences, the model identified optimal allocations for preventive and curative treatments based on the number of affected animals and associated economic losses.

During livestock disease events, behavioural factors exhibit varying degrees of stability and responsiveness. Factors such as risk and time preferences or personality traits (reviewed in Sects. 2.1 and 2.2) are relatively stable over short timeframes (Borghans et al., 2008; Cobb-Clark & Schurer, 2012) and are thus largely fixed during disease outbreaks. For instance, risk-averse farmers may consistently favour preventive measures, irrespective of changes in the disease context. Differences in personality traits or risk attitudes also lead to consistent variations in farmers' responses to prevention and control measures.

In contrast, other behavioural factors (reviewed in Sects. 2.3 and 2.4) are more dynamic and sensitive to evolving disease conditions. For example, risk perception fluctuates with the proximity to and severity of disease outbreaks (Sok & Fischer, 2020), directly influencing decision-making during emergent crises. Similarly, heuristics and cognitive biases, such as the availability heuristic, can become prominent in response to recent or salient disease events. However, the extent to which these dynamic factors shape decision-making is mediated by more stable behavioural characteristics, such as risk and time preferences or personality traits, which introduce heterogeneity in farmers' responses to prevention and control measures.

Figure 4.1 illustrates the spectrum of behavioural factors, categorising them based on their stability over time (stable vs. adaptable) during livestock disease events. The next section elaborates on how different intervention strategies target these behavioural factors to promote livestock disease prevention and control.

While all behavioural factors can evolve over a farmer's lifetime, stakeholders in animal health must account for the temporal dynamics discussed. The bio-economic model by Liebenehm et al. (2016) spanned a 20-year horizon, whereas the agent-based model by Sok and Fischer (2020) focused on a 6-month period. Some interventions aim to leverage short-term behavioural dynamics during emergent disease outbreaks, while others adopt a long-term perspective, such as fostering enhanced farmer networks or cooperative advisory systems. Recognising and addressing the temporal dimensions of behavioural factors is crucial for designing effective interventions tailored to specific contexts and timeframes.

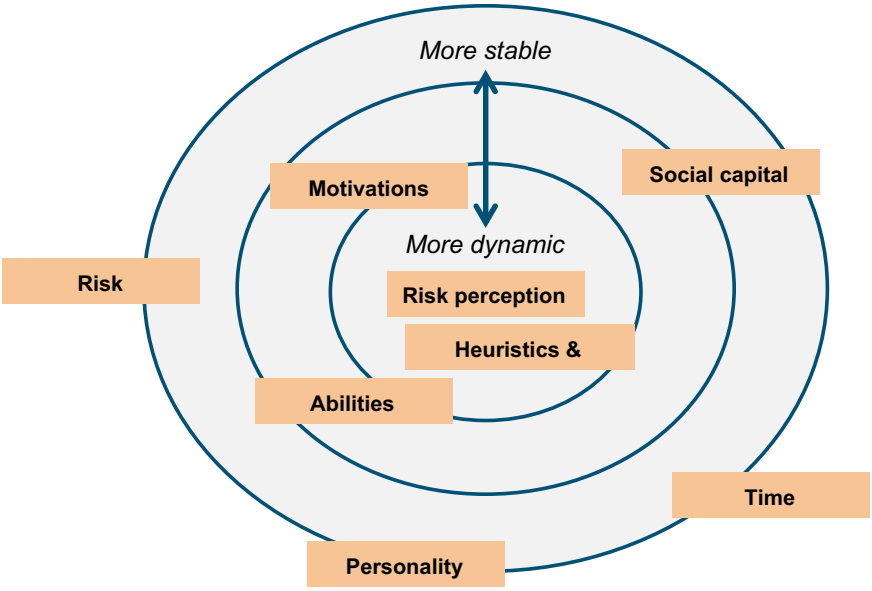


Fig. 4.1 Adaptability of behavioural factors influencing farmer decision-making in livestock disease contexts. More dynamic factors Are in the inner circle, while more stable factors are in the outer circle

3 Aligning Interventions with Behavioural Factors

This section corresponds with our second contribution, which is to align behavioural factors with intervention functions. Different livestock disease prevention and control interventions target distinct mechanisms of behaviour change, engaging both automatic and conscious processes. The widely recognised *stick-carrot-sermon* typology provides a starting point for classifying these interventions and can be complemented with nudging approaches:

- *Sticks* refer to disciplinary measures like fines or regulations that rely on external enforcement to deter undesired behaviours. These interventions often leverage fixed traits, such as risk preferences, to predict and ensure compliance.
- *Carrots* are incentives or rewards like subsidies or tax advantages that aim to motivate behaviour by appealing to short-term goals and economic benefits. They may interact with dynamic factors like perceived risks.
- *Sermons* refer to strategies like moral suasion, persuasion, or information campaigns that appeal to individuals' values, ethics, and sense of duty, aiming to change attitudes and behaviours through communication, education, or social norms.

- *Nudging* represents a subtler approach, leveraging behavioural insights to design environments that steer farmers towards desired decisions without restricting choices or relying on significant financial incentives. Examples include default settings in insurance schemes, reminders about vaccination schedules, or framing information to emphasise losses from inaction rather than potential gains.

To provide a more nuanced understanding of these interventions, we align them with behavioural factors using the refined framework of the Behavioural Change Wheel (BCW) developed in public health (Michie et al., 2011). While the *stick-carrot-sermon* framework offers a high-level typology, the BCW provides a more comprehensive classification of nine intervention functions. This enables a clearer connection between overarching intervention tools and the specific behavioural mechanisms that animal health stakeholders can leverage in practice. For examples of BCW applications specifically in livestock disease contexts, see McLeod et al. (2015) and Farrell et al. (2023). However, these studies considered only capability, opportunity, and motivation as behavioural factors.

Table 4.1 presents a detailed overview of intervention functions that can effectively address livestock disease events through voluntary approaches. For rapid response to emerging disease outbreak, a combination of intervention functions is likely required to achieve high compliance levels and rapid containment, as different interventions target distinct behavioural factors over time. This reflects the multifaceted nature of how individuals assess and respond to risks, whether through analytical appraisal or intuitive emotional responses.

In the early stages of an outbreak, intervention functions such as *persuasion* and *modelling* are particularly critical. These interventions target dynamic behavioural factors and can quickly mobilise early adopters by leveraging emotional appeals, social influence, and observational learning to prompt immediate action (Sok & Fischer, 2020). Importantly, these early adopters often require minimal supportive measures to engage in recommended practices.

For farmers less likely to act immediately, other intervention functions—such as *education*, *incentivisation*, *training*, *enablement*, and *environmental restructuring* (e.g. *nudging*)—are crucial. These interventions address barriers to action and build motivation through strategies such as providing accessible, and credible information, offering financial incentives, equipping farmers with the necessary skills and resources, or creating supportive environments that facilitate the desired behaviours.

When an epidemic livestock disease transitions to an endemic state, the perception of disease risks may shift from being viewed as catastrophic to operational (Valeeva et al., 2011). This change significantly affects the effectiveness of certain intervention functions. For example, interventions that rely heavily on risk perceptions or exploit heuristics and biases may lose effectiveness as farmers adapt to the persistent presence of the disease.

Table 4.1 Overview of the alignment between intervention functions identified by Michie et al. (2011) and the eight behavioural factors reviewed for influencing behaviour during a livestock disease event

Intervention function	Description	Key assumption	Risk pref.	Time pref.	Risk perc.	Heur. & Bias.	Soc. cap.	Pers. trts.	Motiv.	Abil.
Education	Increasing knowledge or understanding to support informed decision-making	Informed individuals will make decisions aligned with desired behaviours	●	●			*Often indirect*		●	
Persuasion	Using emotional appeals or influential communication to motivate action	People are not always rational decision makers; emotions and social influences can drive behaviour as well			●	●			●	
Incentivisation	Offering financial or material rewards to encourage behaviour change	People will respond to tangible rewards; incentives lead to behaviour change	●	●					●	
Coercion	Applying penalties or external pressures to induce compliance	People will comply with desired behaviours to avoid negative consequences	●	●	●				●	
Training	Developing skills and competencies to perform desired behaviours	People will adopt behaviours if they possess the necessary skills and capabilities	●		●					●
Enablement	Removing barriers and providing resources to facilitate behaviour change	Behaviour is more likely when individuals have the support, tools, or resources they need		●						●
Modelling	Demonstrating desired behaviours to encourage imitation or aspiration	People are influenced by observing others' behaviours, particularly when these lead to positive outcomes			●	●			●	
Environmental restructuring	Altering physical or social contexts to make desired behaviours more accessible	Changing the environment can influence behaviour by reducing barriers or creating nudges toward desired actions	●	●	●	●			●	
Restriction	Limiting or prohibiting certain behaviours through rules, laws, or regulations	Mandated behaviours reduce voluntariness, requiring compliance through enforcement								

Beyond managing epidemic and/or zoonotic diseases, this list of interventions is also employed to address broader, long-term challenges such as antimicrobial resistance, food safety, and food security. For these issues, effective strategies should prioritise sustained support mechanisms. Strategies could focus on building strong farmer networks or cooperative advisory systems to stimulate peer learning. Another example is to design strategies that promote preventative biosecurity behaviours that become habitual and integrated into routine farm management.

Higher levels of social capital can significantly enhance the effectiveness of intervention strategies by fostering trust and collaboration. In this way, social capital may function as a hidden fifth mechanism of behaviour change, reinforcing or undermining the effectiveness of other policy instruments. When robust social networks are characterised by norms of reciprocity, strong reputations, group identity, and solidarity, they foster trust and confidence among stakeholders. However, challenges can arise when social distance develops between farmers and other animal health stakeholders, particularly if mutual trust and respect are compromised. To overcome these challenges, regulators and those they regulate must work collaboratively to rebuild trust and agree on shared goals and strategies for livestock disease prevention and control.

Intervention functions targeting heuristics and cognitive biases remain valuable. As in *environmental restructuring,* nudging techniques (Thaler & Sunstein, 2008) are leveraged to modify physical or social environments in ways that engage intuitive and habitual processes, which operate automatically and unconsciously. Nudging steers individuals towards more rational decision-making and reduces the impact of cognitive biases. For example, in the context of livestock disease management, nudges could include automatically enrolling farmers in regular veterinarian visits for biosecurity checks. Such interventions simplify the decision-making process and increase the adoption of biosecurity practices by reducing the need for proactive effort from farmers. Early evaluations of these approaches, such as those reported by Garza et al. (2020), suggest promising results in improving compliance and outcomes.

In contrast, restriction is less suitable for influencing most behavioural factors when opting for voluntary livestock disease prevention and control approaches. This is because restriction aligns more with a mandatory approach that limits choices rather than shaping favourable attitudes or enhancing capabilities (Van Woerkum, 1990), which may explain its limited applicability across different behavioural factors. However, there may be good reasons beyond the design of the intervention that might justify a mandatory approach. For example, when a public good is at stake, or when rapid compliance is necessary to prevent widespread harm, a mandatory approach can ensure uniform adherence to critical measures. This is particularly relevant in scenarios where voluntary compliance may be insufficient to achieve desired outcomes, such as in the case of highly

contagious livestock diseases where the collective welfare outweighs individual preferences. Thus, while restriction may not be the preferred choice for most behavioural factors, it may still be necessary in certain circumstances to achieve broader public goals.

4 Modelling Disease Epidemiology and Farmer Behaviour

In this section, we offer, in line with our third contribution, the findings from our review of studies that combined disease epidemiology modelling with the modelling of behavioural factors. We assessed, in particular, which and how behavioural factors and interventions have been incorporated into these models. Table 4.2 provides a summary of our findings, which are discussed in detail. A range of livestock diseases were studied in both epidemic and endemic situations, but no distinct behavioural considerations for different disease characteristics were identified. Only vaccination and adoption of biosecurity practices were considered in the reviewed models.

An analysis of the publication timeline highlights that Rat-Aspert and Fourichon (2010) were pioneers in integrating state-transition models with farmer decision-making modules within the field of animal health economics. Similarly, Liebenehm et al. (2016) employed a comparable deterministic approach, though their model did not account for how disease prevalence influences farmers' willingness to take preventive or curative actions. Both studies modelled farmer behaviour using a utility function that captured either or both risk and time preferences at the population level over extended time horizons (20–30 years). Rat-Aspert and Fourichon (2010) distinguished between probability and outcomes, explicitly linking probability to disease prevalence in the area. Both studies provided limited exploration of how heterogeneous preferences influence model outcomes. The effects of interventions and behavioural factors are not explicitly modelled in these frameworks. Instead, their impacts on epidemiological and economic outcomes are primarily explored through scenario analyses and adjustments to parameters in the risk and time preference modules. The strengths of these approaches lie in the ability to capture broad patterns and optimal strategies. The limitations in accounting for heterogeneity or behavioural nuances mean that their insights are often more general and less tailored to individual decision-making drivers or specific interventions.

Subsequent studies have shifted to stochastic state-transition models, incorporating more disease stages, with the exception of Bucini et al. (2019). Most studies have also adopted bottom-up, inductive approaches such as network modelling or agent-based models, which enable spatially explicit analyses of disease transmission and individual behaviour. However, in terms of behavioural factors and

Table 4.2 Summary of published studies combining models of disease epidemiology with behavioural-economic factors

Study	Disease characteristics	Which situation	Epidemiological model	Behavioural factors	Interventions
Rat-Aspert and Fourichon (2010)	Bovine viral Diarrhoea (BVD) in *endemic* situation in France	Vaccination, hypothetical example, inspired by the BVD	Deterministic, SIR, analytical, simulation	*Risk preferences* modelled with a decision tree	*Incentivisation* (vaccination subsidies, economic loss compensation)
Liebenehm et al. (2016)	Trypanosomosis in *endemic* situation in West Africa	Drug treatments by smallholder cattle farmers in Mali and Burkina Faso	Deterministic, SEIR, analytical, simulation	*Risk preferences*, *time preferences*, *heuristics*, and *cognitive biases* (loss aversion) modelled with a utility function	No interventions are mentioned specifically, based on scenarios with changes in risk and time preferences
Bucini et al. (2019)	Porcine epidemic Diarrhoea virus (PEDv) in *endemic* situation in the United States	Increase biosecurity levels in swine production chain with producers, feed mills, slaughter plants	Stochastic, SI, agent-based, transportation network	*Risk preferences* (averse, opportunist, neutral, tolerant), *heuristics* and *cognitive biases* (psychological discounting). Utility and threshold function based on the number of neighbours infected	No interventions are mentioned specifically, based on scenarios with varying percentages of risk preference compositions
Sok and Fischer (2020)	Bluetongue (BTV-8) in *epidemic* situation in the Netherlands	Vaccination in the dairy farm sector in the Netherlands	Spatial-explicit, discrete time, stochastic, SLIR, agent-based	*Motivations*, *risk perception*, *social capital*. Utility function derived from an integrated choice and latent variable model framework, and social network structure	*Education/persuasion*, *incentivisation*, *modelling* (preferences for vaccination scheme attributes are used)

Yang et al. (2021)	Foot-and-mouth disease (FMD) in *epidemic* situation in the United States	Increase biosecurity levels in the beef cattle production chain with producer agents and a transportation agent	Stochastic, SEIR, agent-based.	*Risk preferences* (averse, tolerant), connected with an update function based on the number of infected producers	*Education* (called a risk communication strategy that changed the initial biosecurity level distribution)
Hill et al. (2022)	Foot-and-mouth disease (FMD) in *epidemic* situation in England	Vaccination of either cattle herds or sheep flocks in two countries	Spatial-explicit, discrete time, stochastic, SEIR	*Risk preferences* (precautionary, reactionary, non-vaccinators), farmers in the reactionary group possess a distance to the closest infection function	*Incentivisation* (reducing relative vaccination costs)

interventions incorporated, these studies still envision the decision-making process predominantly following a rational (risk) attitude perspective. Consequently, the decision-making process is primarily informed by disease risk information, assuming farmers are not significantly influenced by social network effects or perceived social pressures. Farmers typically make personal cost-benefit calculations primarily based on instrumental and financial considerations, guided by their risk preferences. Most studies in this review employed a straightforward clustering approach, representing heterogeneity in farmer behaviour by grouping farmers based on different risk attitudes and parameter values. For example, Hill et al. (2022), categorised the population into precautionary farmers who always vaccinate from the outset, reactionary farmers who vaccinate based on a certain risk threshold, and non-vaccinators who never vaccinate.

Emotional aspects (risk as feeling) or social influences were only considered in two studies. Using insights from an online digital field experiment (see Koliba et al., 2022), Bucini et al. (2019) incorporated psychological discounting or distancing in their decision model, which leads to a relaxation of compliance with biosecurity protocols as time passes without experiencing disease. While several studies have employed network modelling, only Sok and Fischer (2020) integrated farmer behaviour within a social network context, thereby allowing the decision-making process to be influenced by both risk considerations and behaviour of others.

5 Summary and Implications

Animal health stakeholders must carefully assess the trade-offs between mandatory and voluntary approaches. A key part of this process is recognising the impact of behavioural factors and interventions on farmers' adoption of prevention and control measures.

We now summarise and align the main observations and findings, highlighting their implications for the study and design of livestock disease interventions. Previous reviews on behavioural factors in livestock disease prevention and control have primarily focused on motivational and persuasion aspects. Our first objective was to conduct a scoping review to categorise behavioural factors from a broader perspective than motivations alone. Building on the insights from our review, our second objective was to explore how the design of prevention and control strategy designs can be improved by better aligning policy options and intervention functions with key behavioural factors. Third, we discuss the advantages and limitations of various mathematical modelling approaches for incorporating behavioural-economic factors into epidemiological models for improved livestock disease interventions.

A first overall observation from our review indicates that the animal health economics literature broadly encompasses the behavioural factors identified in the wider behavioural agricultural economics literature (Wuepper et al., 2023; Finger et al., 2024). Risk and time preferences significantly influence how farmers assess and respond to uncertainty, such as the likelihood of a disease outbreak, and how they weigh immediate versus future outcomes, ultimately affecting their willingness to invest in measures with delayed benefits. For instance, farmers with high risk aversion may be more likely to purchase insurance against livestock disease, while those with lower time preferences may be less inclined to invest in long-term biosecurity measures. However, beyond risk and time preferences, other behavioural factors such as social norms, trust in institutions, and heuristics also shape decision-making. For instance, peer influence and perceived social approval may encourage farmers to adopt vaccination programmes if they see their neighbours doing so, while distrust in government agencies might reduce compliance with mandatory disease control measures. Additionally, cognitive biases like status quo bias can lead to inertia, making farmers less likely to change existing disease prevention practices.

Despite these insights, most studies integrating epidemiological (or bioeconomic) modelling with behavioural factors have concentrated primarily on risk attitudes and financial incentives. Broadening the scope to include interventions targeting alternative behavioural factors, such as leveraging social networks for knowledge exchange, using nudges like reminder messages for vaccination schedules, or framing biosecurity measures in ways that align with farmers' mental models, could enhance the toolkit available to animal health stakeholders in livestock disease prevention and control efforts.

We identified a gap in research methodologies specifically designed to assess behavioural factors in response to their dynamic nature in the context of disease transmission. Researchers in this field appear to have limited awareness of the temporal and evolving dimensions of disease events. For example, the Bluetongue epidemic, which prompted a mass vaccination campaign across Europe in 2008, began in 2006 and concluded around 2010, spanning less than 5 years. Over such timeframes, factors like risk preferences, time preferences, personality traits, and social capital are likely to remain relatively stable (Borghans et al., 2008; Cobb-Clark & Schurer, 2012). However, other factors like risk perceptions, heuristics, cognitive biases, motivations, and perceived abilities tend to fluctuate in response to the disease's progression and the actions of animal health stakeholders. Farmers' behaviour is not solely driven by "hard epidemiological facts"; rather, it is their perceptions of these facts that shape their decision-making processes (Funk et al., 2010).

Empirical studies mapping key behavioural factors have predominantly relied on qualitative or cross-sectional quantitative approaches. While risk preferences have been frequently examined in relation to economic and epidemiological outcomes, there is a lack of research capturing the dynamic nature of factors such as risk perceptions and motivations in disease transmission contexts. Additionally, as noted by Gilbert and Rushton (2018), there remains a significant gap in understanding how farmers' time preferences influence their decision-making. Reports from experimental or longitudinal studies on behavioural factors with intervention evaluations are scarce. This highlights the need for more coordinated, intensive data collection methods that can offer deeper causal insights into behaviour change mechanisms, rather than relying on scattered and smaller data collections.

Improved research designs are also essential to evaluate the potential of nudging in livestock disease prevention and control. Nudges, which are part of environmental restructuring interventions, specifically target heuristics and cognitive biases. Research suggests that nudges are most effective when used synergistically, or in combination with other policy instruments that address both reflective and automatic motivational processes (Drews et al., 2020; Howley & Ocean, 2021). To better understand the conditions under which nudges and other incentives are effective, it is important to assess potential crowding-in or crowding-out effects resulting from conflicts between intrinsic and extrinsic motivation (Frey & Jegen, 2001; Sok, van der Lans, et al., 2018b).

The dynamic context of disease prevention during an outbreak, combined with advanced state-based epidemiological modelling, presents a valuable opportunity to enhance our understanding of behavioural factors such as risk preference, risk perception, and time preferences in economic decision-making. In modelling studies, state-based approaches could be expanded to incorporate more general risk preference models (Quiggin & Chambers, 2001; Chavas & Briec, 2019). When designing interventions, it is crucial to distinguish between the effects of risk perception, risk preference, and time preference, as each of these behavioural levers implies different interventions in practice. We encourage studies that model risk as an appraisal within state-transition frameworks and explore a variety of human decision models rather than relying on a single fixed approach. Alternative decision model specifications could include those based on cumulative prospect theory or state-dependent risk preferences. This broader perspective would also facilitate the integration of heuristics, cognitive biases, and experiential or affective components (i.e. risk as feeling) into economic and epidemiological analyses (e.g. Skrip & Townsend, 2019;

Cicerale et al., 2022). Expanding modelling approaches in this way would allow for a wider range of interventions beyond financial incentives, as prospect theory is frequently used in psychology alongside risk and health communication strategies (e.g. Stone et al., 1994; Harrington & Kerr, 2017).

We also note a limited focus on social networks and information diffusion processes, despite their crucial role in shaping the effectiveness of interventions and targeting behavioural factors. Many interventions gain traction and influence behavioural change through these networks (Just et al., 2002; Heffernan et al., 2008; Bauch & Galvani, 2013; Zhang & Centola, 2019). While agent-based modelling as a spatially explicit simulation framework might be an obvious choice to explore these processes, bio-economic optimisation modelling has also begun to incorporate social network structures and utility functions that include injunctive and descriptive norms (Ricozzi et al., n.d.).

In addition to these limitations, it is of paramount importance to consider how behavioural factors may translate from the developed country context to LMICs. With poor access to expert care, or fractionalised provision of services (Rao et al., 2015), behavioural biases and tendencies may be exacerbated, making management and control of outbreaks much more difficult. This is a supreme concern where livestock often plays a central role as a store of wealth, and insurance against weather and other livelihood shocks (Herrero et al., 2013). A lack of private and public resources could necessitate extreme regulatory responses to emerging disease in the face of unpredictable or privately motivated behavioural responses by farmers. This highlights the keen need for more in situ research exploring farmer behavioural response to disease management in LMIC contexts.

In summary, our research highlights the need for taking a comprehensive perspective on behavioural-economic factors in farmers' animal health management. Integrating this knowledge with epidemiological insights can inform the design of interventions and policies that enhance farmers' willingness to adopt livestock disease prevention and control measures. This requires careful consideration of the temporal dynamics of disease events, recognising that while some behavioural factors are relatively stable, others can be more effectively influenced through targeted interventions. Advancing integrated behavioural-economic and epidemiological modelling offers promising directions, including state-based risk preference modelling and the modelling of information diffusion processes. However, researchers must remain cautious of the limitations inherent in their models, as a "too-narrow focus" may overlook critical factors such as emotions and social dynamics.

Appendix

Table 4.A1 Key behavioural factors that drive farmers' adoption of prevention and control measures

Behavioural factor and definition	References/examples	Gaps and open issues
Risk preferences: The product of probability and outcomes or consequences (e.g. disease infection) reflects the expected value of a decision under risk. Risk preferences encompass an individual's attitude towards risk itself, which may be influenced by risk perception, with both shaping how farmers react to different probabilities and outcomes In the context of livestock disease decision-making, farmers who are risk-averse prefer to avoid or minimise risk and choose safer options with lower but more certain payoffs and thus may be more willing to take prevention and control measures	Using face-to-face interviews, Gao et al. (2022) show that Chinese hog farmers' risk preferences impact their willingness to adopt genomics technology for breeding African Swine Fever-resistant hogs, with more risk-averse farmers likely delaying adoption despite the potential benefits Using bio-economic model simulation and empirically elicited risk and time preference parameters based on prospect theory, Liebenehm et al. (2016) show that cattle farmers' risk preferences influence treatment strategies for African Animal Trypanosomosis, with risk-averse farmers favouring preventive treatments, and lower risk aversion affecting treatment rates and economic outcomes Using decision tree simulation, Sok et al. (2014) show that risk-averse farmers in the Netherlands are more likely to re-vaccinate against Bluetongue, and that the provision of financial incentives can be adjusted to the farmers' willingness (expected utility) to vaccinate over time	Most studies that include behavioural factors in assessments of livestock disease prevention and control typically assume risk aversion. But there are no studies that have reported empirically assessed risk preferences in this domain. Such studies do exist but were designed context-free. The domain specificity likely influences farmers' assessments, even across different diseases with distinct characteristics. Understanding these nuances is crucial for developing targeted interventions and strategies in disease prevention and control (see also risk perceptions)
Time preferences: The value placed on immediate versus future costs and benefits. A high discount rate (being less patient) means that people prefer to avoid immediate costs or receive benefits now, even if it means incurring higher future costs or forgoing future benefits In the context of livestock disease decision-making, farmers with high discount rates may be less willing to invest in preventive measures, as the benefits are realised in the future and the costs are incurred immediately	Using bio-economic model simulation and empirically elicited risk and time preference parameters based on prospect theory, Liebenehm et al. (2016) show that patient farmers favour preventive measures and those with lower patience opt for fewer treatments, highlighting the need to consider individual risk and time preferences in disease control interventions	Time preferences are understudied in research on farmer behaviour regarding livestock disease prevention and control (Gilbert & Rushton, 2018). No articles were found that empirically studied how time preferences affect, e.g. vaccination decisions

Risk perceptions: Subjective judgements about the severity and likelihood of risks. Risk perceptions are influenced by individual experiences, beliefs, emotions, and cultural factors. They can vary between farmers, even when the objective probabilities of the outcomes are the same In the context of livestock disease decision-making, farmers with increased perceptions of risk may be more willing to take prevention and control measures	Using a survey approach, Baye et al. (2024) show that US farmers' risk perceptions significantly influence their willingness to invest in biosecurity, with those having a higher share of income from production being more willing to report suspected infections Using several approaches including interviews, Galli et al. (2022) show that Swiss pig farmers' varying levels of risk perception regarding disease transmission pathways significantly impact their adherence to biosecurity measures, with trust in colleagues and external collaborators influencing these perceptions Using a field experiment, Rao and Zhang (2020) show that insurance participation reduces Chinese hog farmers' precautionary measures due to perceived risk protection, resulting in increased hog mortality rates through moral hazard, although it also improves disease reporting to the government	Risk perceptions can vary depending on the characteristics of the disease and are not static over time. For example, endemic livestock diseases may be perceived as an operational risk due to their ongoing and manageable nature, whereas epidemic livestock diseases could be viewed as a catastrophic risk because of their sudden and severe impact on livestock and potentially humans as well. Research methodologies assessing prevention and control strategies do not often account for these properties of disease risk perception
Heuristics and cognitive biases: While some individuals make decisions through careful analysis and comparison of different options, others depend on intuitive and habitual processes that operate automatically and unconsciously (cf. dual-system theory) In the context of livestock disease decision-making, the willingness to take prevention and control measures can be influenced by heuristics and biases in several ways, including social influence, recent experiences, risk aversion, resistance to change, overconfidence, preference for current methods, and selective information processing	Using a survey approach, Mingolla et al. (2019) show that attitude and subjective norm strongly influence adoption intentions of Belgian Blue cattle farmers to take mange control approaches, while biases such as the bandwagon effect and loss aversion negatively impact intentions Using a survey approach, Xu et al. (2022) show that risk perceptions of Chinese farmers are affected by prior experiences with African swine fever epidemic, and that both factors improve post-outbreak production recovery Using a discrete choice experiment approach, Asindu et al. (2024) show that farmers' preferences for Rift Valley fever vaccines in Uganda are significantly influenced by choice heuristics such as risk attitudes and conditional perceptions, with a single-dose vaccine being the most highly valued vaccination attribute, indicating the need to account for these cognitive biases when designing vaccination promotion policies	Reviewed research on heuristics and biases has mainly relied on survey and self-report approaches. In research on emotions, a distinction is often made between anticipated and immediate emotions (risk as appraisal or as feeling) However, stronger evidence can be obtained by using experimental approaches to assess whether livestock disease prevention and control interventions targeting automatic processes influence choices in a lasting rather than temporary manner

(continued)

Table 4.A1 (continued)

Behavioural factor and definition	References/examples	Gaps and open issues
Social capital and culture: The factors embedded in social networks, such as norms, values, and trust. Culture shapes these factors In the context of livestock disease decision-making, social capital and cultural factors significantly influence the effectiveness of cooperation and coordination mechanisms among farmers in adopting prevention and control measures	Using a qualitative research approach, McAloon et al. (2017) show that cultural and social capital significantly influence farmers' decisions on control measures for Bovine Johne's Disease, with social perceptions of neglect and poor farming practices fostering a culture of secrecy and hindering effective disease management Using a qualitative research approach, Hidano et al. (2019) show that farmers' livestock purchasing behaviour and biosecurity practices are shaped by their farm environment and culture, with disease outbreaks and other factors serving as triggers for change Using a qualitative research approach, Delabouglise et al. (2017) show that cockfighting activities in rural Thailand hindered the reporting of HPAI cases due to the high value of fighting cocks, yet the central role of cockfighting practitioners in information networks and their strong social ties could be leveraged to improve disease surveillance	In deciding between voluntary and mandatory livestock disease prevention and control approaches, it is crucial to understand and predict how interventions can utilise social networks and extension or advisory services for information diffusion. More research is needed to better understand how and whether social networks factors, such as norms, values, and trust, contribute positively or negatively to disease prevention and control efforts
Personality and individual differences: These are traits or characteristics that distinguish people from one another, encompassing both cognitive and non-cognitive aspects Cognitive skills refer to the mental processes for acquiring, processing, and using information for reasoning and problem-solving. Non-cognitive skills refer to a range of personal qualities, habits and general attitudes that influence how, for example, farmers approach tasks and deal with different situations In the context of livestock disease decision-making, personality and individual differences can explain why some farmers are more inclined to adopt prevention and control measures than others	Using a survey approach and a cluster analysis, Sok, Hogeveen, et al. (2018a) show that in the context of Bluetongue epidemics, risk perceptions interact with personality traits, trust and confidence, and with the intensification of dairy farming operations. Personality traits such as conscientiousness and openness played significant roles in shaping Dutch farmers' attitudes towards vaccination Using a survey approach and visiting 127 duck farms, Delpont et al. (2021) show that French farmers' adoption of biosecurity practices following the 2016–2017 H5N8 Highly Pathogenic Avian Influenza epidemic is significantly influenced by personality traits, with higher conscientiousness and action-orientation leading to better compliance, while low conscientiousness and high stress result in poorer biosecurity measures Using a survey approach among UK sheep farmers, O'Kane et al. (2017) show that higher conscientiousness was linked to better compliance and lower disease prevalence, while negative emotions and low conscientiousness correlate with non-compliance and higher prevalence of lameness	The focus in cognitive and non-cognitive skills research in the context of farmers' disease prevention and control behaviour is mostly on the Big Five personality traits. While this research helps explain individual differences in these behaviours, there is a lack of understanding of how these skills can be effectively utilised by policymakers and veterinarians to improve interventions for behaviour change

Motivations to engage in a behaviour: Understanding why farmers engage in voluntary behaviour requires an analysis of their motivations, which can be intrinsic or extrinsic. Intrinsic motivations stem from personal interest and satisfaction, while extrinsic motivations arise from external rewards and pressures In the context of livestock disease decision-making, stronger motivations typically lead to higher adoption rates of prevention and control measures. However, the source of motivation can vary among farmers	Using an agent-based modelling approach, Sok and Fischer (2020) show that effective voluntary livestock disease control can be enhanced by well-designed risk communication strategies, which motivate farmers to increase vaccination uptake as effectively or more than financial compensation Using a discrete choice experiment approach in Northern Vietnam, Pham et al. (2017) show that farmers' willingness to report swine diseases is primarily influenced by the likelihood of compensation and the type of culling implemented Using a survey approach that includes economic games and the COM-B framework, Prosser et al. (2022) show that UK cattle farmers' motivations, such as altruism, trust, and psychological proximity to veterinarians, significantly influence proactive disease control behaviours for Bovine Viral Diarrhoea (BVD)	More attention can be devoted to improving the measurement of uptake and adoption variables. Studies relying on intentions could benefit from disaggregating intention into stages. Research employing stated preference approaches could enhance their methodologies by utilising more sophisticated choice card designs or incorporating qualifying questions to better understand respondents' stated choices
Perceived abilities to perform a behaviour: Perceived behavioural control refers to the extent to which people believe they have the ability (more internal) and/or resources (more external) to perform a particular behaviour. It can also include the expectation of controllability or autonomy, i.e. whether they feel it is within their power to perform the behaviour. This includes constructs such as self-efficacy and locus of control In the context of livestock disease decision-making, higher perceived abilities are likely to lead to higher uptake rates of prevention and control measures. However, the source of perceived ability can vary among farmers	Using a survey approach among US dairy farmers, Vasquez et al. (2019) show that farmers' ability and perceived control over prudent antimicrobial use are crucial, with perceived behavioural control being the primary driver of intention within the theory of planned behaviour framework, influenced by factors such as saving money, integrating practices into daily routines, and receiving effective veterinary guidance Using a survey approach, Imam et al. (2023) show, based on a sample of 137 commercial chicken farms in Bangladesh, that farmers' inappropriate antimicrobial usage is primarily driven by short-term health goals for their chickens, with farmers' perceived abilities and control (self-efficacy) having a marginal influence on these short-term goals Using a survey approach, Richens et al. (2018) shows that the staged adoption intentions by cattle farmers in Great Britain of biosecurity practices are limited by a perceived lack of control over disease prevention, considering it inevitable	Most studies assessing motivations and abilities (e.g. using the Theory of Planned Behaviour, TPB) rely on cross-sectional survey research to map the factors explaining intentions and behaviours. These studies often only evaluate mean responses, with little attention given to exploring heterogeneity. Experimental or longitudinal research designs are seldom employed in this context

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5 Procrastination and Psychosocial Drivers of Farmers' Planned and Actual Adoption of Biofortified Crop Varieties

Janet M. Mutiso, Carl-Johan Lagerkvist, Julius J. Okello, and Penina N. Muoki

Abstract

This chapter examines the relationship between the present bias, psychological barriers procrastination, technology information nudges, and their combined influence on the intentions and actual uptake of biofortified crops. It uses an information field experiment with 320 sweetpotato farmers in Kenya. Nudges were in the form of information on agronomy and crop biofortification process. The chapter draws on the theory of planned behaviour, model-based recursive partitioning using classification and random forest-based regression trees. Findings show nuanced relationship in intentions and adoption with agronomic and biofortification information nudges depending on the interaction of subjective norms, agency, past behaviour, and unintentional procrastination. It discusses the implications of promoting biofortified crops.

Keywords

Present bias · Procrastination · Behavioural nudges · Planned and actual adoption · Biofortified crops

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1 Introduction

Biofortified crops are a cost-effective and scalable strategy for tackling micronutrient malnutrition (Low & Thiele, 2020). Estimates indicate that more than two billion people globally are malnourished because of a lack of regular access to nutritious food (Bouis et al., 2024; UN, 2025; WHO, 2024). Thus, biofortification, the process of enhancing the nutrient content of staple crops, can contribute to the fight against malnutrition and complement food fortification and supplementation in low-income/developing country populations whose diets are dominated by starchy staples (Samuel et al., 2024). Orange-fleshed sweetpotato (OFSP), which is high in beta-carotene, a precursor for vitamin A, is one example of a successful case of biofortification of staple crops consumed by low-income households in developing countries.

OFSP was bred to tackle the high incidence of vitamin A deficiency among vulnerable populations, especially children under the age of 5 years old and pregnant or lactating women (Low & Thiele, 2020). It can also be processed into puree, a versatile composite product with many applications in the bakery industry and, therefore, a source of income to growers. Due to the processing traits, it can fetch higher prices, estimated to generate incomes of up to USD 425 per acre per year, compared to USD 250 per acre per year for the non-biofortified varieties (Tedesco & Stathers, 2015). Some varieties of OFSP are early maturing, providing food to households that are producing food earlier in the season to alleviate food deficit. Some varieties of OFSP yield higher than the non-biofortified types and are also resilient to weather-related shocks (Clearinghouse, 2021).

Despite these benefits, past studies have indicated that adoption of OFSP is still quite low. Low and Thiele (2020) find that the adoption of biofortified sweetpotato in sub-Saharan Africa (SSA) is about 6.9%. Consequently, recent efforts at promoting OFSP have focused on interventions and strategies aimed at creating demand and tackling the barriers to adoption. Some of those barriers are presented in Textbox 1. One of the strategies used involves the use of messaging tailored around the benefits of biofortified crops and designed to stimulate demand (Low & Thiele, 2020). However, these have not translated into big gains in demand creation, with evidence of the role of information provision remaining mixed. A strand of evidence shows a positive relationship between knowledge, sensory evaluation, and the adoption of OFSP in the setting of nutrition-framed messages (Mwiti et al., 2020; Lagerkvist et al., 2016). However, de Brauw et al. (2018) found no effect. Moreover, the evidence has not attempted to assess how information moderates the explanation of farmers' intention to adopt and the prediction of the actual adoption of biofortified crops. One approach that can help in improving the understanding of the low uptake of biofortified crops is to investigate the behavioural and psychosocial factors driving or mediating farmers' decision-making process.

Okello et al. (2020) and Okello et al. (2019a, 2019b) demonstrate that farmers' decision to invest in or use quality seeds of improved potato varieties is influenced by psychosocial factors. In the former case, the authors find that farmers associate the adoption of recommended disease management practices with such

Textbox 1: Barriers to Agriculture Technology Adoption and Role of Nudges

de Janvry and Sadoulet (2019) summarise the barriers to agriculture technology adoption as: (i) Lack of access to credit, collateral and savings, as well as complex and expensive microfinance and repayment structures that often misalign with the production cycle. (ii) An underdeveloped insurance market and low utilisation of insurance schemes to address fluctuation in weather, pest, and prices risks compounding the issues. (iii) Lack of awareness of the benefits of agricultural innovations resulting from the poor reach of extension services and unreliable market information. (iv) The weak market linkages and poor access to complementary quality inputs. (v) Insecure land tenure that limits the participation in commercial processes. Regarding biofortified crops, barriers to adoption include farmer concerns about the yield and changes in texture of new varieties, lack of knowledge about required production practices, and inadequate extension support (Huey et al., 2024). Other factors include consumer resistance to changes in colour (e.g. in the case of sweetpotato), regulatory issues in biofortified wheat, maize and rice, and limited appreciation of their benefits (Bouis et al., 2024).

There is however, evidence, albeit limited, that behavioural interventions show promise in stimulating the demand and adoption of biofortified crops. Muange and Oparinde (2018), for instance, demonstrate in Rwanda that information from social networks influences the willingness to pay for iron beans. They find, for high iron beans (HIB), that the spread of negative information about these crops can reduce their demand. Pérez et al. (2018) show that willingness to pay for HIB among Guatemalan consumers increases with repeated exposure to information. Jada and van den Berg (2024), in Ethiopia, indicate that willingness to pay for biofortified crops increases with nutrition messages and that social norms strongly influence the effect. With respect to sweetpotato, Ojwang' et al. (2022) find that information nudges targeting caregivers of preschoolers influence knowledge about OFSP and create positive attitudes towards it. Ojwang' et al. (2021) further find that various combinations of nudges increase the adoption of OFSP. In a school setting in Ethiopia, Okello et al. (2022) found that nudges increase the consumption of biofortified foods by school children. Just et al. (2022) found similar results on the short-term effect of nudges on the consumption of OFSP meals in Nigerian school settings. In a similar school study in Nigeria, Lagerkvist et al. (2018) found that consumers were more likely to respond to promotion messages about information on the sensory characteristics rather than on the functional quality (i.e. nutritional benefits) of biofortified foods.

psychosocial factors as *happiness, security, long life, peace*, aspirations, and perceptions. More recently, Mayanja et al. (2024) applied social psychology theories and found that farmers' perceived behavioural control, perceived usefulness, and knowledge significantly influence their intention to adopt agricultural technologies in sweetpotato production. While relatively new to agriculture, the effect of procrastination, defined as the tendency to delay—potentially indefinitely—an action, has been widely studied in psychology. Farmers who procrastinate are likely to postpone or put off indefinitely the decision to adopt innovations (Luong et al., 2022). Alwang et al. (2019), for instance, find that procrastination affects farmers' decisions to use integrated pest management techniques. Duflo et al. (2011) found that procrastination affects the decision to invest in fertiliser use.

Another behavioural factor that is gaining importance in the analysis of adoption behaviour is the use of nudges. Congiu and Moscati (2022), following Thaler and Sustein (2022), define a nudge as "any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives" (p. 191). Within the broader context of nudges, scientists have recently tested the effect of informational nudges on adoption behaviour. Examples of this framing of nudges include Shikuku (2019), Balew et al. (2023), and Okello et al. (2023). In these studies, an informational nudge is a kind of information delivery mechanism framed as a social incentive aimed at predictably altering behaviour/decision (Bao & Ho, 2015; Costanigro & Jablonski, 2021). These studies find mixed effects of nudges in agriculture. For instance, Shikuku (ibid) found a positive effect of information nudges among Ugandan farmers, while Okello et al. (2023) found no effect among farmers in the same country.

This chapter examines how procrastination and psychosocial factors explain farmers' decision to adopt biofortified crops and how nudges mediate such decisions in the form of information regarding: (i) the superior agronomic attributes of such crops and (ii) the biofortification process (see Textbox 2: Information Nudges). It therefore contributes to the literature by identifying subgroups of farmers based on behavioural and psychosocial factors that explain the intention to adopt biofortified crops, the actual adoption levels, and how such decisions are moderated by information nudges relating to superior agronomic traits and the biofortification process.

Textbox 2 Information Nudges

The informational nudges deployed in the study reported in this chapter were twofold:

The first nudge emphasised agronomic advantage: superior yielding ability, disease resistance, drought tolerance, and marketability. The premise is that knowledge of these agronomic advantages of OFSP varieties aids farmers' decisions and encourages them to adopt biofortified crops (Talsma et al., 2017). The agronomic information provided emphasised economic viability and contribution to food security. Specifically, it stated that: (i) OFSP varieties

(continued)

Textbox 2 (continued)

mature faster, hence providing food early in the season; (ii) early maturity means that farmers sell when supply is low in the market, hence at higher prices resulting in higher income; and (iii) the varieties are more resistant to pest and diseases and thus have higher yields. Okello et al. (2019a, 2019b) report that farmers associate having more food and income with less stress and ultimately to a healthy life.

The second nudge described the biofortification process and its goal: This nudge emphasised OFSP is developed through biofortification, which involves breeding crops to increase their nutritional value. It emphasised that: (i) nutrient enhancement in the crop is through conventional breeding similar to production of any hybrids, (ii) the aim was to address vitamin A deficiency, a public health problem affecting more than 84% of children under 5 years of age in Kenya at the time of the study, (iii) while increasing vitamin A content in sweetpotato, it affected some sensory attributes by for instances making boiled roots softer and less mealy. This nudge was designed to inform farmers about the health benefits of OFSP and increase their valuation and acceptance of OFSP (Talsma & Pachón, 2017; Birol & Bouis, 2023). The details of the framing of these information nudges are provided in Appendix 1.

Next, we discuss the conceptual framework that guides the selection of psychosocial factors. Then, we focus on the methods, followed by the presentation of the results and discussion and implications.

2 Conceptual Framework: Theory of Planned Behaviour

This chapter draws on the Theory of Planned Behaviour (TPB) (Ajzen, 1991), which posits that behaviour depends on volitional and external factors. The theory is widely used in targeting modifiable social and behavioural factors. It argues that the intention to undertake a behaviour and perceived behavioural control directly influence the actual behaviour. The variables of the theory account for individuals' readiness to change and the biases that influence decision-making. The TPB provides a suitable framework to explore the moderating effect of nudges, focusing on agronomic attributes of OFSP versus those focusing on the biofortification process on the cognitive (i.e. psychosocial) processes that underlie the intention to undertake a behaviour, which in our case is the intention to adopt OFSP. Under TPB, three psychosocial factors are hypothesised to influence intention. These are as follows:

(i) *Attitude*—the predisposition to engage in behaviour based on the belief that doing so will result in outcomes being either positive or negative.
(ii) *Subjective norms*—the rating of opinions, views, and thoughts of whether important people (also known as referents) would approve or disapprove of a behaviour. This construct relates to a person's evaluation of the course of action

that their family, people they value, or role models in their community would want them to take regarding engaging in a behaviour, such as the adoption of OFSP.

(iii) *Perceived behaviour control* is an assessment of personal agency to undertake behaviour successfully. It embodies the evaluation of capabilities, such as skills and abilities, as well as necessary resources and opportunities to perform the behaviour.

2.1 Additional Variables

Intention, as a variable, when measured at a single point, may not reliably predict actual behaviour. This is because of its activation in real-life contexts (Ajzen & Sexton, 1999). The intention-behaviour gap signals the fact that the predictive validity of the variable *intention* can diminish over time due to intervening factors that alter behavioural, normative, or control beliefs. When this happens, it can affect the stability of intention as a variable. The instability of *intention* can, on the other hand undermine its predictive power (Sheeran et al., 1999). Hence, including additional variables might be necessary to explain behaviour (Conner & Armitage, 1998). In this chapter, we incorporate past behaviour, salience, knowledge, and procrastination into the TPB to enhance its predictive accuracy.

The inclusion of *past behaviour* in the model is premised on the fact that past behaviour exerts powerful effects on cognition and, therefore, is expected to affect intentions independently of the other TPB variables, including perceived behaviour control (Ajzen, 1991; Conner & Armitage, 1998). The temporal distance between the assessment of intentions and observation of behaviour significantly influences this correlation, with shorter intervals generally showing stronger relationships (McEachan et al., 2011). Although past behaviour does not fully meet the TPB criterion of being a direct causal antecedent of intention, it indicates habit strength rather than directly shaping current intentions.

Salience and *procrastination* are included to assess how intentional pursuits are formed and maintained over time. Salience is defined as the prominence of characteristics of objects concerning individual objectives. It can enhance behaviour forecasting and measure the degree to which one willingly exerts control over one's conduct (McArthur & Ginsberg, 1981). For instance, if an individual perceives a behaviour to be highly salient to their goals or values, they may be more likely to perform that behaviour.

Procrastination is defined simply as the tendency to delay or avoid action or performing a behaviour. Procrastination can therefore reduce individuals' perceived behaviour and control, as well as the ability to follow through on intentions (Steel et al., 2018). Procrastinators typically delay the completion of intended tasks even when undesirable outcomes are associated with the postponement (Lay, 1986). Due to the failure to self-regulate, an individual's ability to follow through with intention is compromised (Steel, 2007). This can occur in a context where the task is

perceived as hard when the effort is demanding or when the rewards are not immediate (Sirois & Pychyl, 2013). This chapter examines the case of unintentional and general procrastination (see Fernie et al., 2017). The latter comprises aspects of both intentional and unintentional procrastination (Lay, 1986).

Knowledge is a key determinant of the adoption of agricultural innovations, where information on the correct use of innovation is necessary for optimal outcomes. Under TPB, two types of knowledge are usually considered, namely, objective and subjective knowledge. Objective knowledge refers to the factual and measurable information that a person knows about a particular topic (Vollmer, 1984). Assessment of objective knowledge is important because it can reveal gaps or inaccuracies in known information that affect decision-making and behaviour. Subjective knowledge, on the other hand, refers to people's subjective perceptions of what or how much they know about or are familiar with an innovation. It is usually based on one's subjective interpretation of what one knows.

3 Methods

3.1 Sampling and Data

Data were collected from a field experiment in a longitudinal study conducted in Kenya in 2017 and 2018. Sampling proceeded as follows: First, 12 wards[1] were randomly selected from a total of 23 administrative wards in four counties using probability proportionate to size sampling. This approach ensured that more wards were selected from larger counties and vice versa. The resulting sample comprised four wards in Bungoma, four in Busia, two in Homa Bay, and two in Migori. These were the counties that were earmarked for implementation of the Accelerated Value Chain Development (AVCD) project. The project promoted the production and consumption of OFSP using social behaviour change communication approaches between 2017 and 2019. It also disseminated the seed of OFSP to households with children under the age of 5 years, a pregnant woman or a breastfeeding woman. From a pre-compiled list of eligible farmers in each selected ward, a random sample of 320 respondents was selected, again using probability proportionate to size sampling, to participate in a baseline survey conducted in 2017. The selection process resulted in 84 respondents from Busia, 26 from Migori, 95 from Homa Bay, and 115 from Bungoma.

The data were collected using structured and pre-tested questionnaires administered through personal interviews conducted by trained enumerators. Interviews were conducted in Kiswahili or the local vernacular language, depending on the respondent's preference and fluency. Each interview lasted approximately one and

[1] An administrative and geographical unit formed to facilitate the legislation of county governments in the devolved system of governance in Kenya.

a half hours. In 2018, 150 farmers were randomly selected from the 320 respondents surveyed during the baseline for a follow-up survey aimed at assessing adoption 1 year after the project interventions were rolled out. Of these, 113 respondents completed the surveys, resulting in a response rate of 75.3%. The high attrition rate (24.7%) was mainly due to relocation to cities/other areas, absences due to sickness and/or events such as funerals, and was not systematic. Adoption was assessed as a count variable using 27 statements (Min = 0; Max = 11) summarised in Table 5.1.

Table 5.2 summarises the characteristics of the respondents. As shown, the respondents' years of completed schooling were 8 (min = 0, max = 22, SD = 2.84), and they were young farmers with an average age of 32 years (min = 17, max = 84, SD = 10.44). In addition, the majority were females, married, and living with spouses.

Table 5.1 Performance of OFSP-related activities

Statement	% yes
Adoption and persistence in planting OFSP	
Grows OFSP despite family preference for other varieties	71.7
Continues to grow OFSP despite difficulty in finding buyers	38.1
Travels far to obtain OFSP vines	8.8
Waits for weeks after rains to access vines	40.7
Spends a lot on transporting vines	9.7
Relies on free vines from neighbours when needed	38.1
Uses ridges to reduce root bruising during harvest	21.2
Plants on ridges to lower harvesting costs	23.9
Visits agricultural offices to learn how to grow OFSP commercially	10.6
Persists with OFSP despite difficulties in conserving vines during dry seasons	61.1
Commercialisation and production challenges	
Hires labour to increase OFSP production for sale	7.1
Buys quality OFSP vines despite high costs	38.1
Stores roots in sand for later sprouting (triple s)	7.1
Continues to grow OFSP despite rapid root spoilage	44.2
Practices crop rotation to control diseases	91.2
Plants different sweetpotato varieties in separate plots	84.1
Grows OFSP even when roots are hard to sell locally	30.1
Grows OFSP even if the only buyer is a processor	6.2
Consumption and utilisation of OFSP	
Incorporates OFSP flour into chapatti and mandazi	21.2
Mashes OFSP with other foods for young children.	51.3
Adds OFSP to traditional dishes (e.g. githeri, nyoyo)	47.8
Consumes OFSP leaves as a vegetable	18.6
Marketing and economic factors	
Produces OFSP that meets buyer standards	15.9
Grow OFSP even when surplus is fed to livestock due to a lack of market	20.4
Joins a farmer group for better market access	12.4
Grows OFSP despite low prices offered by traders	27.4
Continues planting despite losses from delayed buyer pickups	21.2

Table 5.2 Farmer characteristics

	Percent
Gender	
Female	90
Male	10
Marital status	
Single	4
Married, living with a spouse	79
Married, spouse living away	12
Widow/widower	4
Separated	1
Education	
No formal schooling	2
Primary, not completed	44
Primary, completed	23
Secondary, not completed	17
Secondary, completed	9
Tertiary/university, not completed	2
Tertiary/university, completed	4

3.2 Using Machine Learning Methods to Assess the Relationship of the Psychosocial Factors

Studies based on the TPB employ structural equation modelling to predict intention and behaviour. Following Zeileis et al. (2008), this chapter instead uses model-based recursive partitioning (MOB) to classify farmers by their intention to adopt OFSP and the actual adoption levels. Textbox 3 outlines the model estimation process. The decision to use MOB over SEM is because it has the following advantages:

Model specification: MOB is flexible and allows data-driven exploration of psychosocial relationships. It is beneficial in moderation analysis when using many variables, which complicate model specification.
Low statistical power: Our study has a small sample size, but it measured multiple dimensions of TPB variables. Moreover, in the estimation of the model, we need to control several demographic factors, including education, age, and gender of the farmers. The small sample size and the large number of variables to control for highly reduce statistical power, making MOB a better choice.
Non-monotonic relationships: TPB variables can moderate each other, making MOB more suitable for capturing these non-linear relationships if they exist.
Interpretation of the relationship of variables: Tree-based methods facilitate repeated detection of interactions and non-linear patterns in data and are easy to interpret and visualise.

Textbox 3 Estimation of Model-Based Recursive Partitioning (MOB)
The estimation of the MOB follows four steps (Garge et al., 2013; Zeileis et al., 2008; Strobl et al., 2008; Hothorn et al., 2006):

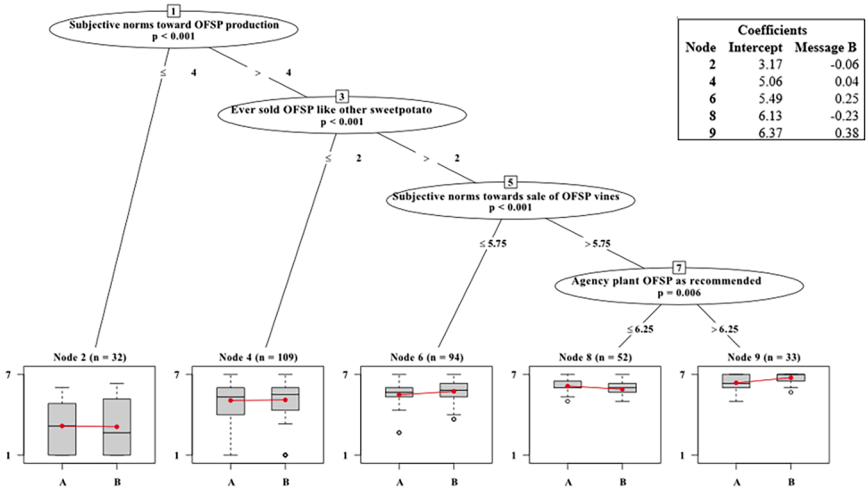
1. *Fitting the model*: A specified model is applied to all the data in a specific group (the node). All observations in the node are subjected to a predetermined generalised linear model. Thus, the psychosocial variables description (i.e. attitude, subjective norms, perceived behavioural control, past behaviour, procrastination, salience, knowledge) and the demographic factors (namely, age, education, gender, etc.) are all included in the model as explanatory variables. Appendix 2 provides the measures of the psychosocial variables used.
2. *Testing for instability*: The algorithm checks if the model's parameters are unstable (i.e. whether they might change) when the moderating variables in the dataset (i.e. the information nudges in form of agronomic or biofortification process described in Textbox 1) are introduced as partitioning variables. If model instability is detected, the moderating variable most responsible for the instability is selected for further analysis. Next, using a moderating/partitioning variable, the algorithm determines whether the model's parameters differ among subgroups.
3. *Choosing the best split*: The algorithm then determines the best way to split the data using the selected variable. The split point will improve the model's performance the most.
4. *Repeating the process*: The data are divided into two smaller groups (or "child nodes") based on the split. The algorithm then repeats the process for each new group, continuing until it reaches a point where further splitting is unhelpful.

To assess the relative importance of psychosocial factors in explaining adoption, we employed the MobForest package in R, with the parameters mtree and mtry set at 100 and 13, respectively (R Core Team, 2024). It enabled us to estimate a generalised linear model with a Poisson link using adoption (captured as a count variable) as the dependent variable.

4 Findings and Discussion

4.1 Intention to Plant Biofortified Crops

Figure 5.1 shows five subgroups presented by nodes 2, 4, 6, 8, and 9. The subgroups depicting *the intention to plant OFSP* are moderated by the nudges and explained by the interaction of four psychosocial variables. As shown, subjective norms towards production are the most important psychosocial factor explaining farmers' intention to plant OFSP. This implies that farmers who feel that important people in the network will approve of their decisions are more likely to be willing to plant



MOB classification tree to identify factors moderated by agronomic (message A) and biofortification (message B) nudges based on farmers' reported intention to plant OFSP as a common crop in the next planting season. The psychosocial variables included attitudes toward OFSP production, subjective norms toward OFSP production, subjective norms towards the Sale of OFSP vines, subjective norms towards planting sweetpotato if rich, subjective norms towards the purchase of sweetpotato, subjective norms male farmers planting sweetpotato, agency plant OFSP, agency pay for OFSP vines, agency plant OFSP as recommended, salience, attitudes toward trader consumers, knowledge, ever sold OFSP like other sweetpotato. Background factors: lack of land barrier to OFSP as cash crop, Lack of market prevents producing OFSP for sale, gender, age, marital status and education. The intention was measured on a scale of 1 to 7; therefore, the estimation used a generalized linear model family link Gaussian. The red dots show specific subgroups' average intention levels (calculated as the difference between agronomic and biofortification nudges). The red line connects these averages. In the box plots, the middle black line represents the median, and the other two lines indicate the first and third quartiles. The child nodes are 1, 3, 5 and 7, showing the significant psychosocial variables and their interaction to classify farmer groups with different intention levels. Terminal nodes 2, 4, 6, 8 and 9 show the formed farmer sub-groups.

Fig. 5.1 Relationships of psychosocial factors predicting farmers' intention to plant OSFP moderated by information nudges

OFSP. For instance, farmers who believe that their spouses or important members of their community will approve of the practice are likely to have a relatively high intention to plant OFSP. The findings are in line with those of Negi et al. (2020), who found that farmers who seek to have their opinions approved by and/or imitate others within their network are more likely to adopt innovations after learning about their benefits from peers or network members. This finding also corroborates that of Jenkins et al. (2018), who indicate that social influence plays a key role in farmers' decisions to adopt sweetpotato varieties, including OFSP. It further aligns with findings in other contexts, showing that promotion messages that appe al to social norms are an effective approach to increasing the uptake of biofortified crops (Jada & vn den Berg, 2024). The implication of this finding, therefore, is that it is important to target subjective norms in any form of demand-creation interventions aimed at promoting the planting of OFSP.

Nudges Relating to Agronomic Attributes

Node 2 comprises the classification of farmers with the lowest intention to plant OFSP. It presents the case where farmers' subjective norms are rated at four points and below. The intention to plant OFSP among farmers who received nudges relating to agronomic attributes of OFSP is 3.17, which is higher compared to that of the group that received nudges relating to the biofortification process by approximately

0.06 points. Similarly, in Node 8, the intention to plant OFSP for the group that received agronomic information nudge is 6.13, which is higher than for the group that received nudges relating to the biofortification process by approximately 0.23 points. The diagram thus shows the interaction between the intention to plant OFSP with social norms towards OFSP production (>4), past behaviour (>2), social norms towards selling OFSP vines (>5.75), and the agency to plant OFSP following recommended practices (≤6.25) to determine the subgrouping of farmers.

Notably, the agency to plant following recommended practices is declining in Node 8 compared to Node 9. This implies the need for training, highlighting the fact that the agronomic practices for planting OFSP are like those used in planting other sweetpotato varieties. Previous research indicates that farmers perceive that production practices associated with planting OFSP are difficult to integrate into their existing farming methods because they require more knowledge and labour (Huey et al., 2024). Jenkins et al. (2018) add that the emphasis on proper field preparation, the use of clean seeds to control diseases and pests, and the use of proper spacing during planting can be a barrier to adoption because they feed into the belief that it takes more effort to plant OFSP compared to the white varieties. Samuel et al. (2024) further argue that farmers' perception of planting OFSP as being risky and the feeling that OFSP seed is expensive also explains the importance of improving their agency through training.

Nudges Relating to the Biofortification Process

The second classification represents the case where the interaction of social norms towards OFSP production with psychosocial factors is more than four points. Here, the farmer's past behaviour (represented by the variable "ever sold OFSP") is the determining psychosocial variable. As shown, Node 4 characterises a subgroup of farmers whose experience selling OFSP (i.e. "ever sold OFSP" before) is two times or less (i.e. ≤2), that is, for those who have sold OFSP no more than two times in the past. The intention to plant OFSP was rated at a level of 5.06 points for those farmers who received nudges relating to the agronomic attributes of OFSP. This rating increased by about 0.04 points for farmers in this subgroup who received nudges relating to the biofortification process. This finding indicates that nudges in the form of information about the biofortification process benefit more farmers with stronger subjective norms but have less experience in the commercial production of biofortified crops (as proxied by "ever sold OFSP"). Our finding, therefore, supports Saltzman et al. (2017), and Birol et al.'s (2015) argument that the benefits of biofortification (i.e. nutritional advantage) are more effectively realised when farmers have limited experience in selling biofortified crops.

The second-largest group comprises farmers with subjective norms towards OFSP production greater than four and a previous history of selling OFSP more than twice (>2). For this subgroup of farmers, the subjective norms towards the sale of OFSP vines ≤5.75 are the determining psychosocial variable. It gives rise to Node 6 in Fig. 5.1. In this classification, the intention to plant OFSP is about 5.49 for farmers who received information nudges relating to the agronomic attributes of OFSP. On the contrary, farmers in this subgroup who received information nudges

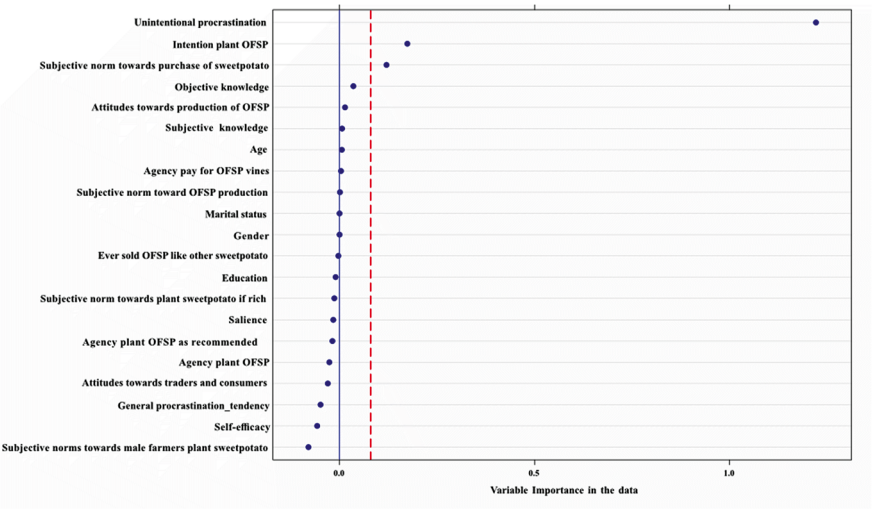
relating to the biofortification process have 0.25 points higher intention to plant OFSP. These results suggest that farmers who have previously engaged in selling OFSP exhibit moderate intention to plant OFSP, and that nudges relating to the biofortification process enhance their intention to plant them in future. This finding is consistent with previous research findings indicating that prior commercial engagement influences technology adoption (Waized et al., 2015). It further indicates that a lack of demand for and participation in the OFSP market can discourage adoption. The increase in intention to plant associated with information nudge relating to the biofortification process supports the finding that informing farmers about the nutritional benefits of biofortified crops can enhance their decision to adopt such crops (Samuel et al., 2024, 2025; Talsma et al., 2017).

Lastly, Node 9, with the highest intentions overall, shows an interplay of norms towards OFSP production, past behaviour, norms towards selling OFSP vines, and agency to plant OFSP as recommended. The level of intention to plant OFSP is about 6.37 for farmers who received agronomic information nudges. This level increased by 0.38 points for farmers in this subgroup (or node) who received nudges relating to the biofortification process. The high rating of this node by farmers and the interaction of the four psychosocial variables are associated with the highest intention to plant OFSP. These results clearly demonstrate that interventions promoting OFSP production should focus on reinforcing positive social norms, leveraging past behaviour, and enhancing farmers' sense of agency to follow recommended agronomic practices in planting biofortified crops.

4.2 Adoption of OFSP

In this section, we present the results of the mediating effect of procrastination on the actual adoption of OFSP. Adoption is defined by the vector of practices presented in Table 5.1. To assess adoption, and given the wide range of variables considered, we first use random forest analysis to identify the variables that are most important in driving the process. Note that in this analysis, we include both measures of procrastination (i.e. general and unintentional) as well as the intention to adopt OFSP alongside a host of psychosocial, farmer-specific variables. Figure 5.2 presents the plot of variable importance from random forest analysis with MOB. The horizontal axis represents the average increase in regression accuracy gained by using a specific variable in the raw data compared to using the same variable in permuted data.

Positive values indicate that the variable correlates with the adoption of OFSP. Variables to the right of the broken line are those with the strongest association with the adoption-moderating for information nudges. Figure 5.2 shows unintentional procrastination, subjective norms towards purchasing sweetpotato, and intention to plant OFSP, which are located to the right of the broken line. This indicates that they have the strongest association with OFSP adoption. We use these factors in the MOB classification model to assess the drivers predicting adoption. As before, we examine how the outcomes are influenced by the kind of information nudges received.

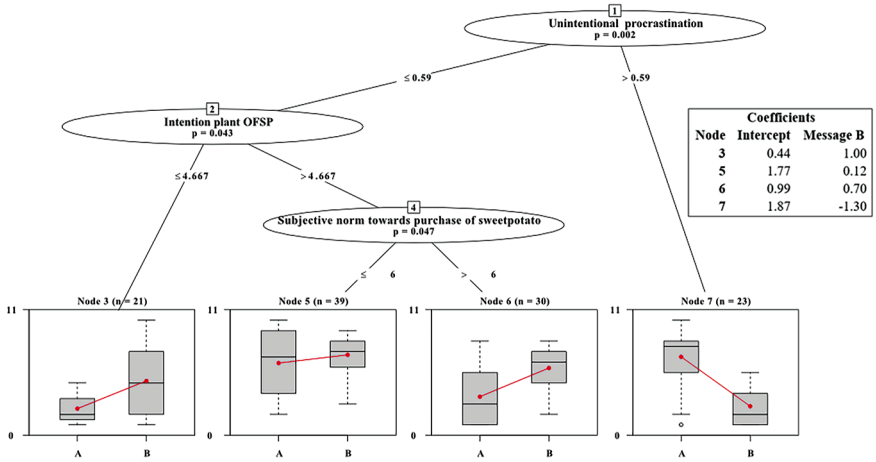


Variance-importance plot for model-based recursive partitioning trees using the random forest to identify factors correlated with the intensity of adoption of practices related to OFSP two seasons after the nudges. The horizontal axis represents the average increase in classification accuracy gained by using the specific variable in the 'real' data, compared with using the specific variable in permuted data. Positive values indicate that a variable predicts adoption and performs better than random noise. Variables to the right of the red line are selected for the classification tree modelling. We applied the step as we could only conduct a follow-up on the baseline sample and achieve a 75% response rate.

Fig. 5.2 Variables' importance and correlation with the adoption of OFSP, controlling for the information treatments ($N = 113$)

Effect of Agronomic Information Nudges on Actual Adoption of OFSP

Figure 5.3 presents the results of the MOB classification tree analysis. Three variables identified by the random tree analysis are significant and interact with information nudges to predict the adoption of OFSP. Node 7 presents the case of a subgroup of farmers with unintentional procrastination scores greater than 0.59, which is a high level of procrastination. Among this subgroup of farmers, those who received information nudges relating to agronomic attributes have significantly higher adoption levels than their counterparts who received nudges relating to the biofortification process. Indeed, for this subgroup of farmers, the provision of information on the biofortification process reduced the adoption level by 1.30 times. For the farmers who had high unintentional procrastination, intention to plant OFSP does not predict actual adoption, as shown by the lack of this variable on this arm of the decision tree. The finding corroborates that of Owens et al. (2008). They argue that a lack of intention-building causes procrastination, which delays actual adoption. Further, the variable "subjective norms towards the purchase of OFSP" is also absent in this arm of the decision tree relating to high unintentional procrastination. This finding suggests the lack of social reinforcement in the evaluation and decision to plant OFSP or otherwise. The finding that, for farmers with high levels of unintentional procrastination, the provision of information nudges relating to agronomic attributes of OFSP leads to higher levels of adoption compared to when the same farmers are provided with information nudges relating to the biofortification



The MOB classification tree identifies factors moderated by agronomic (message A) and biofortification (message B) nudges. Variables included in the MOB are unintentional procrastination, subjective norms towards purchasing, and intention to plant OFSP. Adoption was a count variable; therefore, we used a Poisson link in the model specification. The red dots show the average adoption levels (calculated as the difference between agronomic and biofortification nudges) for specific subgroups. The red line connects these averages. In the box plots, the middle black line represents the median, and the other two lines indicate the first and third quartiles. The child nodes are 1, 2 and 4, showing the significant contribution of psychosocial variables. Terminal nodes 3, 5, 6 and 7 show the formed farmer subgroups with different adoption levels.

Fig. 5.3 Relationship between psychosocial factors predicting farmers' adoption intensity moderated by information nudges

process strongly suggests the importance of accompanying the promotion of biofortified crop varieties with positive information about their agronomic attributes.

In this study, the positive agronomic attributes highlighted were short crop maturity, thus providing access to food early in the season and attracting higher prices, and resistance to pests and diseases, which is associated with higher yields and larger volume of marketable roots, which generates greater surpluses for sales and more income for the households. These aspects seem to have been quite persuasive to farmers and to have provided greater incentive, resulting in higher actual adoption of OFSP among farmers who are prone to delayed decision-making because of high procrastination. Agronomic information nudges highlighting the immediate advantages of growing OFSP may have helped overcome the behavioural inertia resulting from procrastination. In contrast, the negative aspects presented as part of the information on the biofortification process, especially the softness of cooked roots and lack of mealiness, may have dampened the incentive to grow OFSP, resulting in lower actual adoption.

Effect of Biofortification Nudges on Actual Adoption of OFSP

Node 3, in Fig. 5.3, represents the subgroup of farmers with unintentional procrastination scores less than 0.59, that is, low unintentional procrastination. For this group of farmers, the intention to plant OFSP is a significant mediating variable and has a score of 4.667 or lower. Exposure to agronomic information nudges by this subgroup of farmers results in much lower actual adoption than exposure to nudges relating to the biofortification process. To the contrary, Fig. 5.3 shows that exposure

to nudges relating to the biofortification process increases the actual adoption of OFSP by 1.00 point. The low actual adoption levels because of the combined effect of low procrastination with low intention may be related to individual perceptions of self-efficacy, that is, belief in one's ability to perform a behaviour successfully (Sniehotta et al., 2005). When individuals doubt their ability to carry out a behaviour successfully, they may be less likely to form strong intentions or take action, even if they do not procrastinate. According to Bandura (1997), self-efficacy affects the agency; it shapes motivation and the initiation and persistence of planned behaviour. Individuals with low self-efficacy are less likely to form implementation intentions, which undermines goal pursuit (Gollwitzer & Sheeran, 2006).

Nodes 5 and 6 represent subgroups of farmers, among which the actual adoption of OFSP is mediated by procrastination, intention to plant, and subjective norms towards the purchase of sweetpotato. Here, actual adoption levels were higher among farmers exposed to information nudges relating to the biofortification process than among those exposed to nudges relating to agronomic attributes, with an increase of 0.12 points when subjective norms towards the purchase of sweetpotato were less than or equal to 6.25 points. In the TPB, goal intention is part of the regulating mechanism of planned behaviour. People with high procrastination are, therefore, likely to shirk this phase in decision-making. Hence, farmers with lower unintentional procrastination, intention to plant, and subjective norms towards purchasing sweetpotato may promote adaptive strategies to overcome barriers to making actual adoption decisions. Indeed, Shin and Kelly (2015) argue that adaptive strategies reduce procrastination in the pre-decisional phase.

Our results clearly indicate that information nudges on the biofortification process were more effective for farmers with a lower tendency for unintentional procrastination, moderate to high subjective norms, and a strong intention to plant OFSP. This finding supports that of Adekambi et al. (2020). They found that providing farmers with information on the nutritional benefits of OFSP (as covered by information on the biofortification process in our study) increases their intention to plant it.

5 Conclusion and Implications

In this study, we used the extended theory of planned behaviour (TPB) to assess farmers' intention to plant biofortified crops and predict actual adoption and how informational nudges and procrastination mediate those decisions. We focused on nudges relating to information on agronomic attributes of OFSP varieties and nudges relating to the biofortification process. Two forms of procrastination were examined, namely, general and unintentional procrastination. The results indicate that subjective norms towards the production of OFSP, past behaviour, subjective norms towards selling OFSP vines (seeds), and agency to plant OFSP explain farmers' intention to plant OFSP. Informational nudges moderate these TPB variables. Results further indicate that three key variables moderate the actual adoption of OFSP. These are unintentional procrastination, intention to plant OFSP, and

subjective norms regarding purchasing sweetpotato. Hence, an interplay of behavioural and psychosocial variables influences the actual decision to plant OFSP. These findings imply the importance of combining several strategies in the promotion of biofortified crop varieties. It highlights the importance of psychological and behavioural factors in promoting the adoption of biofortified crops. Thus, nudges relating to agronomic attributes can be used to target farmers with low levels of subjective norms towards production, low agency for planting OFSP as recommended for sweetpotato, and those with high unintentional procrastination.

The finding that subjective norms—that is, perceived social pressure to undertake a behaviour—are a major driver of intention to adopt OFP implies interventions aimed at promoting OFSP need to consider the dominant social norms that shape behaviour in targeted communities. For instance, OFSP promotional campaigns should incorporate influential members of the community or role models whose opinions and approval matter to other farmers as endorsers. This study does not identify the source of social pressure with the most influence. However, existing evidence highlights the significance of addressing the identity of the person in peer and social network learning to exploit the potential of information and innovations disseminated.

Our finding that some farmers have high subjective norms but little perceived behavioural control (i.e. agency) over planting OFSP following the recommended practices suggests the need to increase such farmers' agency through training on the recommended agronomic practices. Such training should incorporate interactive activities that emphasise hands-on learning. An example of this is the use of varietal performance demonstration plots that allow farmers to observe, evaluate, and discuss the performance of new varieties.

Two major implications arise from our findings relating to the importance of unintentional procrastination in mediating the actual adoption of OFSP. First, to increase adoption rates, interventions should focus on increasing motivation among farmers. Providing farmers with clear and actionable information on the benefits of OFSP and how to grow it, coupled with follow-up support and frequent nudging with reminders, can help farmers overcome decision inertia. Second, the promotional messages should highlight beneficial traits such as yield advantage of variety, pest resistance and early maturity. Information campaigns and seed dissemination should be organised as close to the planting season as possible, and goal-setting calendar strategies integrated.

The findings of this study further indicate that nudges relating to the biofortification process can be more effective among farmers with higher ratings of subjective norms, some experience selling OFSP, and high agency to plant as recommended to increase intention to plant. These findings further indicated that nudges relating to the biofortification process are more effective when the rating of these psychosocial factors is high. With respect to adoption, they are suitable for farmers with low unintentional procrastination. Together, these findings imply that agronomic messages used for nudging the adoption of psychosocial factors should be easily understood by farmers, including those with low ratings for psychosocial factors.

Appendixes

Appendix 1: Information Nudges Framing for the Field Experiment

Agronomic information (message 1) or biofortification information (message 2). The message A stated that: "OFSP as a crop grows quite fast with some varieties maturing in 3–4 months, giving farmers food early in the season and the ability to sell the product quicker than the other sweetpotato varieties that mature in 6 months. OFSP varieties are more resistant to some of the diseases and pests that frequently negatively affect other sweetpotato types. This implies that a farmer can get more produce from a given piece of land area".

Message B balanced information about the biofortification process outcome, including both the changes in texture effects and the agronomic information. This group received the following information:

> OFSP as a crop grows quite fast with some varieties maturing in 3-4 months, giving farmers food early in the season and the ability to sell the product quicker than the other sweetpotato varieties that mature in 6 months. OFSP varieties are more resistant to some of the diseases and pests that frequently negatively affect other sweetpotato types. This implies that a farmer can get more produce from a given piece of land area.
>
> OFSP contains beta carotene, which is converted into vitamin A needed by the body. Vitamin A deficiency (VAD) is a major public health problem in Kenya, other African countries. It causes blindness and childhood diseases, such as diarrhoea. Children under five years of age and pregnant women, especially in the last trimester, are most at risk of VAD. VAD can occur due to insufficient consumption of vitamin A-rich foods. Plant-based products such as OFSP are an efficient and sustainable approach for addressing VAD among vulnerable groups. OFSP is improved, just like hybrid maize, and is rich in vitamin A in addition to energy. However, there are perceived drawbacks associated with the process of improving the nutrition properties of OFSP. Some consumers have felt that, when boiled, OFSP becomes too soft (mushy), compared to the other sweetpotato types, while other consumers have argued that OFSP isn't as tasty/sweet (or sugary) as the other types they are used to.

The information was then followed by showing the participant a sliced OFSP root to distinguish it from the yellow-fleshed sweetpotato.

Each nudge was delivered to individual farmers by trained researchers. The researchers were instructed to follow the scripts only and offer no additional elaborations to ensure uniformity and minimise their influence on the responses. After delivering the nudge, the research assistant allowed the farmer to seek clarification and explain their understanding of the message. Then, they conducted an oral test (it was scripted that all the assistants used the same questions and introduced no additional information) to ensure that the main issues in the message were understood by assessing the psychosocial factors. The message was repeated if the farmer did not understand, based on the simple test.

Appendix 2: Measures of Psychosocial Variable

Category	Statement	Response	Cronbach's α
General attitudes to planting OFSP	For me and my household, planting OFSP as a common crop during the next planting season is…	Bipolar items (1–7): good/bad; unpleasant/pleasant; not useful/beneficial; interesting/not interesting	0.73
Subjective norms relating to OFSP production	Most people …… me think that I should plant OFSP as a common crop during the next planting season	That are important to (true: 1–7/false) Opinion I value would approve (improbable: 1–7/probable) I respect and admire (unlikely: 1–7/likely) People like me (agree: 1–7/disagree)	0.73
Subjective norms towards purchasing sweetpotato	Most people …… me think that I should buy sweetpotato from the local market whenever sweetpotato is not available on my farm	That are important to (true: 1–7/false) Opinion I value would approve (improbable: 1–7/probable) I respect and admire (unlikely: 1–7/likely) People like me (agree: 1–7/disagree)	0.83
Subjective norms relating to the sale of OFSP vines	Most people …… me think that OFSP vines, which are the seeds for OFSP, should be sold just like any other seeds	That are important to (true: 1–7/false) Opinion I value would approve (improbable: 1–7/probable) I respect and admire (unlikely: 1–7/likely) People like me (agree: 1–7/disagree)	0.53
Subjective norms regarding planting sweetpotato if one becomes richer	Most people …… think that I should plant and eat less sweetpotato if I become richer	That are important to (true: 1–7/false) Opinion I value would approve (improbable: 1–7/probable) I respect and admire (unlikely: 1–7/likely) People like me (agree: 1–7/disagree)	0.78
Subjective norms about male farmers growing sweetpotato	Most people …… to me think that male farmers should not grow sweetpotato as a major crop	That are important to (true: 1–7/false) Opinion I value would approve (improbable: 1–7/probable) I respect and admire (unlikely: 1–7/likely) People like me (agree: 1–7/disagree)	0.69

(continued)

Category	Statement	Response	Cronbach's α
Agency to plant OFSP (perceived Behavioural control)	I can plant OFSP as a common crop during the next planting season	I am confident (true: 1–7/false) It is completely up to me (disagree: 1–7/agree) If I really wanted to (likely: 1–7/unlikely) It is under my control (not at all: 1–7/completely)	0.75
Agency to pay for sweetpotato vines	I can pay for vines of orange-fleshed sweetpotato if introduced in my village	I am confident (true: 1–7/false) It is completely up to me (disagree: 1–7/agree) If I really wanted to (likely: 1–7/unlikely) It is under my control (not at all: 1–7/completely)	0.78
Agency to plant OFSP as recommended	Plant orange-fleshed sweetpotato according to the recommendations required for sweetpotato	I am confident (true: 1–7/false) It is completely up to me (disagree: 1–7/agree) If I really wanted to (likely: 1–7/unlikely) It is under my control (not at all: 1–7/completely)	0.75
Salience	Perceived quality of OFSP grown in the area	True/false/do not know statements	–
Procrastination	Assessed using Steel et al. (2018)	(4-point scale: 1 = do not agree, 2 = agree slightly, 3 = agree moderately, 4 = agree completely)	–
Attitude toward consumer awareness	Buyer awareness, trader, and consumer preference	(Likert-type scale)	0.79
Farmers' intention to plant OFSP	I …… to plant OFSP as a common crop during the next planting season:	Intend (definitively do: 1–7/definitely do not) Will (for sure) (likely: 1–7/unlike) Am willing (false: 1–7/true) Plan (agree: 1–7/disagree)	0.74

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6 Behavioural Nudges, Cultural and Social Norms, and the Purchase of Quality Seed by Smallholder Farmers

Julius J. Okello, David R. Just, Arjan Verschoor, and Hugo Campos

Abstract

Culture plays a significant role in the behaviour of individuals including farmers. In this chapter, we report findings of a study that tested the effect of nudges which appeal to the cultural norms of a farming community in Uganda on the demand for agricultural innovations namely quality seed improved varieties of sweetpotato. Demand for was measured using the decision to purchase seed after exposure to research interventions. The study involved 1600 smallholder sweetpotato farmers from 120 villages spanning the entire district of Amuria, in the major sweetpotato-producing region of Eastern Uganda. The study finds that nudges built around cultural norms do have positive, albeit non-robust, effect on the purchase of quality seed by targeted farmers. In terms of policy, the effect is significant enough to warrant attention. However, further studies are needed to better understand the other factors affecting demand for quality seed in the presence of cultural nudges. That notwithstanding, this chapter concludes that behavioural nudges that appeal to cultural norms of farmers can increase uptake of agricultural innovations.

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Keywords

Culture and social norms · Nudges · Adoption · Quality seeds · Smallholder farmers

1 Introduction

This chapter focuses on the role culturally framed behavioural interventions/nudges can play in promoting the use of quality seed and reversing the decline in sweetpotato production and productivity in Uganda. Its main objective is to examine the effect of behavioural nudges that appeal to farmers' cultural practices and norms on the uptake of agricultural innovations, focusing on sweetpotato in Uganda. Sweetpotato is a major staple crop grown mainly for subsistence by farmers in more than 117 countries, including Uganda (Campos & Ortiz, 2020). It is grown as a high-energy source but is also a good source of other micronutrients, including potassium and dietary fibre. In sub-Saharan Africa, the leading sweetpotato-producing countries have traditionally been Nigeria and Uganda, but the latter has fallen behind in recent years (Okello et al., 2019).

Uganda is the secondary centre of diversity of sweetpotato production globally. That is, it has the second highest genetic diversity of sweetpotato varieties worldwide and is second only to central and south America where sweetpotato is native (Gichuki et al., 2003). Zawedde et al. (2014) estimate that Uganda hosts more 3000 varieties of sweetpotato. A large majority of these varieties are landraces. That means that they do not originate from the national crop breeding programme. This level of diversity is observed at household level as well in Uganda. It is estimated that, on average, smallholder sweetpotato farm households maintain, on average, four varieties of sweetpotato in their farms, majority of them landraces (Okello et al., 2022).

In line with the global trend, sweetpotato is mainly grown in most African countries for home consumption, with the surplus sold in local markets. Culture plays a major role in the production and consumption of sweetpotato. Specifically, in Uganda, this is most apparent at two levels, namely, at cultivation and at utilisation/food preparation levels. At cultivation level, culture is most evident in the way sweetpotato seed system operates, the acquisition seed for planting and in the in-plot crop management/husbandry. Culture drives the sweetpotato seed system. How seed is acquired and shared is deeply entrenched in a social network of family, friends, and neighbours in which culture and social norms play a significant role (McGuire, 2016). Seed sharing and exchange with neighbours and members of a social network, usually for free, is seen as part of being a good neighbour (McGuire, 2008—see details in Textbox 1). Most farmers use own/saved seed but turn to their social network work when own seed source is not sufficient to meet sweetpotato production needs. Members of the farmer's social network provide seed for free, expecting reciprocity of favours when their turn comes. Typically, the seed flowing through this social network has recircled for several seasons. Occasionally, farmers go for new varieties outside their social network when unable to source from the

network, when the new variety is perceived to perform better than what is owned or can be found within the network, or following seed promotion effort that is accompanied with free provision of seed (Kyamanywa et al., 2011; Ricciardi, 2015). In the latter case, new seed is acquired from outside the social network for experimentation purposes.

In the utilisation of sweetpotato culture plays a major role in how sweetpotato is prepared and consumed in Uganda. In central Uganda, among the Baganda—the dominant community—sweetpotato is typically boiled stacked together with other foods, especially cassava and green bananas (Asada, 2019). The pile is wrapped in banana leaves and steamed giving it a distinct flavour. Sweetpotato is therefore culturally an integral part of the food preparation and is consumed as part of the household meal (Katongole & Mukama, 2024). The boiled sweetpotato root forms part of what is culturally referred to as a "food" that is typically comprised of different

Textbox 1 McGuire (2008): Seed Systems as Social Systems (https://link.springer.com/article/10.1007/s10745-007-9143-4)

Majority of developing-country farmers obtain seed from own sources or from within the community. This is especially true for vegetatively propagated crops (VPCs), a group of crops that are propagated using clones or live material from an existing plant, to which sweetpotato belongs. A wide range of other crops with no strong commercial seed system rely on this type of seed system. One example, the focus of McGuire's study, is sorghum. As with VPCs, sorghum farmers mostly rely on seed saved from previous crop harvest. However, when farmers lose their seed stock, family and neighbours/friends or the community become the next major source of replacement seed. Seed transactions with this seed network are built on mutual reciprocity and are dictated by cultural and social norms. Seed exchange revolves around strong social relationships and ties, and occurs regularly within farmers' social networks comprising family, friends and neighbours. The exchange is mostly free, a mutual aid for supporting neighbours and kin/family in time of need, with expectation that the favour will be reciprocated 1 day. Exchange can, in some cases, be in form of a barter trade with another commodity. In most communities, norms around seed exchange are enduring, rather than being static. They change when societies are disrupted by war or displacement caused by natural disasters.

Seed circulating within a social network will usually have been planted multiple times. Indeed, as McGuire explains, seed quality (defined as seed health and genetic integrity) can change over time as the material changes hands within the community. Seed health can change/deteriorate as a result of accumulation of pest and diseases in the vegetative material used as seed. Genetic integrity is compromised through natural cross-pollination, resulting in variety mixes.

combinations of *matooke* (the boiled mashed green banana, the base food), stiff porridge (known as *posho*), rice, and boiled cassava root. The "food" is eaten with some form of protein stew (i.e. beef, beans, fish, or chicken) (Gibson et al., 2008; Katongole & Mukama, 2024).

In the eastern (and neighbouring northern) region of Uganda, the leading sweetpotato producer in the country, sweetpotato plays a major role as a hunger-season crop and is a key part of cultural identity as well (Asekenye et al., 2023; Masters, 2021—see also Textbox 2). Here, roots are consumed in fresh boiled form, usually with thick ground nut paste known as *odi* or alongside other foods in a meal. Extra roots are peeled, chipped, dried, and stored for consumption during the long dry season when other food stocks are in low supply. This practice is especially a major cultural aspect among the Teso community. The dried chips, known as *amukeke*, are later boiled and mashed alone or with peanut paste to form a popular stiff paste, also known as *amukeke* eaten with tea or singly (Ebregt et al., 2004; Kpaka et al., 2019; Bayiyana et al., 2024).

Despite its cultural and economic importance as food, sweetpotato production in Uganda has been in decline for several years. As demonstrated in Fig. 6.1, the decline cuts across multiple dimensions—namely, area cultivated, production and yield.

Textbox 2 Culture and Cultivation of Sweetpotato in Uganda

The review article by Alonso and Swinnen (2016) brought the aspect of food culture into mainstream thinking on food production and security. Food culture is a relatively new concept in the economics of agricultural development. There is no unifying definition of food culture, but one that broadly relates to the theme of this chapter defines food culture thus: "*the collective habits, rituals, beliefs, values, lifestyle, and practices around producing, procuring, and intaking food. It shapes the way people live and feel. It affects their identity and their culture*". Other authors add to this the aspect of norms and argue that culture relates to "all socially transmitted information" (Alonso & Swinnen, 2016; Mutiso, 2026). In psychology, culture is perceived a major factor in motivating human behaviour. Olum et al. (2017) argue citing Noack and Pouw (2015) that "food has important social and cultural functions and is seen as essential to keeping families together and to the maintenance of functioning communities".

In Uganda, sweetpotato production is anchored on a rich culture, from production to consumption. It is generally believed that sweetpotato was introduced in Uganda. Since then, the crop has evolved to become a major staple. Sweetpotato is grown and consumed in all the regions of Uganda. Differences in ecology, people's farming and cultural practices, and food consumption norms have led to a great diversity of varieties of sweetpotato, estimated at 3000 by scientists at the National Agricultural Research Organization.

In the Teso and surrounding regions, attachment and culture influence the types (varieties) of sweetpotato grown as well as how it is consumed. "Teso was synonymous with sweetpotato" said a district administrator. "In Kampala, consumers buy sweetpotato only after *our* Osukut is finished", said another. Sweetpotato in this region is not just a crop; it defines a people. More

(continued)

Textbox 2 (continued)

importantly, it is the way sweetpotato is consumed. While the rest of the country normally consumes sweetpotato in fresh boiled form, in Teso region, the most important form is the amukeke. Amukeke is food made from peeled and dried sweetpotato chips that goes by the same name. The chips are boiled in water and mashed with groundnuts and eaten, as a breakfast meal, with tea, milk, or plain water. The dried chips can last 4–5 months. They are typically consumed during the long dry season when stocks of other foods are low. Amukeke therefore connects the Teso people to their "culture". It makes them proud of who they are and is viewed as a cultural heritage.

The decline is attributed to several factors. First, Okello et al. (2019) argue that the lucrative trade in cereals, especially maize, between Uganda and its neighbours (specifically Kenya) may be playing a role. They argue that increased demand for maize by Kenya has made it more profitable to grow maize in the predominantly sweetpotato growing areas of east and north-east regions. The result is that farmers are substituting maize for sweetpotato.

The second reason cited for the decline in sweetpotato production in Uganda is the use of pest and disease-infested planting material (henceforth referred to as vines) (Bayiyana et al., 2024). The major disease of sweetpotato is the sweetpotato virus disease (SPVD), which can cause up to 98% yield losses in sweetpotato (Gasura & Mukasa, 2010), while the most devastating sweetpotato pest is the sweetpotato weevil. Infestation with the sweetpotato weevil forms black spots on the flesh of sweetpotato roots and tunnels on the root surface making infected roots unmarketable. The recommended management practice for SPVD and sweetpotato weevil is the use of certified/quality vines. As a viral disease, SPVD has no chemical remedy. However, farmers continue to rely on seed from their own fields or members of their social network within the community thus perpetuating the circle of pest and disease-infestation and prevalence.

Beyond the technology, that is, sweetpotato seed, there are other constraints that come into play and are likely contributors to the observed decline in sweetpotato production and productivity in Uganda. Particularly important is the weakness of farmer advisory services (Van Campenhout et al., 2021). The public extension system in Uganda, as in other countries, is weak and faces human and financial capital constraints. Most farmers therefore rely on their social network for crop production/management information.

This study draws from a field experiment that deployed behavioural nudges designed to stimulate demand for quality seed of improved sweetpotato varieties by smallholder farmers. The nudges were delivered in the form of a poster. The intervention was designed to resolve two major constraints that characterise smallholder farmers' seed system, namely, seed access and seed quality assurance. The seed access constraint was resolved by making seed available within the study communities, at a subsidised fee, while the seed quality authentication problem was resolved through seed inspection and certification. We describe details of the nudges and how constraints were resolved

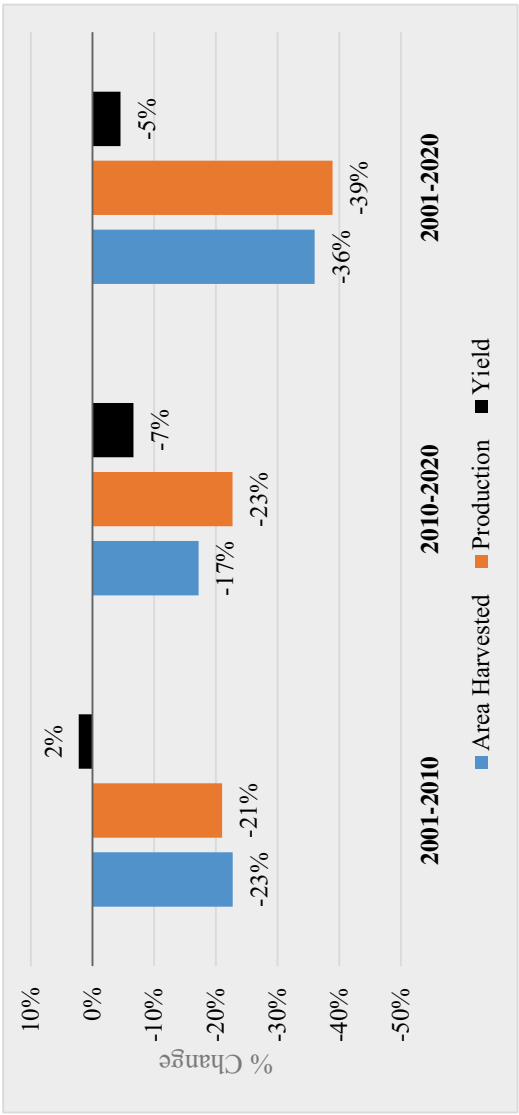


Fig. 6.1 Changes in sweetpotato acreage, yield, and production, 2001–2020. (Data Source: FAOSTAT (https://www.fao.org/faostat/en/#data/QCL))

in the subsequent sections. The specific research question addressed in this chapter is: What is the role of culture and social intervention nudges in the adoption of agricultural innovations specifically focusing on quality seed of improved sweetpotato varieties. To address this question, we summarise findings of recent studies conducted in Eastern Uganda. Details of the studies are in Okello et al. (2025a, b).

The rest of this chapter is organised as follows: Below, we start by first describing the study area, the nudge interventions, and the analytical technique. This is followed by the study findings in Sect. 3. Finally, Section 4 presents the conclusions and implications of the findings for policy and practice.

2 Study Methods

2.1 Study Area and Participants

This study was conducted in the Amuria district of Uganda. The district is in the Teso sub-region of Eastern region and is comprised of 9 sub-counties, 47 parishes, and 539 villages. Each village has approximately 100 households. Nearly all the households in the district grow sweetpotato.

Study participants were selected from all the counties, sub-counties, and parishes/wards. In each parish/ward, a list of all the villages was drawn, and 120 villages were randomly selected proportional to the size of the parish. Using this selection approach allowed for selecting more villages in larger parishes, and vice versa. Based on power[1] calculations, and to cater for potential study dropouts, 10 households were selected in each of the 120 villages, yielding a total of 1200 households. All 1200 households participated in a baseline survey conducted in December 2021 to establish the baseline conditions relating to sweetpotato production practices and the sources and use of seed. After the baseline survey, the 1200 study households were cluster randomised, with the village as cluster, into two treatments described below.

2.2 The Interventions

(a) *The Nudge Intervention*

The study deployed a bundle of social/behavioural nudges aimed at stimulating demand for quality seed of improved varieties, namely, nostalgia and loss aversion. Nostalgia appeals to an individual's culture and social norms and is broadly defined as a sentimental longing or wistful affection for one's past events and practices (Okello et al., 2025a, b). It is the feeling of fondness about important events and is often associated with childhood experiences and relationships. In this study, we used nostalgia to activate fondness for farming and food cultural habits and practices.

The concept of nostalgia is new to agriculture but widely studied in psychology and extensively used in food and product marketing, where it is mostly associated

[1] Power calculations is an evaluation technique that determines the number of sampling units required to accurate estimate the impact of an intervention. For more details, see Okello et al. (2026).

with positive outcomes (Zhou et al., 2012; Rana et al., 2022; Sedikides & Wildschut, 2020). It has been applied in marketing to evaluate social connectedness or a sense of belonging and acceptance by a consumer. Sedikides and Wilschut (2020) indicate that advertising/promotion activities are a key trigger of nostalgia. Hence, this study specifically explored how fondness for cultural/ancestral farming and food preparation practices can be leveraged to promote uptake of novel agricultural innovations, namely, quality seed. It was designed to use local knowledge of imagery associated with popular cultural/ancestral food made from sweetpotato known as *amukeke* to activate nostalgic feelings. The imagery was combined with an advertisement placed at strategic locations within the village to activate nostalgia. The advertisement was in the form of a poster depicting *amukeke* and was accompanied by a short narrative that explained the imagery in English and vernacular languages used by the study communities (see Textbox 3). Loss aversion, on the other hand, is the feeling that loss associated with a bad outcome (such as depressed yield) are much greater than comparable gain from a positive outcome. Balew et al. (2023) describe this phenomenon for the case of knowledge diffusion in wheat innovations in Ethiopia while Mutiso (2026) discuss gender aspects of behavioral interventions in Uganda.

(b) *Deployment of the Interventions*

The interventions were deployed over two seasons, namely, April 2022 long rain season and July 2022 short rain season. Quality seed was delivered for sale at designated sales points (see Fig. 6.2) in each of the 120 villages. In treatment villages, the poster with the nudges was displayed at the sales point alongside the bags of quality seed. While in control villages, only quality seed was displayed for sale. Each sales point (in both treatment and control villages) received 12 bags of quality seed of improved varieties over a period of 4 weeks during each production season. A salesperson recruited from among the progressive/model farmers in each study village was responsible for displaying seed and recording sales transactions.

Quality seed of four sweetpotato varieties were used in this study, namely, Tanzania, Ejumula, Narospot 1 (also known as New Dimbuka), and Naspot 13 (also known as Joweria). Figure 6.3 provides information about the varieties promoted. Ejumula and Tanzania are widely grown varieties in the district. However, the seeds of these varieties displayed at the sales points were of superior quality to those found in the community. They were obtained from a source that was monitored, inspected, and certified as being free of the debilitating viruses.[2] As shown, Ejumula is orange-fleshed, hence high in beta carotene, a precursor for vitamin A, while Tanzania is yellow-fleshed. NAROSPOT 1 and NASPOT 13 were new introductions in the study district and were also obtained from an SPVD-free source. The former

[2] Besides the government inspection, samples of vines from the inspectors were also collected by the research team and tested for the SPVD viruses. They were found to be free of SPVD. Further, the research team maintained close control of starter material used by the multipliers to produce study vines to ensure that they were traceable back to a certified tissue culture lab used as main source.

Textbox 3 Activation of the Social Nudges

The poster used to deploy the social nudges had four panels. The first panel depicts the case of a farmer using poor quality seed (i.e., own seed harvested from the previous crop), a common practice. Such seed harbour pests and diseases (shown by diseased leaves in the middle collage). When planted, they yield thin roots and pest-infested roots (shown in the right). The emoji symbolises the shock at the bad and insect damaged roots.

The second panel espouses the virtues of planting quality seed (lush looking bundle (left) and good crop (right). The third panel depicts the outcome of planting quality seed—a big harvest, big and good roots, and (by contrast) joy to farmer.

Lastly, the fourth panel springs from the third panel, with more roots—to eat fresh and spare—a farmer can make *amukeke* and still sell surpluses making money. The emoji in the last panel expresses the feeling of making a favourite ancestral food, and money from sales.

The first three panels are designed to activate loss aversion and constitute loss aversion nudge. Panel three and four were, in turn, designed to activate the feeling of nostalgia and hence constitute the nostalgia nudge.





Fig. 6.2 Sales point showing bags of quality seed of improved sweetpotato varieties

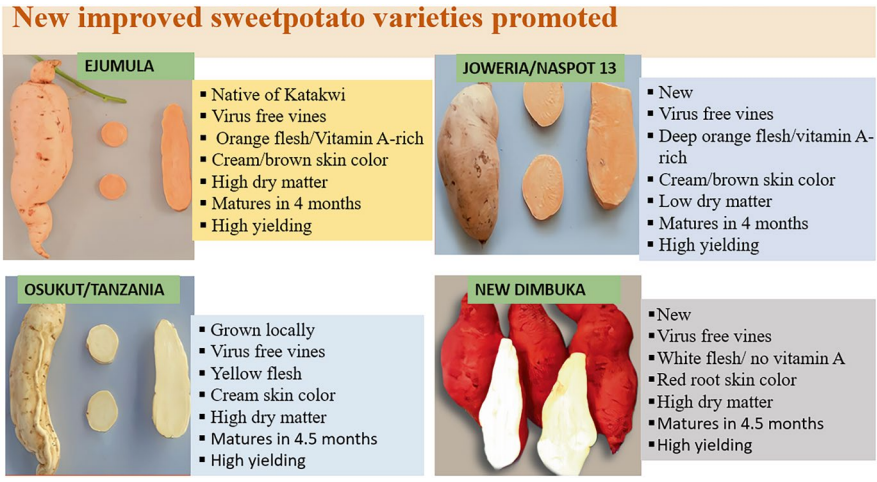


Fig. 6.3 Varieties of sweetpotato used in the study

is currently one of the most popular improved cream/white-fleshed varieties in the country, while the latter is also orange-fleshed, hence rich in vitamin A.

(c) *Analytical Technique*

The effect nudges was estimated by comparing purchase decisions between the treated and untreated groups. Specifically, the average impact of the nudge interventions on farmers' vine purchase decisions was estimated using a Linear Probability Model (LPM) specified as:

$$Y_{csh} = \beta_0 + \beta_1 \text{Treatment}_{csh} + \gamma' X_{csh} + v_c + \varepsilon_{csh}$$

where Y_{csh} is the purchase decision of a household h in village s, sub-county c. Treatment_{csh} is a dummy variable that takes a value of 1 if household h lives within the village that received the nudge interventions and 0 otherwise, v_c is a vector of sub-county fixed effects to control other unobservable sub-county-level characteristics. In other iterations of the base model, we include a vector X_{csh}, a set of household characteristics that are a control for other/household factors likely to influence purchase decisions. These household-level factors include the frequency of purchasing vines before the intervention, households' absolute risk aversion (calculated from survey responses), gender and the education level of the respondents, household size, and the size of households' own cultivation lands. The error term is given by ε_{csh}. The coefficient of interest is β_1. A significantly positive value of this coefficient would provide evidence that nudges encouraged the purchase of quality seed. Moreover, we also assessed the effect of nudges on quality seed purchase decisions when the error terms are clustered at the sub-county level.

(d) *Measurement of Variables*

The main interest in this study was to examine how nudges influence the purchase of quality seed of improved sweetpotato varieties. The outcome variable of interest is therefore the purchase of quality seed. It was measured using a dummy variable equal to 1 if a household purchased quality seed, and 0 otherwise.

The social nudges used were nostalgia and loss aversion. The former was measured using a validated seven-item psychometric scale of general proneness to nostalgia based on an approach used by Routledge et al. (2008). The seven questions administered assessed the frequency and importance of nostalgic emotions experienced by the respondents. Responses were recorded using a 7-point scale, with one denoting "not at all" and seven representing "very much". An index based on the mean value of the seven nostalgia questions was then used as a proxy measure for farmers' general nostalgia level. The scale was adapted to the local language and context of the local population. In addition, three additional Likert scale questions were administered to assess farmers' feeling of nostalgia for: (i) the crops their parents or grandparents had grown (proxy for "fondness to crops"), (ii) the production practices their parents and grandparents had employed (proxy for "fondness to agricultural production"), or (iii) the connection to their ancestors provided by farming (proxy "for connection to ancestors"). Responses to these questions reveal whether farmers have agricultural-specific nostalgia.

3 Results

3.1 Characteristics of Study Participants

Table 6.1 shows that there were no differences in demographic and socioeconomic characteristics between the farmers who received the interventions (i.e. treatment group) and their counterparts (the control group), except in a few cases. This implies, in evaluation language, that the two samples are fairly well balanced. There were slightly more (i.e. 0.4%) farmers in the control group who never purchased sweetpotato vines compared to treatment group.

Notably, the findings above also indicate that farmers in the treatment group had higher level of nostalgia related to a "connection to ancestors". However, the difference is insignificant statistically. General nostalgia, on the other hand, was higher for farmers in the control group—albeit slightly—but also statistically insignificant. We subject these descriptive statistics to more rigorous analysis using regression technique below, after assessing awareness and farmer interaction with the nudges in the next section.

3.2 Awareness of and Sources of Information About Nudge Interventions

The effectiveness of cultural nudges in influencing behaviour depends on farmers' interaction with them. Hence, in this section, we first assess farmers' awareness of the study interventions. Results in Table 6.2 show a high level of awareness of the sale of quality seed of improved sweetpotato varieties within the study village by the respondents. These results are based on an augmented survey sample ($n = 1612$)

Table 6.1 Demographics and socioeconomic characteristics of the study respondents (means by treatment)

Variables	Non-treated	Treatment	*t*-value (Diff)
Outcome variable			
Purchased (1 = yes)	0.446	0.442	0.111
Years of schooling	5.977	5.855	0.546
Respondent sex (1 = male)	0.613	0.582	1.064
Respondent age (years)	41.65	41.96	−0.316
Household size (count)	7.208	7.174	0.171
Own cultivable land (acres)	3.303	3.341	−0.249
Distance to sales point (minutes)	19.480	18.296	0.826
Attitude			
General nostalgia	4.953	4.934	0.308
Connection to ancestors	4.236	4.313	−1.482

Source: Household survey data

Note: Column 4 is the *t*-value of the difference (Diff) between the mean value of the control and treatment groups. Asterisks indicate the following: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.1$

Table 6.2 Awareness, interaction with, and effects of the nudges

	Control (n = 749)	Treatment (n = 863)	Total (N = 1612)	p-value
Aware of vine sales within the village, n (%)	652 (87.0)	765 (88.6)	1417 (87.9)	0.33
Aware of vine sales in another village, n (%)	395 (52.7)	458 (53.1)	853 (52.9)	0.89
Main source of knowledge about quality seed, n (%)				
Co-villagers/friends/relatives	412 (63.2)	472 (61.7)	884 (62.4)	0.56
Local administrators	101 (15.5)	101 (13.2)	202 (14.3)	0.22
Visit to the salesperson	92 (14.1)	89 (11.6)	181 (12.8)	0.16
Saw while passing the sales point	23 (3.5)	38 (5.0)	61 (4.3)	0.18
Agricultural extension worker	25 (3.8)	23 (3.0)	48 (3.4)	0.39
Others (specify …)	100 (15.3)	121 (15.8)	221 (15.6)	0.80

that comprised the 1200 farmers interviewed during the baseline and an additional 412 quality seed purchasers. The 412 farmers were randomly selected from among farmers who purchased quality seed over the two intervention seasons in both treatment and control villages but did not participate in the baseline survey.

The results specifically show that the proportion of farmers who knew about the quality seed was basically the same among treatment (87%) and control (89%) groups, with a significant difference between the treatment and control groups. Respondents learned about the sale of quality seed in different ways. Majority (63% treatment, 62% control) learned about them from co-villagers, friends and family/relatives. Only a few farmers in the control and treatment groups learned about the sale of quality seed from extension workers, underscoring the weak extension system in the study areas, as is usually the case in most developing countries.

Table 6.3a shows that a higher number of baseline respondents in the treatment group villages purchased quality seed than their counterparts in the control group villages, but the difference is again not statistically significant. The table is based on self-reported data collected during the follow-up survey. Overall, nearly 1000 (65%) of the total 1612 study respondents purchased quality vines in the villages within which they lived. A slightly higher proportion of respondents in the control villages (13%) bought vines from a sales point in another village, compared to 11% who did so in the treatment village. As before, however, the differences are statistically insignificant. Mutiso et al. (2024) (see Blog[3]) using the same data however finds that exposure to the nudges, especially through interaction with the poster, significantly increased purchases of quality seed by farmers in the treatment villages. This suggests that interaction with the poster was critical in influencing behaviour.

Table 6.3b breaks down the purchases of quality seed by variety purchased. Clearly, more farmers purchased quality seed of the local varieties, namely, Ejumula

[3] https://nisd.ac.uk/information-and-quality-seed-dissemination-nudges-to-boost-delivery-by-model-farmers/

Table 6.3a Purchase of quality seed of improved varieties by study group and season

	Control (n = 749)	Treatment (*n* = 863)	Total	Test of diff in means
Seed purchase (*count, %*)				
Within the village	420 (64.4)	505 (66.0)	925 (65.3)	Ns
From another village	48 (13.3)	46 (10.7)	94 (11.9)	Ns
Season seed was purchased, n (*%*)				
April	314 (74.8)	358 (70.9)	672 (72.6)	Ns
July	90 (21.4)	121 (24.0)	211 (22.8)	
Both seasons	16 (3.8)	26 (5.1)	42 (4.5)	

Note: ns = not statistically significant at 10% level

Table 6.3b Number of farmers purchasing different varieties of sweetpotato displayed at sales points during season 1

	Control (*n* = 749)	Treatment (*n* = 863)	Total (*n* = 1612)	*T*-test
Variety purchased in season 1, *n* (%)				
Osukut	196 (59.4)	222 (57.8)	418 (58.5)	Ns
Ejumula	101 (30.6)	143 (37.2)	244 (34.2)	*
Narospot 1	88 (26.7)	91 (23.7)	179 (25.1)	Ns
Naspot 13	84 (25.5)	90 (23.4)	174 (24.4)	Ns
Does not recall name	114 (34.5)	125 (32.6)	239 (33.5)	Ns
Was not asked	16 (4.8)	24 (6.3)	40 (5.6)	Ns

ns not significant
Note: *, **, *** denotes 110%, 5% and 1% significance level

and Osukut/Tanzania, than the new introductions. This finding likely reflects the popularity of these varieties in the study district. It is also in line with the overall stated preferences of varieties by the farmers in the study villages (Fig. 6.4). Among the varieties grown by farmers in the study district, Osukut was the second most widely preferred variety after Oboi/Iboi, which is also a local landrace. Note that the introduced varieties, while also mentioned among the top 12 most preferred varieties, come at the tail end. Further, there were no statistically significant differences in the varietal preferences between the treatment and control groups.

As shown in Table 6.4, which reports the varieties bought during the second season/round of the intervention, only a small number of farmers purchased vines/seed during that season, that is, during the July season of 2022. It further shows the same pattern as the purchases in Season 1. Osukut/Tanzania was still the most popular variety, while the introduced varieties (Naspot 13 and Narospot 1) were the least.

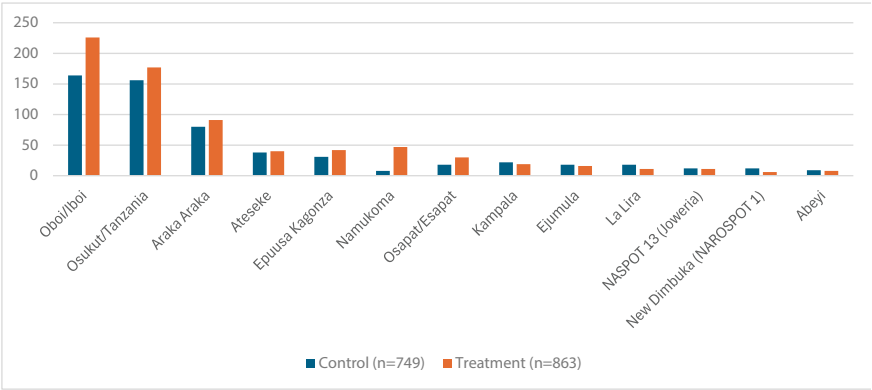


Fig. 6.4 Most preferred varieties by study farmers (Count), by treatment type

Table 6.4 Purchases of quality seed of improved sweetpotato varieties in the 2022 season 2, by treatment type

	Control (n = 749)	Treatment (n = 863)
Variety purchased in season 2, n (%)		
Osukut	58 (54.7)	84 (57.1)
Ejumula	25 (23.6)	48 (32.7)
Narospot 1	23 (21.7)	36 (24.5)
Naspot 13	23 (21.7)	26 (17.7)
Does not recall name	37 (34.9)	47 (32.0)
Was not asked	8 (7.5)	9 (6.1)

The poor performance of the introduced varieties could have been caused by the popularity of Osukut. This variety is deeply embedded in the production and food system of the Teso community. Bayiyana et al. (2024) find that it is extremely popular for both fresh consumption and making *amukeke*. Its re-introduction through provision of quality seed in this study may therefore have overshadowed the rest of the varieties, especially the unknown/new introductions.

We further investigated why some farmers decided against the purchase of quality seed. Figure 6.5 presents some of the reasons for non-purchase of seed among the respondents who did not purchase seed at all from the sales points. Overwhelmingly, lack of money to buy quality seed was the main impediment, indicating that a liquidity constraint played a key role. This is not a surprise, especially in the first season, because it followed two consecutive seasons of crop failure (the main source of income) due to droughts. Moreover, farmers were also just emerging from the COVID-19 pandemic, which disrupted farming and household livelihoods, resulting in liquidity/cash constraints.

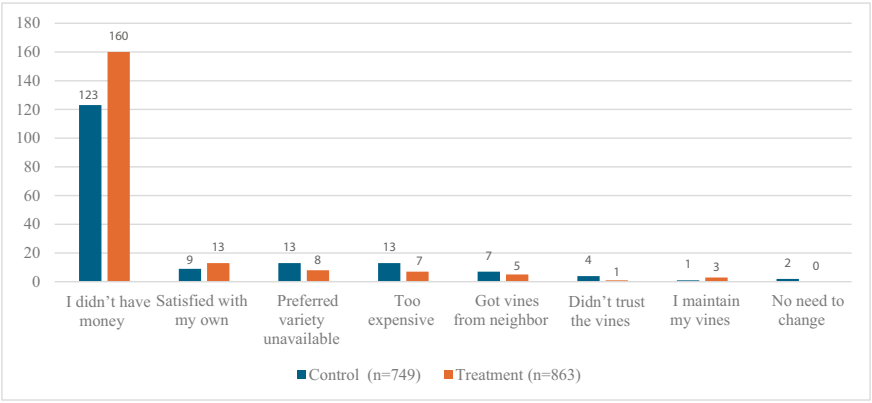


Fig. 6.5 Reasons for not purchasing quality seed of improved varieties (count)

3.3 The Causal Effect of Nudges on Purchase of Quality Seed of Improved Varieties

In this section, the findings of descriptive analysis are subjected to more rigorous scrutiny using econometric analysis. Specifically, the observed differences in purchase between farmers in the treatment group and their counterparts in the control group are examined to understand if they are due to exposure to the behavioural nudges. Further, the mediating effect of culture/social nudges, namely, nostalgia and loss aversion, is assessed. Table 6.5 presents the findings. They are the results of the fixed effects models estimated to examine the combined effect of exposure to the poster containing cultural nudges on decision to purchase quality seed.

The findings of Model 1 indicate that nudges indeed had a statistically significant effect on purchase of quality seed, even though the effect is not strong (as shown by a *p*-value of 0.077). Model 2 is a control for socioeconomic and capacity factors that are likely to influence decision to purchase quality vines. It specifically controls for the gender of respondent, education, household size, and asset (i.e. land) endowment. It finds that education, size of the household, and land endowment have a significant effect on the likelihood of purchase of quality seed. Controlling for these factors increases the effect of nudges on the purchase of quality seed marginally by 1%, but the effect is still statistically weak (now with a *p*-value of 0.079). Notwithstanding the weak effect, these findings indicate that there is evidence to suggest that exposure to cultural and social norm nudges influences demand for quality seed of improved sweetpotato varieties.

Table 6.6 takes a deeper look into how nostalgia, as a cultural nudge, influences purchase decisions. The examination of this effect is very important because nostalgia can act as an incentive to the use/adoption of new innovations but can also dampen it. In particular, holding fast onto traditional low-yielding varieties because of a cultural attachment to them can have lower varietal turnover. Environmentalists and psychologists have underscored the importance of attachment in influencing

Table 6.5 Effect of behavioural nudges on purchase of quality vines of improved sweetpotato varieties: fixed effects model, $N = 1133$

	Model 1 (No controls included)			Model 2 (Other controls included)		
	Coeff	SD	*p*-value	Coeff	SD	*p*-value
Treatment* (1 = treated, 0 = non-treated)	0.06	0.03	0.077	0.07	0.04	0.079
Gender (1 = male)				−0.03	0.02	0.301
Education (years)				0.02	0.00	0.001
Household size (count)				0.01	0.00	0.060
Land (acres)				0.02	0.00	0.001
Constant	0.41	0.02	0.000	0.21	0.03	0.000

Treatment* represents whether the household lives in a treatment village and is interpreted as the average treatment effect of behavioural nudges. Both models include sub-county-level fixed effects

Table 6.6 Mediating effect of nostalgia on behavioural nudges

	(1)	(2)	(3)	(4)
	General nostalgia		Connection to ancestors	
	High	Low	High	Low
Variables				
Treatment	0.152**	0.006	0.116**	0.023
	(2.06)	(0.11)	(2.04)	(0.37)
Constant	0.033	0.132	−0.159	0.238
	(0.19)	(1.06)	(−1.45)	(1.32)
Observations	465	474	436	508
Controls	Yes	Yes	Yes	Yes
Adjusted R-squared	0.054	0.041	0.124	−0.010
Sub-county FE	Yes	Yes	Yes	Yes

Note: Samples are separated based on the median value of different measures of farmers' nostalgia. The Standard Errors (in parentheses) are clustered at village level. Asterisks indicate the following: ***$p < 0.01$, **$p < 0.05$, and *$p < 0.10$

behaviour. The former use it to explain why individuals may hold on to a natural good (landscape, forest, lake, etc) due to the utility obtained from its existence (Chng & Narayanan, 2017; Ihemezie et al., 2021). Such utility is termed attachment value. Proshansky (1983) and Ujang and Zakariya (2015) described attachment as an interplay of affects and emotions, knowledge and beliefs, and behaviours and actions. In social psychology literature, attachment is perceived to be fundamental in transmitting culture (Granqvist, 2021). Indeed, Cassidy et al. (2013) argue that nostalgia-prone individuals are more closely integrated into the attachment behavioural systems.

The results in Table 6.6 are based on the analysis of two forms of nostalgia, namely, general and cultural nostalgia. The latter relates to fondness for common traditions. General nostalgia is calculated by aggregating the response to seven questions, including the frequency and importance of nostalgic emotions experienced by the respondents. The findings of the analysis of general nostalgia are presented in columns (1) and (2). On the other hand, columns (3) and (4) present results of farming-specific nostalgia relating to what the ancestors did, thus cultural, and are based on specific questions in the survey module. The *Treatment* variable captures whether the household is located within a treatment village and is interpreted as the average treatment effect of behavioural nudges. All models include full sets of controls and sub-county-level fixed effects.

The results of general nostalgia indicate that it does have a positive mediating effect on the behavioural nudges but only for the case of those who are more prone to high levels of nostalgia. High nostalgia refers to a case in which an individual's nostalgic feelings are more easily activated by past events. In the case of this study, it constitutes the group of farmers whose nostalgic feelings were more easily activated by the images presented in the poster mounted at sales points in their villages.

In columns (3) and (4), the analysis focuses on nostalgic feelings associated with the feelings of connection to what ancestors did and how they lived. This type of

nostalgia would be activated by things such as the thought of cultural foods ancestors ate, which is a major component of the nudges deployed in this study. Here, again, the results indicate that farmers with higher proneness to nostalgic feelings relating to how sweetpotato connects them to ancestors are more likely to purchase quality seed when exposed to nudges.

4 Summary, Conclusions, and Implications

This chapter reports the findings of a behavioural intervention designed to test the effect of nudges that appeal to cultural and social norms on the uptake of agricultural innovations. The study was conducted in Uganda, a major sweetpotato grower and secondary centre of diversity of sweetpotato varieties globally. The study targeted 1600 smallholder farmers. The nudges were deployed using a poster. They were designed to activate feelings of nostalgia arising from the cultivation and consumption of sweetpotato and feelings of loss aversion arising from losses incurred when poor-quality seed is used. Agricultural innovations were in the form of quality seed of improved sweetpotato varieties. To resolve constraints relating to poor access to seed and quality of seed, the study provided seed within the study villages by establishing sales points in each study village. The study also resolved quality authentication constraints by monitoring, inspecting, and certifying the seed distributed. The data used in this chapter were collected in two rounds punctuated by two seasons of interventions.

The findings indicate high awareness of the interventions in both treated (i.e. those receiving posters containing the nudges) and untreated groups. Descriptive statistics revealed some differences in purchase of quality seed between the treated and untreated groups. Using fixed effects regression analysis to assess the impact of the nudge interventions confirmed the differences. It found significant and fairly sizeable but weak effect of nudges. The treated villages had a 6% higher likelihood of purchase of quality seed among farmers in treated villages, with this effect rising to 7% after controlling for other effects, compared to non-treated villages. Moreover, further/deeper examination of the cultural aspects of the nudges reveals that both general nostalgia and nostalgia relating to connection with the ancestors have a mediating effect on the effect of cultural nudges on the purchase of quality seed of improved sweetpotato varieties. These are promising findings in terms of policy. They suggest that cultural nudges can be used to promote the use of agricultural innovations even among farmers who are closely attached to ancestral beliefs.

More specifically, the findings of this study have two major implications. First, they imply that behavioural nudges can be used to stimulate demand for agricultural innovations in smallholder farm setting even when characterised by a lack of formal seed system but require that other constraints to the use of quality seed be resolved. Second, the finding that nudges increase the purchase of quality seed by farmers with a high connection to how their ancestors lived suggests that they can be used to promote the use of agricultural innovations among farmers that still heed traditional/cultural farming practices.

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Incentives for Social Learning and Diffusion of Improved Crop Varieties

7

Kelvin M. Shikuku and Erwin Bulte

Abstract

We discuss part of the recent literature that considers social learning among smallholder farmers, and particularly several lessons from the field of behavioural economics. In contrast to the expectation that diffusion of information about agricultural innovations will happen "spontaneously", recent evidence suggests that this process requires effort of participants. To induce trained farmers to spread knowledge, material and non-material incentives can be used. The effectiveness of these incentives can be leveraged by applying loss-framed messaging.

Keywords

Innovation diffusion · Social incentives · Social learning · Loss aversion · Effort provision

1 Introduction

The diffusion of agricultural innovations remains incomplete in sub-Saharan Africa (SSA), both in terms of hectarage planted and the producers adopting innovations, yet such diffusion is crucial in agri-food systems transformation for improved food security and nutrition, increased income, reduced poverty, and enhanced resilience

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of livelihoods to climate risks (Pamuk et al., 2014; Barrett et al., 2020; Kosmowski et al., 2020). Smallholders may have low trust in the new products that are offered or the parties offering them (Kholová et al., 2024). Lack of information can cause low trust, consequently impeding diffusion because many farmers simply lack information about available agricultural innovations or how to use them properly. Limited access to information is partly attributed to under-funded extension services and farmer advisory systems that are unable to reach large swathes of their target population (Norton and Alwang, 2020; Suri and Udry, 2022). Most efforts to address informational constraints recognise the crucial role of public and private extension systems, acknowledge their limitations, and focus on the role of peer-to-peer technology transfer, also known as social learning, in strengthening such systems (Bandiera & Rasul, 2006; Conley & Udry, 2010; Beaman et al., 2021).

Social networks are ubiquitous in SSA countries and play multiple roles. These roles include, for example, risk sharing and information diffusion (Jack & Suri, 2014; Bandiera & Rasul, 2006). While using social networks to spread information is a logical approach to promoting diffusion, it requires the selection of the best entry point for knowledge transfer. Who should be trained to pass on knowledge or technology? Several studies examining communication and learning within networks have focused on carefully identifying *central* individuals and seeding information via such nominated individuals (e.g. Banerjee et al., 2019; Beaman et al., 2021, Airoldi & Christakis, 2024). Central nodes in networks are individuals with many edges, or links to other individuals. However, central individuals, as determined by centrality measures of social networks' properties such as degree, are typically not very representative of the broader population, and this may impede learning. Also, it is not obvious that central nodes are always incentivised enough to disseminate information. Other approaches are to work through farmers that more closely resemble the rest of the target group (BenYishay & Mobarak, 2018) or that are part of a cluster of individuals (Chami et al., 2017). Researchers have studied information exchange links probing their determinants (e.g. Shikuku, 2019; Santos & Barrett, 2010), and assessed their effectiveness in the diffusion of innovations (e.g. Vasilaky & Leonard, 2018).

Extension approaches that employ social learning to promote the diffusion of knowledge should, in addition to carefully selecting entry points (the so-called disseminating farmers or "seeds"), also consider how to incentivise these entry points for example by providing material and reputational rewards.[1] Passive social learning whereby some farmers experiment with technologies and their neighbours learn by simply observing them (causing spontaneous diffusion of ideas) may not work in many situations. Success depends on effort by the "seed" to diffuse innovations, and such effort provision is heterogenous (e.g. Beaman and Dillon, 2018; BenYishay & Mobarak, 2018). A consensus emerges that spreading information about agricultural innovation is costly. For example, individuals must travel, expend effort in informing and persuading others, and accrue costs when communicating with their

[1] We acknowledge that sometimes varieties are not adopted because they are not market accepted or even useful. Here, we assume that the knowledge being transferred is good and useful.

neighbours on the phone. This has triggered interest among researchers in understanding the incentives for technology transfer within social networks (BenYishay & Mobarak, 2018; Shikuku et al., 2019; Balew et al., 2023).

This chapter examines several aspects of the role of incentives in the diffusion of agricultural innovations in SSA. Specifically, we look at the effect of intrinsic and extrinsic motivation, goal priming, and loss framing on effort provision in the diffusion of agricultural innovations. We discuss evidence related directly to the adoption of improved crop varieties, as well as findings from studies that address the adoption of improved agricultural practices more broadly.

2 Intrinsic and Extrinsic Incentives for Technology Transfer in Agriculture

Benabou and Tirole (2006) developed a model that provides three motivations for human behaviour, namely intrinsic, extrinsic, and reputational rewards. Their model showed that depending on the social preferences exhibited by people, these three types of motivations can have crowding-in and crowding-out effects. First, people are intrinsically motivated when the social preferences they exhibit are inclined towards caring for others' well-being. Studies have further distinguished between pure altruism and the desire for a "warm glow" (Andreoni, 1990). Second, individuals motivated by extrinsic rewards expend costly effort on a task when they expect a material reward, whether it is pecuniary or not. Third, individuals motivated by reputational rewards seek public recognition of their work—that is, they expend costly effort to perform tasks in the expectation of their good deeds being publicised. These three motives can be translated into different types of incentives to promote effort provision, for example to share information.

A few studies have explicitly evaluated the effect of these three types of incentives on technology diffusion in agriculture in SSA. BenYishay and Mobarak (2018), using experimental data from rural Malawi to study the diffusion of a soil and water conservation technique, found that extrinsic material rewards effectively motivated peer farmers to supply effort, that is, those selected to be representative of an average farmer in the village and not necessarily literate, but keen on trying new ideas. This was less true for the so-called lead farmers, that is, better-educated farmers capable of sustaining experimentation costs, but socially distant from neighbours. Shikuku et al. (2019) focused on peer farmers and varied the type of reward offered for knowledge diffusion– either a material or reputational reward for the dissemination of information about drought-tolerant crop varieties in rural Uganda. They found that, without incentives, peer farmers did not share much knowledge with their neighbours. However, incentives work. Indeed, when incentivised with social recognition, for example the promise of announcing the peer farmer's good performance in a community meeting, peer farmers made greater effort to reach out to their neighbours than when they were provided with a material reward. For a broader discussion of these dynamics, refer to Ashraf and Bandiera

(2018) who showed that social incentives are powerful motivators that should be considered in the design of organisational policies.

3 Goal Priming as an Incentive for Technology Transfer

Goal priming refers to the activation of a goal by external cues, which can affect information processing and behaviour to pursue the primed goal (Custers & Aarts, 2005). The assumption here is that the product, innovation, technology, or practice that people are primed to set a goal about is good and potentially welfare enhancing.[2] In an agricultural context, a goal is a state or behaviour including knowledge acquisition and sharing that has reward value and, therefore, motivates a person to pursue it. When individuals perceive an outcome or behaviour as desirable and linked to a reward, they are more likely to invest effort in keeping the goal active and overcoming barriers to its pursuit (Custers & Aarts, 2007; Papies & Aarts, 2016).

Evidence about the effect of goal priming on the diffusion of agricultural innovations is thin. To our knowledge, only Okello et al. (2023) have attempted the idea of goal priming as a nudge for the adoption of agricultural innovations. They implemented a randomised experiment in rural Uganda, selecting progressive farmers (i.e. those who were already working with government extension workers) and training them in agronomic practices and benefits associated with biofortified orange-fleshed sweet potato.

A randomly selected subsample of trained progressive farmers was asked to set a personal goal for sharing knowledge with their neighbours.

In their experiment, goal priming was bundled with a reputational reward in the form of social recognition. Okello et al. (2023) found that progressive farmers worked less when they were trained, primed to set a goal, and promised social recognition of effort compared to when they only received training. The authors speculated that an *over-justification effect*, a phenomenon that arises from losing the benevolent spirit after feeling targeted by change agents/communicators (McRaney, 2011), attenuated the effect of goal priming combined with social recognition because progressive farmers were already famous.

4 The Role of Loss-Framed Incentive Contracts

Reference dependence, that is, the behavioural tendency to evaluate potential outcomes relative to a reference point, has been shown to influence human decision-making (Rabin, 1998; DellaVigna, 2009; Kőszegi, 2014). Kőszegi and Rabin (2006) proposed a model that builds on, extends, and generalises ideas from prospect theory (Tversky & Kahneman, 1991). Specifically, the Kőszegi and Rabin (2006) model captures an individual's utility as consisting of two components:

[2] Where the technology is not proven, goal priming can be welfare reducing and ethically undesirable.

conventional consumption utility and the so-called gain–loss utility. Gain–loss utility emerges as outcomes deviate from a reference point, and loss aversion implies that the disutility of a loss is larger than the utility of an equivalent gain.

Formally, the Kőszegi and Rabin (2006) model assumes that utility depends on a consumer's k-dimensional consumption vector $\boldsymbol{c}$ and on a reference vector $\boldsymbol{r}$, as follows:

$$u(c \mid r) = \sum_k m_k(c_k) + \sum_k \mu\left(m_k(c_k) - m_k(r_k)\right). \tag{7.1}$$

Utility depends on two components, separable across dimensions. The first term on the right-hand side captures classical utility, or utility derived from consuming good k. The second term captures gain–loss utility, which is where reference dependence enters. Value function μ is defined as: $\mu(x) = \eta\, x$ for $x > 0$ and $\mu(x) = \eta\lambda x$ for $x < 0$. Parameter η is the weight attached by the consumer to gain–loss utility, and $\lambda > 1$ is the coefficient of loss aversion. The latter coefficient captures that utility losses associated with outcomes c_k below reference value r_k are greater than utility gains from equal-sized realisations more than that reference point.

Empirical application of the Kőszegi and Rabin (2006) model in agriculture is limited. Notable exceptions include Shikuku et al. (2023) in the context of fish trading, Balew et al. (2023) in the context of integrated pest management, and Bulte et al. (2020) in the context of labour supply. Shikuku et al. (2023) conducted a field experiment in which consumers could trade a known food item for a novel food item that was superior in terms of food safety or vice versa. They found that endowments matter for reference point formation but also documented a reverse endowment effect for a subsample of respondents. Expectations seemed to affect bidding behaviour for subjects "trading up" to obtain the food safety-certified food product, but they did not affect bids for subjects "trading down" to give up this novel food item. In the context of adoption of improved seed varieties, these findings possibly suggest that expectations-based reference dependence can be leveraged to nudge farmers to upgrade from traditional to modern varieties.

Consistent with the Kőszegi and Rabin (2006) model, can loss aversion be leveraged to increase effort provision in the diffusion of agricultural innovations? Studies seeking to answer this question focus on loss-framed incentive contracts. Such contracts involve incentives framed as losses from an earnings benchmark rather than as gains from a zero earnings default (Hossain & List, 2012; Imas et al., 2016). Leveraging loss aversion can increase labour supply. Bulte et al. (2020) exogenously allocated subjects to perform a real-effort task in either a bonus regime (with a bonus after completing a task) or a claw-back regime (where the reward was provided up-front but had to be returned in case of non-completion of the task). They found that the claw-back regime induced larger productivity increases compared to the bonus regime.

Consistent with the Kőszegi and Rabin (2006) model, Balew et al. (2023) combined incentives with loss-framed messaging to leverage loss aversion in the adoption of integrated pest management. Their experiment had five arms: (1) control (no incentives), (2) gain-framed private reward incentive, (3) loss-framed private reward incentive, (4) gain-framed social prestige incentive, and (5) loss-framed social

prestige incentive. Like BenYishay and Mobarak (2018) and Shikuku et al. (2019), Balew et al. (2023) found that incentives increased diffusion effort. In addition, their study showed that combining incentives with loss-framed messaging increased effort further. However, they also documented that "clawing back" up-front rewards is difficult in a real-life setting if there is a considerable period between the moment of payment and the moment of reckoning. The widespread applicability of claw-back regimes is therefore not evident.

5 More on Reference Points and Anchoring

Policymakers, firms, and NGOs sometimes promote the diffusion of innovations by temporarily subsidising them. These subsidies allow poor and cash-constrained farmers to try out new technologies and assess their effectiveness. The learning effect of temporary subsidies has been established in several domains, including health (Dupas, 2014), storage technologies (PICS bags; Omotilewa et al., 2019, and Shukla et al., 2022), and agricultural innovations (Balew et al., 2024). However, subsidies may also invite "anchoring" on the low (subsidised) price, inviting a loss in utility when the subsidy is lifted, and negatively affecting willingness to pay in follow-up periods. There is no robust evidence that subsidies invite anchoring (Shukla et al., 2022). However, anchoring does seem to occur after "full subsidisation", or when innovations are (temporarily) offered at zero cost like in the case of providing free small seed packs to induce demand for newly released crop varieties. There seems to be something special about zero-pricing. While zero-pricing can induce recipients to anticipate future subsidies, develop a sense of entitlement, and refuse to buy commercially, in the case of a new technology, this subsidy approach can "create awareness, help with the evaluation process—learning-by-doing—and provide information about the technology, thereby accelerating early adoption and the diffusion process" (Omotilewa et al., 2019). Both Shukla et al. (2022) and Balew et al. (2024) find that free provision of an innovation shifts the demand curve for that good inwards. Hence, free provision encourages hands-on experience with the technology, which fosters learning and updating of beliefs about the benefits of usage, but it also seems to cause anchoring. These anchoring and learning effects may pull in opposite directions, and the one that dominates is an empirical question. In the context of SSA where subsidy programmes are increasingly used to encourage technology use, learning effects imply that one-shot zero-pricing can induce sustainable adoption of technology. However, there is a need for policy implementation to include monitoring and evaluation to assess such programmes and ensure that anchoring effects do not dampen the learning effects.

6 Conclusion

While social learning holds promise in the strengthening of extension systems to increase the diffusion of agricultural innovations, it is important to incentivise effort provision in reaching out to neighbours. Relying on passive learning will not yield the desired results. Literature has shown that individuals selected to aid with the

spread of information respond to material rewards and social recognition. The productivity effect is larger for social recognition than for material rewards. Further, there is strong evidence indicating that individuals respond better to loss-framed incentives than gain-framed incentives. A few questions, however, remain for future research. First, empirical evidence is needed to document the persistence of the framing effect over time (most studies observe behaviour for short periods). Evidence about the effect of goal priming is still low. Even the study by Okello et al. (2023) looked at a bundled intervention comprising priming with social recognition. There is a need for studies that disentangle the effect of goal priming from that of other incentives. Given the narrow evidence base, future studies should focus on generating more evidence about the role of goal priming on effort provision in technology diffusion. Goal priming, where peer and lead farmers are carefully selected and enabled to set realistic goals, can be a useful social nudge to induce sustained effort provision in the diffusion of agricultural innovations. Agricultural extension strategies increasingly recognise the role of social learning and peer-to-peer technology transfer. Incorporating social nudges in the form of goal priming can provide a low-cost approach to enhancing the success of agricultural extension strategies in SSA.

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Part III

Extension, Communication, and Digital Nudges

8

Mobile Phone-Based Text Message Reminder Nudges and Agriculture Technology Adoption: Experiences from India and Kenya

Reddy S. S. Jayanth, Srinivasulu Rajendran, and Julius J. Okello

Abstract

Agricultural technology adoption remains a central challenge for improving productivity, food security, and rural livelihoods in developing countries. Despite the availability of improved inputs and farming practices, many smallholder farmers face information gaps, behavioural constraints, and limited access to extension services that slow the diffusion of agricultural innovations. Rapid expansion of mobile phone use has created new opportunities to deliver agricultural information at scale through digital extension tools such as text message reminders. This chapter examines the role of mobile phone–based text message reminder nudges in promoting agricultural technology adoption among smallholder farmers in India and Kenya. Drawing on policy initiatives, field experiments, and case studies, it analyses how SMS reminders influence farmers' adoption of digital tools and agricultural practices. This chapter compares experiences from the two countries, highlighting differences in institutional environments, digital ecosystems, and implementation strategies. It further explores how socioeconomic factors such as literacy, gender, and social group shape the effectiveness of these interventions. By synthesising evidence from both contexts, this chapter discusses the potential of SMS-based nudges as scalable and cost-effective complements to traditional extension systems, while also outlining key

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challenges and policy considerations for designing inclusive and impactful digital agriculture interventions.

Keywords

Mobile phone nudges · Agricultural technology adoption · Digital agricultural extension · Smallholder farmers · Behavioural interventions in agriculture

1 Introduction

Agricultural technology adoption is widely recognised as a critical driver of productivity growth, food security, and rural income improvement in developing countries (Abdulai, 2022; Krishna et al., 2019). In regions like India and sub-Saharan Africa (SSA), where agriculture employs a large share of the population, accelerating the uptake of improved seeds, fertilisers, irrigation methods, and good agronomic practices can substantially boost yields and resilience. For instance, agriculture provides livelihoods for over 80% of Kenya's population and 70% of its rural people while accounting for about one-third of the national GDP (FAO, 2025b). In India, although the Green Revolution enabled broad adoption of high-yielding crop varieties in the late twentieth century, the country still has over 82% of farmers classified as small or marginal (operating <2 hectares) (FAO, 2025a), and many of these farmers have yet to adopt newer innovations. Slow diffusion of modern technologies among smallholders contributes to persistent yield gaps and rural poverty (Krishna et al., 2019). Improving Agri-tech adoption is therefore a policy priority to ensure food systems in India and Africa become more productive and sustainable.

A range of strategies and interventions have been implemented to spur agricultural technology adoption. Traditional approaches include agricultural extension services, farmer field schools, demonstration plots, input subsidies, and credit programmes, which aim to provide farmers with the knowledge and resources needed to use new technologies. Studies have shown that well-designed extension interventions can significantly increase farmer knowledge and uptake of improved practices—for example, field demonstration days in eastern India led to higher adoption and large gains in farm income (Larochelle et al., 2019). However, conventional face-to-face extension is often costly and limited in reach, leaving many smallholders (especially those in remote or marginalised communities) with inadequate access to quality information (Arouna et al., 2021; Larochelle et al., 2019). In recent years, governments and development organisations have turned to information and communication technology (ICT) solutions to complement or substitute for in-person extension, given the rapid spread of mobile phones even in rural areas (Deichmann et al., 2016; Fabregas et al., 2019b; Steinke et al., 2021). Disseminating advice via radio, mobile phone calls, or text messaging has the potential to reach millions of farmers quickly and at a very low cost per person. Several public and private digital information initiatives have been deployed in emerging economies over the past decade (Abdulai, 2024; Camacho & Conover, 2019). These include

mobile apps, helplines, SMS advisory services, and interactive voice response systems that deliver agricultural information and reminders on demand.

Among ICT-based approaches, mobile phone text message reminders have gained attention as a simple but potentially effective tool to nudge farmers towards adopting beneficial technologies and practices. Text message "nudges" draw on insights from behavioural economics: they can serve as timely reminders that mitigate problems of inattention, procrastination, or forgetfulness, which often cause farmers to delay or forgo the implementation of new practices. By sending concise prompts or tips at key moments (e.g. at the beginning of the planting season or right before a fertiliser application is due), SMS reminders keep recommended actions salient. This is especially relevant in agriculture, where the benefits of new technology (e.g. an improved seed or conservation practice) may not be immediately obvious and where farmers face many competing demands on their time. Text messages can also reinforce and complement information farmers have previously received via training or demonstrations, thus acting as post-training follow-ups to improve retention and execution. Another unique advantage of text reminders is their scalability and cost-effectiveness: once content is developed, an SMS can be broadcast to thousands of farmers almost instantly at a cost of only a few cents or less per message (Roxanne, 2015). In India, the marginal cost of sending an agricultural SMS has been as low as $0.005, and in Africa, bulk SMS services also offer inexpensive rates, making this approach affordable for large-scale outreach. Moreover, SMS interventions can be personalised—messages can be tailored to a farmer's crop, location, or even language, increasing their relevance (Roxanne, 2015). Further, in Kenya, for example, the government uses personalised messages to send fertiliser subsidy vouchers to farmers, informing them of the number of bags they can collect and the fertiliser type. These features distinguish text messaging from more traditional extension methods and even from newer ICT channels like smartphone apps (which typically require internet access and higher digital literacy).

A growing body of research has examined the impacts of mobile phone-based agricultural advisories and reminders. Several randomised controlled trials (RCTs) have been conducted in recent years to rigorously test whether receiving agricultural text messages leads to changes in farmer behaviour. Results are somewhat mixed, suggesting that context and design details matter. In some cases, positive impacts have been observed: as noted, Larochelle et al. (2016) in Ecuador found higher adoption of pest management techniques with SMS reminders. Similarly, an advisory service for cotton farmers in India, which provided information via mobile (though through a voice hotline and callbacks rather than pure SMS), led to increased self-reported adoption of recommended inputs (Altenbuchner et al., 2016). On the other hand, a study of an SMS-based information service in India by Fafchamps and Minten (2012) found no significant changes in farmer practices or incomes, although it did improve knowledge of crop prices. A recent meta-analysis combining six RCTs in East Africa (Kenya and Rwanda) found that SMS reminders encouraging farmers to use an agricultural input (lime to reduce soil acidity) resulted in a modest increase in adoption (pooled odds ratio ~1.21) and knowledge, but these effects were not sustained into the following season once messages stopped (Fabregas

et al., 2019a). Interestingly, in that analysis, repeating the same messages multiple times had a statistically significant positive effect on adoption, whereas adding extra informational content (such as more detailed soil data or a hotline for questions) did not yield additional benefits. This implies that repetition and timely reinforcement may be more crucial for farmer behaviour change than the complexity of the information. Overall, the evidence suggests that text message interventions can lead to small but meaningful improvements in technology uptake, especially when they are low cost and reach large numbers of people. Even if the percentage change in adoption is modest, the high scalability means such programmes can be highly cost-effective on a per-farmer basis.

Randomised Controlled Trials
RCTs are experiments where participants are randomly assigned to a treatment or control group. This helps ensure that differences in outcomes can be confidently attributed to the intervention being tested, not other factors. They are widely used to measure causal impact.

Despite these encouraging findings, important questions remain about how well text-based nudges work across different contexts and populations. There is also a need to understand the social and demographic factors that influence the effectiveness of SMS reminders (Abdulai et al., 2023). Factors such as farmers' education levels, gender, or social group (caste/ethnicity) may mediate who benefits most from digital advisory services. For instance, if a farmer cannot read, a text message in written form provides little value—in Kenya, early SMS programmes discovered that low literacy among farmers was a major hurdle (Fabregas et al., 2019a; Ulmann, 2023). Gender is another key consideration: women farmers often have less access to mobile phones and tend to be excluded from traditional extension, so will they be reached or empowered by SMS initiatives, or will the digital gender gap cause them to lag? In India, women are 11% less likely to own a mobile phone than men (72% vs 81%) as of 2022 (Chakraborty, 2023), and this gap was even larger (over 40%) a few years ago (Moore & Sabherwal, 2017). In a few Kenyan households, women's phone use is mediated by male family members. Caste dynamics in India may also shape how information spreads—research has shown that socially disadvantaged castes have lower access to public extension services and benefit less even when they do access them (Krishna et al., 2019). These intersecting issues justify a closer look at how SMS-based interventions play out in the specific sociocultural environments of India and Kenya, which differ in important ways.

India and Kenya make for an enlightening comparison in examining mobile reminder nudges for agriculture. Both countries have large smallholder farming sectors and have invested in digital agriculture initiatives, yet their contexts vary in terms of infrastructure, culture, and institutional support. India has a far larger population and a history of state-led agricultural programmes (e.g. input subsidies and price support schemes), along with rapidly growing smartphone penetration in recent years. Kenya, often dubbed the "Silicon Savannah", has been an early adopter

of mobile technologies (most famously mobile money) and features a vibrant ecosystem of Agri-tech start-ups and public-private partnerships targeting farmers. Mobile phone ownership is widespread in both countries—about 1.14 billion mobile subscriptions in India (2023) and over 70 million in Kenya (2024), translating to penetration rates exceeding 90% of adults (including many who share phones) (FAO, 2025b; Gilbert, 2021). However, rural network connectivity and electricity access remain challenges in both countries, affecting the consistency of phone usage for agricultural purposes. By studying India and Kenya side by side, we can observe how text message reminder interventions are implemented under different governance structures and how factors like social groups or gender play a role in each setting. The objective of this chapter is to synthesise evidence and experiences from these two countries on using mobile text reminders to accelerate Agri-tech adoption, identify what has worked or not, and draw lessons for scaling up such interventions. In the sections that follow, we delve into the Indian case and the Kenyan case, and then compare the insights, before concluding with broader implications for policy and practice.

2 The Indian Case

2.1 Text Message Interventions in Indian Agriculture: Policy and Industry Perspectives

India's vast geography and farming population pose a perennial challenge for agricultural extension. Recognising the limits of traditional approaches, Indian policymakers and industry stakeholders have increasingly turned to mobile telephony to reach farmers with timely information. The Government of India launched the *mKisan* SMS Portal in 2013 as a flagship initiative under the National e-Governance Plan for Agriculture, explicitly aiming to leverage the "potent and omnipresent tool" of mobile phones for agricultural extension (MAFW, 2022). The mKisan platform enables government agencies, research institutes, and Krishi Vigyan Kendra (extension centres) to send free text advisories to registered farmers in their local language. As of mid-2019, the portal had sent over 24 billion SMS messages to more than 50 million farmers across India (MAFW, 2022)—an unprecedented scale of outreach. These messages cover a range of topics: weather forecasts, pest alerts, best practices for crop and livestock management, market price information, and announcements of government schemes. By pushing relevant information directly to farmers' phones, the government seeks to overcome the "last-mile" gap in extension delivery and create a more level playing field for small and marginal farmers.

Beyond government efforts, the private sector in India has also played a significant role in deploying text message-based agricultural services. One early pioneer was Reuters Market Light (RML), launched in 2007, which offered subscription-based SMS alerts on crop prices, weather, and agronomic advisories to farmers. RML demonstrated that farmers were willing to pay for tailored, reliable information—at its peak, hundreds of thousands of farmers subscribed. According to RML's

chief financial officer, the service showed direct benefits by increasing farmers' incomes and reducing uncertainties: prior to such services, Indian farmers typically received only 20%–25% of the end consumer price for their produce (vs. 40%–50% in developed markets), due in part to lack of timely market information. Mobile information services like RML helped narrow this gap by empowering farmers with knowledge of prevailing prices and better negotiation leverage. IFFCO Kisan Sanchar Ltd. (IKSL), a venture of the Indian Farmers Fertiliser Cooperative, is another prominent example. IKSL distributed special SIM cards to rural users that provided free daily voice messages and SMS tips on farming, reaching millions of farmers through a cooperative network (Smriti, 2024). In recent years, numerous Agri-tech start-ups have incorporated text messaging into their platforms—for instance, companies offering soil testing or precision advisory content often send SMS summaries of recommendations to clients, and seed or fertiliser companies use texts to share usage instructions or promotional offers with farmers.

India has about 0.1 extension workers per 1000 farmers (far fewer than recommended), and those agents often struggle to reach remote villages or women farmers. Mobile messaging provides a channel to deliver advice continuously without requiring farmers to travel or gather in one place (Caine et al., 2015). Government reports have lauded *mKisan* and related mobile services for widening the outreach of experts down to the block level (MAFW, 2022). However, challenges remain. Providers like RML learned that tailoring and relevance are key to sustained use. In fact, RML and others have emphasised improving specificity (e.g. pest alerts triggered by local weather events) and bundling information with other services like input purchase or insurance to enhance value for farmers. Low literacy and the many local languages in India also pose a hurdle—text messages must be in the local language and preferably succinct. In some cases, voice messages or call centres are combined with SMS to assist those who cannot read, as was done by IKSL and the government's Kisan Call Centre.

2.2 Impacts of Text Message Nudges on Agri-Tech Adoption in India

Recent studies, including field experiments, have begun to quantify the impact of text message reminders on technology adoption in the Indian context. Cole and Fernando (2018) evaluated a mobile advisory programme for cotton farmers in Gujarat, India. In that programme, farmers could call into a hotline for advice and receive periodic text or voice reminders about recommended practices. The research found that farmers who participated and received mobile advisories were more likely to adopt recommended agricultural inputs (like certain pesticides and fertilisers) compared to a control group without access to the service. This suggests that even in a setting with many traditional extension activities, the additional push from mobile-based reminders can lead farmers to try out new inputs or techniques they learned about. The exact magnitude of adoption increase varies by practice, but the direction was positive for most outcomes, indicating the intervention's success in nudging behaviour.

Reddy et al. (2022) evaluated the impact of text message nudges on the adoption and usage of a mobile farming application (Na Panta) and its subsequent effect on farm outcomes in rural India. A randomised controlled trial was conducted with 1006 farmers, half of whom received periodic SMS reminders to use the app. The results showed that these nudges significantly increased app adoption—farmers in the treatment group were much more likely to install and log into the app compared to the control group. However, the messages did not significantly increase the total time spent using the app, suggesting that while nudges encouraged frequent access, deeper engagement depended on content relevance. To measure economic impact, the study used instrumental variable (IV) methods, leveraging the randomised SMS assignment as an instrument for app usage. The findings revealed that higher engagement with the app led to lower expenditures on pesticides and fertilisers, implying that access to trusted, independent input-use information helped farmers avoid unnecessary spending. Furthermore, app users secured better prices for their produce—likely by using real-time market information to time sales and choosing better marketplaces. Notably, the depth of engagement (measured by time spent on the app) had a stronger positive effect on both input savings and price realisation than just frequent access. Interestingly, the study found that marginalised groups, such as Scheduled Caste farmers, benefitted significantly from app usage, suggesting that digital tools can act as social equalisers. However, women farmers continued to receive lower crop prices, highlighting the need for complementary measures to enhance gender inclusion in agricultural markets. Overall, the study demonstrates that simple text message nudges can increase digital tool adoption, and that mobile apps can enhance farmer profitability by improving input efficiency and market outcomes.

2.3 Heterogeneity in Adoption: Caste, Gender, and Education in India

India's rural society is heterogeneous, and the effectiveness of any intervention—including text message nudges—can vary across different segments of farmers. Across various studies, three socio-demographic factors stood out as influencing Agri-tech adoption: social groups (caste), gender, and education, as shown in Fig. 8.1.

Social groups: The caste system in India, though officially abolished in terms of discrimination, still manifests in rural communities in social networks and access to resources. Higher-caste (forward caste) farmers often have larger landholdings and better connections to extension agents or input dealers, whereas lower-caste groups (Scheduled Castes and Scheduled Tribes, and many Other Backward Classes) have historically been marginalised. We found that the baseline adoption of new technologies was lower among lower-caste farmers, likely reflecting less exposure to extension information and greater risk aversion due to fewer assets. More notably, the impact of the SMS reminders in our trial appeared somewhat smaller for lower-caste farmers (though the difference was not statistically large). One interpretation

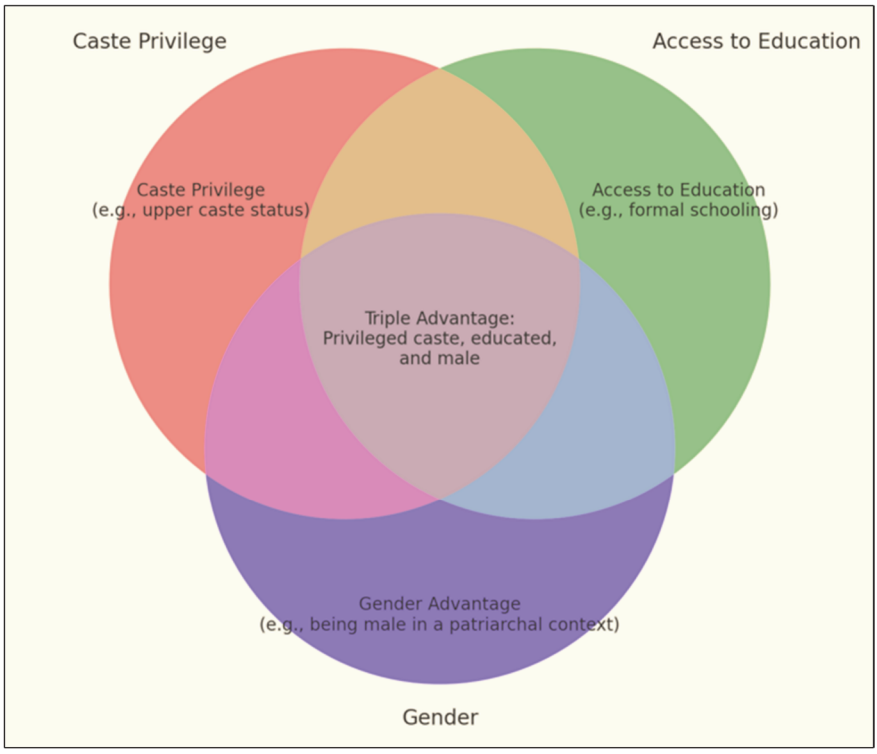


Fig. 8.1 Intersections of caste, education, and gender in India

is that lower-caste farmers may have harboured scepticism about the advice delivered via SMS if they perceived it as coming from an external authority that historically overlooked them. Social science literature supports the idea that caste-based segregation leads to uneven information diffusion—for example, marginalised castes have a significantly lower probability of accessing public extension services in India (Krishna et al., 2019). Even when they do receive information, they might be less able to act on it due to resource constraints. Krishna et al. (2019) noted that socially marginalised castes hardly benefitted from extension services in terms of income gains, even if they got the same advice as others. This indicates a need to customise interventions in a socially inclusive way—perhaps by involving local peer farmers or using trusted community figures to disseminate SMS content to lower-caste groups, thereby enhancing credibility and relevance.

What is Caste?
Caste is a traditional social hierarchy in India, where people are grouped by birth into rigid categories. These categories often determine one's occupation, social status, and access to resources, and continue to influence social and economic outcomes.

Gender: Gender disparities are pronounced in Indian agriculture. Women constitute a large proportion of farm labour, and many are de facto farm managers (especially in male-outmigration areas), yet they receive disproportionately little extension attention and often lack decision-making power over inputs. Mobile phone-based interventions risk exacerbating gender gaps if not carefully addressed, because women are less likely to own phones or to have unrestricted access to them (Hidrobo et al., 2024). This would likely contribute to a smaller direct influence of SMS on women's behaviour or knowledge. It raises the point that phone-based services must proactively include women, for instance by registering multiple household members or specifically targeting messages to women farmers' groups. Nationally, only about 38% of women farmers in India have ever used mobile phones to access agricultural information, compared to a much higher rate (51) for men (Moore & Sabherwal, 2017). The gender gap in mobile ownership (recently estimated at 11% nationally (Chakraborty, 2023), and higher in rural areas) means any digital extension approach must close this divide. Some positive efforts are underway: the government's mKisan portal allows a woman's name to be registered even with the husband's phone, ensuring messages are at least addressed to her; NGOs have tried donating phones to women self-help groups for collective use. Still, cultural norms in parts of India limit women's phone use—for example, women in certain communities must seek permission to use a handset, or husbands may monitor their incoming messages (Moore & Sabherwal, 2017). These realities imply that a simple SMS blast may not reach or empower women effectively.

Education: Farmer education and literacy level strongly influence the uptake of technology in general, and this was evident in our study as well. Farmers with at least a secondary school education adopted the recommended practices at considerably higher rates than those with little or no formal education. Education improves farmers' ability to process new information and reduces the cognitive barriers to trying unfamiliar techniques/experiment with new technologies (Krishna et al., 2019). Regarding the SMS nudges, literate farmers could read and comprehend the messages directly, whereas illiterate farmers had to rely on someone else (a family member or neighbour) to read the text aloud. In rural India, a sizable share of older farmers (especially women) remain illiterate—as of the 2011 census, only about 58% of rural women and 77% of rural men were literate (MOSPI, 2016). Not surprisingly, the positive effects of the SMS intervention on adoption are more pronounced among farmers with at least basic literacy. This does not mean SMSs are useless for others, but complementary measures (like pictorial messages via MMS or having village facilitators follow up) could enhance effectiveness for low-literacy audiences. The good news is that younger cohorts of farmers in India have higher literacy rates, and many can read SMSs (often in their local language script). Additionally, familiarity with phones is growing—even if some cannot read English, they can navigate phones to some extent. Nonetheless, education remains a key determinant: a farmer who understands why a practice is beneficial (thanks to education) is more likely to respond to a simple reminder about it.

Interaction effects: The three factors above often intersect. For example, in many villages, lower-caste farmers also have lower education levels and smaller, less

profitable farms, and women from those households face triple disadvantages. These intersectional farmers (low-caste, low-education women) were the least likely to adopt new technologies in our baseline data, and an SMS on its own may do little to change that without addressing underlying constraints. Reddy et al. (2022) observed that the farmers who reaped the most benefit from the text nudges tended to be relatively better-educated men of middle or higher-caste groups—essentially, those already somewhat privileged. This points to a risk that digital interventions could preferentially help those who are better off, potentially widening social gaps if no corrective action is taken. Policymakers should consider coupling SMS programmes with inclusive strategies, such as community readings of messages for all (to help illiterate members), or targeting extra support to marginalised farmers alongside the digital messages. On the positive side, mobile technology itself is becoming cheaper and more widespread, which could democratise information access. Unlike an extension officer who might unconsciously favour wealthier or higher-status farmers during farm visits, an SMS system does not inherently discriminate—everyone who is registered gets the same message. The task then is to get all groups registered and able to act on the information. In India, schemes to register women and marginal farmers into mobile advisory databases, and to develop audio/visual content for those with low literacy, are steps in the right direction. To raise the utilisation of information and increase the productivity of all groups, targeted interventions in input subsidy might be an option. Low resource endowment seems to be one of the most binding constraints. In Kenya, even though the fertilisers are highly subsidised, many poor farmers still keep away after receiving the message (voucher code) due to other related costs like transport from NCPB depots and delays. Having agents in local markets can really enhance the adoption.

Interaction Effect
An interaction effect in regression occurs when the impact of one independent variable on the outcome depends on the level of another variable/s. It shows that the combined effect of two (or more) variables is different from their individual effects.

3 The Kenyan Case

Agriculture continues to be a cornerstone of Kenya's economy, significantly contributing to its GDP, employment, and foreign exchange earnings. The agricultural sector employs over 70% of Kenya's rural population, constituting about 40% of the total population, and is responsible for about 65% of foreign exchange earnings, primarily from tea, coffee, and horticultural products (FAO, 2025b). Despite this significance, agriculture—particularly among smallholders—faces persistent productivity challenges. Approximately 80% of Kenyan farmers cultivate small plots (often less than 1 hectare, typically under 5 hectares) and predominantly engage in

semi-subsistence farming (FAO, 2025b; Walsh, 2018). Consequently, many of these farmers often become net buyers of food, indicating an underlying dependency on markets to supplement their consumption needs (ASFG, 2013).

In order to address various challenges of Kenyan farming, Information and Communication Technology (ICT)-based solutions have been promoted as potential remedies to information gaps and market inefficiencies. Kenya has a notable history of ICT-enabled agricultural interventions such as DrumNet, KACE, RATIN, NLMIS, and M-Farm, which were initiated primarily to bridge the informational divide faced by smallholder farmers. Mobile phone ownership in Kenya has surged, and network coverage has expanded. Affordable feature phones and smartphones have become available even in rural markets. Internet-enabled platforms such as *DigiFarm*, *Digicow*, *ViaziSoko*, *Tulaa*, *Twiga Foods*, and *Mkulima Young* have emerged, providing more comprehensive services ranging from market information, input supply linkages and e-commerce, credit and insurance, to digital extension services. *DigiFarm*, supported by Safaricom (Kenya's largest telecom operator), for instance, boasts over 1.4 million registered users and reports income increases of up to 40% for participating farmers (Langat, 2021). Through a mobile app and SMS system, *DigiFarm* offers input purchase on credit, weather alerts, tailored farming advice, and access to markets, all integrated with the *M-Pesa* mobile money platform for payments. This bundling of services represents a new generation of digital agriculture interventions that go beyond one-way information flow to interactive and transactional platforms.

However, despite a reported mobile phone penetration of around 90% (measured by SIM card subscriptions) in Kenya (Amboko, 2023), field observations suggest the prevalence of "phone sharing", where around 11% farmers might only possess SIM cards but regularly borrow phones for usage, indicating that actual access to a personal mobile device is lower than the subscription rate implies. This discrepancy, known as the issue of phone access versus ownership, complicates the notion of uniformly high mobile penetration. It suggests that while nearly every adult might be *reachable* via some phone, not everyone has the same ease of access to mobile services whenever needed. For example, a household may have one mobile handset that is primarily with the male head of house, while the wife uses it only occasionally. Or a farmer may own a SIM card (to maintain a phone number for mobile money) but not a handset, instead inserting their SIM card into a friend's phone when they need to transact. These realities mean that any mobile-based intervention must account for shared usage patterns—for instance, important SMSs might be missed or delayed if the phone is not always in the farmer's possession. Such intervention should also recognise that phone ownership and access differ significantly between men and women, as shown in Fig. 8.2.

Literacy remains another critical barrier to effective use of mobile phones for agricultural information dissemination in Kenya. Initially, text messages were the primary method of information transmission, which disadvantaged farmers unable to navigate text-based content due to low literacy. Despite an average of about 8 years of schooling among Kenyan farmers (reflecting completion of primary education on average), a significant portion still struggles with basic phone operations

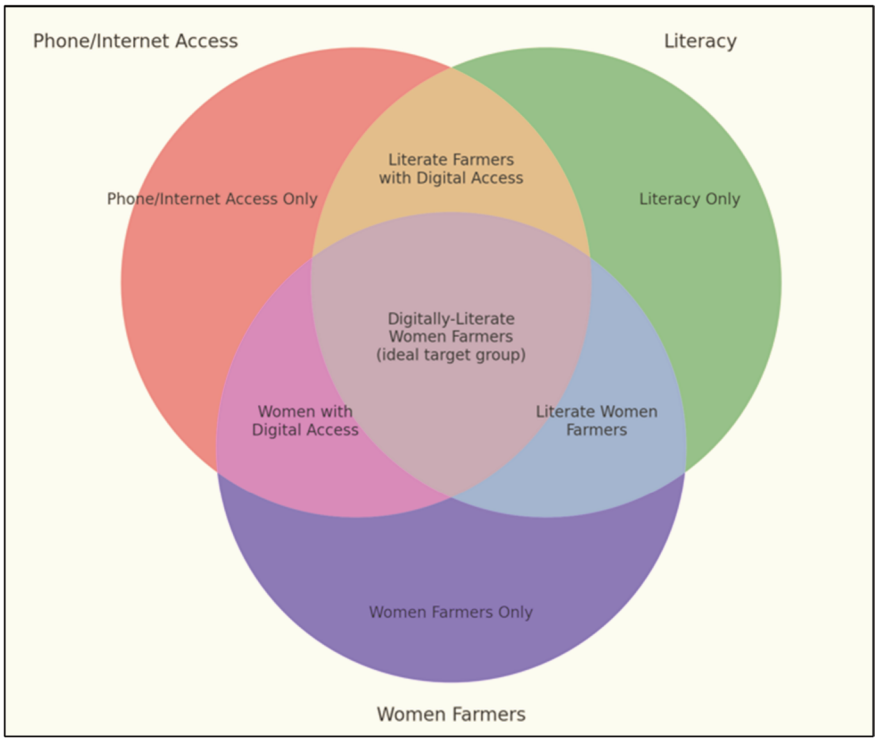


Fig. 8.2 Intersection of phone/internet access, literacy, and women farmers in Kenya

and reading lengthy texts. Recent research reaffirms that literacy issues remain a substantial impediment even among farmers with relatively higher educational attainment. This indicates that literacy constraints persist alongside infrastructural limitations such as inconsistent electricity supply, particularly in remote areas.

Gender dynamics further complicate mobile phone use in Kenyan agriculture (Zougmoré & Partey, 2022). Studies consistently show a gender divide in phone ownership and usage. Women generally have less access to the financial resources necessary for phone purchase and airtime, leading to lower phone ownership rates compared to men. Cultural practices and intra-household power dynamics often exacerbate this divide, with women facing explicit restrictions on phone ownership or usage controlled by male household members. Consequently, women's ability to benefit fully from mobile-based agricultural services remains limited, highlighting the critical need to address these gender-specific barriers in technology interventions. In Kenya, it has been reported that women are about 27% less likely than men to own a mobile phone (Poole, 2024), a gap that digital development programmes are striving to close through initiatives like providing smartphones on flexible payment plans to women (such as M-KOPA's programmes).

The Kenyan experience is exemplified by a recent case study of a mobile phone-based intervention to promote the adoption of orange-fleshed sweet potato (OFSP),

a biofortified crop high in vitamin A. This intervention, implemented in western Kenya to combat vitamin A deficiency, utilised a randomised controlled trial (RCT) design to test the impact of phone-based nudges (text message reminders) in combination with nutritional education. Farmers in the study were divided into groups: one received text message reminders only to encourage planting and consuming OFSP (Treatment 1), a second group received text reminders plus branded educational materials for children (to create demand for OFSP among preschoolers, Treatment 2), and a third group received an integrated package of text nudges with nutrition education materials targeting both caregivers and children (Treatment 3). A control group received no intervention. The expectation was that the nudges would significantly increase both cultivation and consumption of OFSP, given that farmers often forget or neglect new vitamin-rich crops without prompts, and that engaging children might further spur households to grow OFSP for their benefit.

The results, however, showed nuanced findings. Counterintuitively, the study found lower cultivation rates of OFSP among the treatment groups compared to the control group. In the season following the intervention, 82% of control group farmers planted OFSP (likely due to prior promotional programmes and availability of vines in the area), whereas only 57% of those who received text-only nudges (Treatment 1) planted OFSP. In other words, the group receiving just SMS reminders had a substantially lower adoption rate than even the no-intervention group. This unexpected outcome suggested that the text messages alone might have been insufficient to motivate new planting, or possibly even caused some complacency or confusion. On the consumption side, the nudges alone did improve OFSP consumption modestly among those who had it, but the major gains were seen in the group that received both nudges and child-focused nutrition education (Treatment 3). In that integrated treatment, both cultivation and consumption of OFSP rose significantly. Caregivers who received educational storybooks and materials for their preschool children, alongside the farming reminders, were much more likely to grow OFSP and incorporate it into family diets. The combination of approaches appears to have reinforced the value of the crop from both the production and consumption angles—the text messages prompted agricultural action, while the child education component created a pull factor (children asking for the sweet potato, or mothers prioritising it for health). Treatment 2 (nudges plus materials only for children) fell in between: it had some positive effect, but less pronounced than Treatment 3, which involved both generations.

This Kenyan OFSP case demonstrates the necessity of combining informational nudges with complementary strategies to effectively stimulate agricultural technology adoption. A pure SMS approach, in this instance, did not yield the expected outcome and was even associated with lower planting rates, possibly due to behavioural or contextual factors that need further investigation (such as message fatigue, misinterpretation, or farmers' expectations of receiving free inputs, which did not happen). However, when the SMSs were integrated with an educational intervention that addressed underlying attitudes and knowledge (nutrition education in this case), the results were much more favourable. The significant improvements in OFSP adoption and vitamin A intake in Treatment 3 suggest that tackling both supply and

demand-side constraints—providing reminders to plant and fostering desire/knowledge to consume—is crucial for success.

While mobile phone penetration appears high in Kenya and digital innovations are proliferating, practical realities indicate substantial barriers to usage for agriculture-related activities. Phone sharing practices, low literacy levels, infrastructural constraints (like inconsistent electricity), and significant gender disparities all temper the optimistic outlook for purely mobile-based solutions (FAO, 2025b). ICT-based interventions, although promising in theory, must address these socioeconomic, educational, and cultural barriers comprehensively to realise their full impact. The case of OFSP adoption via text nudges in Kenya underscores that technology nudges alone may be insufficient unless supported by complementary measures that address behavioural and informational gaps. Integrated strategies—combining mobile messaging with on-the-ground education, trust-building, and perhaps incentives—emerge as critical for promoting agricultural technology adoption among smallholder farmers in Kenya.

4 Comparison Between Indian and Kenyan Cases

Having examined the Indian and Kenyan experiences separately, we now compare these cases across several dimensions: agricultural landscapes and challenges, technology adoption trends, use of mobile phones in agriculture, the role of government versus private sector in digital interventions, and the socioeconomic factors affecting adoption. This comparative lens highlights both common themes and context-specific differences that inform the design of mobile reminder programmes.

4.1 Agricultural Landscape and Key Challenges

Both India and Kenya have agrarian economies with a large base of smallholder farmers, but the scale and context differ markedly. Landholding patterns: India has about 146 million operational holdings with an average size of only 1.08 hectares (RBI, 2019), and 86% of these farms are small or marginal (<2 ha) (Saini & Chowdhury, 2023). Kenya, similarly, is dominated by small farms—over 80% of farms in Kenya are smaller than 1 hectare (especially in densely populated regions) (Walsh, 2018), and typical smallholder plots average ~0.5 ha. Thus, fragmentation and small-scale farming are common in both, which can limit mechanisation and economies of scale. However, the total area under cultivation and variety of agro-ecological zones is far greater in India, ranging from irrigated plains to rainfed areas, whereas Kenya's arable land is more concentrated, mainly rainfed and much of the country is arid/semi-arid.

Contribution to the economy: Agriculture's share of GDP has been on a declining trend in both countries but remains significant. In India, agriculture accounted for about 23% of GDP and 59% of employment in 2016 (CABI et al., 2025; FAO, 2025a) (and about 18% of GDP, 42% employment by 2019). In Kenya, agriculture contributes roughly 33% of GDP directly (and up to 60% if including

agro-processing linkages) and employs 40% of the total population (FAO, 2025b). Both countries therefore rely heavily on agriculture for livelihoods, especially in rural areas (where ~70% of people in India and ~72% in Kenya reside). A key difference is that India is now a food-surplus country in staples (with over 275 million tons of grain output), whereas Kenya often struggles with staple self-sufficiency (e.g. frequent maize shortages) and relies on imports for certain commodities. This ties into productivity and adoption gaps.

Productivity constraints: Indian agriculture benefitted from the Green Revolution, achieving high adoption of improved wheat and rice varieties in irrigated belts, which boosted yields in those regions. Yet, many rainfed areas in India still have low yields and slower adoption of innovations. Kenya did adopt hybrid maize early (with adoption rates of around 70% by the 1990s in some areas), but national average yields for maize remain around 1.6–2 tons/ha, much lower than India's average maize or rice yields (x t/ha). The challenges outlined in Kenya—input costs, information asymmetry, credit constraints, climate variability—are *also present in India*, but perhaps to different extents. For example, Indian farmers face high input costs too, but many receive fertiliser subsidies and have government procurement at Minimum Support Prices (MSP) for certain crops, providing some cushion. Kenyan smallholders operate more in open markets and are very exposed to price fluctuations. There is now a government programme (Esubsidy) aimed at ensuring that registered farmers have access to subsidised fertilisers (current KES 2500 for 50-kg bag). Market price ranges from KES 6000 to KES 7000. The programme registers farmers and their farm acreage to determine quantities of fertiliser to allocate. Fertiliser type depends on the area and season. Farmers in Nyandarua county receive planting and topdressing fertilisers for both potatoes and maize.

Key constraints for adoption: The motivation for introducing text message nudges in both countries stems from similar recognition of constraints—farmers not adopting improved technologies due to lack of information or behavioural biases. In India, a lot of technology (new varieties, practices) is developed by research institutes, but dissemination is a bottleneck. In Kenya, technologies suitable for smallholders (like OFSP, disease and pest-tolerant varieties, or fertiliser micro-dosing, or lime for acidic soils) exist, but getting farmers to become aware and try them is a hurdle amid the other aforementioned constraints. Thus, the core challenge that mobile reminders seek to address—the knowledge/attention gap—is common. However, the baseline awareness and institutional support differ: Indian farmers often have some contact with extension agents (though limited), and there are national campaigns for certain practices (e.g. soil health cards, or Swastha Kisan for training). Kenyan farmers, due to structural adjustment in past decades, have fewer government extension agents on the ground, so ICT services are trying to fill more of a void.

Knowledge-Attention Gap
The knowledge-attention gap refers to the disconnect between what people know and what they pay attention to. Even when individuals have access to useful information, they may ignore or forget it due to distractions, low motivation, or competing priorities.

Another difference is the market structure. Indian farmers selling staples have a network of regulated APMC markets and often government procurement (for rice/wheat)—while far from perfect, this system provides price information and a buyer of last resort. Kenyan farmers historically lacked such guaranteed markets, facing more volatility—one reason why digital platforms like *Twiga* or *DigiFarm* that aggregate farm output found fertile ground in Kenya. For adoption, this means Kenyan farmers might be hesitant to adopt a new crop without market assurance, whereas Indian farmers might adopt if they know the government will buy it (e.g. many Indian farmers rapidly adopted pulses or oilseed varieties when government announced procurement schemes). Text reminders in Kenya might need to be coupled with assurances of market opportunities to succeed, whereas in India, reminders might focus on optimal input use to increase yields for self-consumption and local sale.

APMC Markets
APMC (Agricultural Produce Market Committee) markets are government-regulated marketplaces where farmers sell their produce to licensed traders. Set up to ensure fair trade and protect farmers from exploitation, these markets often control who can buy, sell, and set prices within their jurisdiction.

4.2 Technology Adoption Trends in Agriculture

In terms of overall technology adoption, Indian agriculture has seen significant progress in some domains (near-universal adoption of high-yielding varieties in irrigated areas, widespread use of fertiliser, and increasing mechanisation such as tractors and harvesters in many states). Yet, adoption of more advanced or sustainable technologies (like micro-irrigation, precision farming, organics, or new climate-resilient crops) remains uneven. Government programmes often drive adoption by subsidising certain technologies—for example, drip irrigation systems are heavily subsidised, leading to higher uptake in states like Gujarat and Maharashtra, but less so elsewhere. In Kenya, adoption of basic Green Revolution inputs like hybrid seed and fertiliser has improved over time (thanks in part to programmes like subsidised input vouchers in the 2010s), but many smallholders still use traditional seed varieties or insufficient fertiliser due to cost. The six RCT meta-studies mentioned earlier in Kenya/Rwanda found that even when farmers were repeatedly nudged to use lime and fertiliser, the actual adoption increase was modest.

One noticeable trend is that Kenya's farmers have been quicker to adopt some digital or fintech solutions (like mobile money for agriculture, digital credit for inputs) compared to Indian farmers. The success of *M-Pesa* in Kenya has spilled into agriculture: many Kenyan farmers use mobile money to pay for labour and veterinary services, buy inputs or receive crop payments (Elliott, 2018). In India, only recently with widespread smartphone use and UPI payments are farmers beginning to use digital payments more. This means Kenyan mobile interventions can

often integrate financial services (credit, payments) more seamlessly, which might encourage adoption of technologies by easing financial constraints. *DigiFarm's* model of offering input credit and sending SMS reminders to use the inputs is a good example—it addresses both access and knowledge gap. India has some examples (e.g. e-wallets for fertiliser subsidy), but generally, the financial inclusion of farmers via phones is still evolving. Another difference is the variety of languages and content localisation. India's linguistic diversity means any large-scale SMS campaign must translate messages into multiple languages (Hindi, Bengali, Telugu, Marathi, etc.), whereas in Kenya, most farmers can understand either Swahili or English to some degree (with Swahili being the lingua franca for rural messaging). This makes implementation a bit simpler in Kenya language-wise, but literacy in English can be an issue for older farmers, so using Swahili is key. In our review, we saw that Indian services like *mKisan* take care to send messages in the local language chosen by the farmer (PIB, 2022). This adds a layer of complexity and could affect adoption—if a message accidentally goes out in a language the farmer is not fluent in, it is lost. Kenya's relative linguistic unity (plus some use of local languages like Kikuyu or Luo in certain areas) might give an edge in communication consistency.

Technology adoption trends show that both countries have a mix of successes and gaps. Text message nudges are more likely to work when they complement an existing trend (e.g. remind farmers to use inputs they already believe in) rather than trying to single-handedly create demand for an entirely new practice that may not yet be culturally or economically accepted (as seen in the Kenya OFSP example). The comparison suggests that interventions should be tailored: in India, nudges might focus on improved timing and dosage of inputs for known technologies (since access exists but usage efficiency is an issue), whereas in Kenya, nudges might be used to encourage initial trial of relatively newer improvements (like lime or improved seed) coupled with support to obtain those inputs.

4.3 Use of Mobile Phones and Digital Solutions in Agriculture

Mobile phone use in agriculture has grown in both India and Kenya, but Kenyan smallholders arguably rely on mobile services more directly for lack of alternative infrastructure. Mobile penetration: India has over 1.2 billion mobile connections, but many rural farmers until recently only had basic phones and often limited connectivity. With smartphone proliferation (India has an estimated 750 million smartphone users as of 2023), app-based Agri-platforms (market linkage apps, weather apps, etc.) are becoming popular among younger, progressive farmers (Kumar, 2023). Kenya's mobile penetration by SIM cards is even higher (over 90% of adults), and feature phones are common; smartphone adoption is lower than in India in absolute numbers but fairly high relative to population (about 53% of Kenyan farmers in a 2018 survey owned a smartphone) (Elliott, 2018). Kenyan farmers have embraced services like WhatsApp groups for farmer discussion, mobile banking,

and even YouTube for learning farming techniques (Kumar, 2023). Indian farmers too use WhatsApp extensively for exchanging farming tips and market info, and the government has launched apps like *Kisan Suvidha* and *e-NAM* for market access.

A key difference is mobile money and payments integration: In Kenya, mobile phones are a tool not just for information but for transactions—paying for inputs and veterinary services, receiving crop sale proceeds, saving and borrowing money (e.g. via *M-Shwari* or *DigiFarm* loans). This integration means digital agricultural platforms in Kenya can close the loop from advice to action: for example, send an SMS about an improved seed, include a mobile link to order the seed on credit, and then confirm via SMS pickup details. In India, mobile payments in agriculture lag—many farmers still deal in cash for inputs and crop sales, though that is changing post-demonetisation and with UPI. The difference in digital financial inclusion can affect adoption: Kenyan farmers might adopt a new tech if an easy mobile loan is attached, whereas Indian farmers might need a subsidy or cash credit from a cooperative.

Digital public goods versus private innovation: India's approach heavily features government-driven ICT solutions (like *mKisan*, commodity price portals, etc.), which are provided as a public good free to users. Kenya's scenario has more private or NGO-led digital services (Safaricom's *DigiFarm*, *AgriFin* by Mercy Corps, One Acre Fund's digital extension, etc.), often requiring some form of payment or commercial sustainability model. The presence of profitable telecom companies and start-ups in Kenya has spurred innovation, while in India, big telecoms (e.g. Reliance Jio) have only recently started focusing on rural/Agri content (Jio has a farming app, but it is still new) (GRAIN, 2021). This means Kenyan farmers might have multiple competing platforms to choose from, whereas Indian farmers receive a lot of messages from one centralised source (the government), which can be both a strength (standardised quality) and a weakness (lack of personalisation or innovation).

Extent of use: Survey data indicate that word of mouth remains the dominant information source for farmers in both places, despite the growth of mobile services. A GeoPoll survey in Kenya found that even among mobile-phone-owning farmers, most still cited other farmers and agricultural officers as their primary information sources, rather than mobile apps or social media (Elliott, 2018). Similarly, Indian farmers often trust input dealers or progressive neighbours more than an anonymous SMS. This underlines that mobile solutions are not yet the primary mode of agricultural advice uptake; rather, they complement existing channels. Over time, as digital-native younger farmers take over, this might shift. Mobile phone usage in agriculture is high and rising in both India and Kenya, but Kenya leads in integrating phones into the full cycle of farming operations (information, finance, market access), whereas India is catching up on the digital integration front but currently uses phones largely for disseminating information and advisories. Both cases show that simply providing information via mobile is not enough—it must be intertwined with the means to act on that information.

4.4 Role of Government and Private Sector in Promoting Digital Interventions

The role of government versus the private sector in digital agriculture interventions differs significantly between India and Kenya, shaping how text message programmes are implemented and scaled. In India, the Ministry of Agriculture's investments in platforms like *mKisan*, numerous state government initiatives (such as *eSagu* in Andhra Pradesh in the 2000s, or various state-level SMS alert systems), and public sector research organisations developing content all indicate that the public sector sees digital extension as an extension of its mandate. This top-down approach means funding is often not an issue for sending millions of messages (as evidenced by billions of SMSs sent for free to farmers; MAFW, 2022). The government also enlists state agricultural universities and Krishi Vigyan Kendras to generate locally relevant content, ensuring some scientific credibility. On the flip side, government systems can be less agile; content might be generic, and there is sometimes duplication (multiple agencies sending similar messages). There have been PPPs too—for example, the government partnering with private telecom providers for outreach or with NGOs like Digital Green to use mobiles for training dissemination. The private sector in India has innovated at the margins: agribusiness companies using SMS for extension marketing (fertiliser companies sending tips to product buyers), or start-ups creating farmer networks. But often, scale for private ventures is a challenge due to the willingness-to-pay issue—small farmers have low ability to pay for information services. Many private projects therefore rely on donor or CSR funding (as RML initially did via Reuters, or IKSL via IFFCO's cooperative structure).

In Kenya, the government's direct role has been relatively limited in digital extension until recently. The agricultural extension function was devolved to county governments (FAO, 2025b), and while there is policy recognition of ICT (e.g. in Kenya's Agricultural Sector Development Strategy), resource constraints mean most county extensions do not have sophisticated SMS systems of their own. Instead, Kenya's success stories are often public-private partnerships or fully private ventures. For instance, *DigiFarm* is a partnership involving Safaricom (private telecom), iProcure (a private input supplier), and government endorsement but not direct operation. *M-Farm* was a start-up by young entrepreneurs providing price information via SMS on a subscription basis. One Acre Fund (an NGO) and Precision Agriculture for Development (PAD) have collaborated with the Kenyan government research institute (KALRO) but essentially drive SMS programmes through donor support. The advantage of private sector leadership is innovation and user-centric design—Safaricom, for example, conducted user research and found ways to bundle services that farmers need (Langat, 2021). They also heavily marketed *DigiFarm*, which led to rapid uptake especially during COVID-19 as noted. The private sector is also more active in addressing last-mile issues by leveraging its networks (e.g. Safaricom setting up *DigiFarm* depots in villages for input distribution, as per the Reuters piece). The limitation is that private models need revenue: *DigiFarm* can justify free SMS because it earns from input sales and loan interest.

But not all beneficial practices can be monetised easily, so purely private models might neglect important advisory content (like soil health advice) that does not generate revenue. This is where NGOs or donors step in; Mercy Corps' *AgriFin* has funded content development for *DigiFarm* on good farming practices, essentially subsidising the public good aspect.

The Kenyan government, recognising the importance, has started to collaborate more—for example, during the pandemic, the Ministry of Agriculture worked with Safaricom and other telcos to send SMS blasts about food supply chain coordination. They have also considered zero-rating some farmer SMS services (making them free for users). In India, conversely, the private sector is now piggybacking on government infrastructure—for example, some start-ups use the *mKisan* database to reach farmers with permission, or telecom companies working with state governments to implement localised SMS schemes for weather insurance, etc. Trust and credibility also differ. In India, a message coming from a government source may carry authority (farmers might think "this is from the agriculture department, I should heed it")—although if overused, it can also be seen as spam. In Kenya, farmers might trust Safaricom's brand or a known NGO more than a government SMS, simply because they have seen these services deliver value (like *M-Pesa's* trust spilled to *DigiFarm*). The text of messages in Kenya often mentions partnerships (e.g. "from KALRO and One Acre Fund") to give credibility. In India, messages sometimes include the name of the agricultural university or KVK.

Policy environment: India's policy explicitly pushes for a "Digital Agriculture" mission, with huge government budgets earmarked for Agri-digitisation and even plans to create farmer databases linked to their mobile numbers for personalised advisories. Kenya's policy environment encourages private innovation and seeks to create enabling conditions (like improving rural network connectivity, partnering in ICT projects). Both governments see the value, but the execution model differs. Overall, India leans more towards public sector-driven digital extension, whereas Kenya relies more on private sector innovation and PPPs. Both approaches have merits: India achieves massive reach through public funding but must work on content quality and engagement; Kenya achieves high innovation and potentially better services through competition and business models but must ensure inclusivity and coverage of non-commercial topics. For text message reminder programmes, scaling approaches differ by country: in India, implementation often involves working closely with government channels—such as through partnerships like PAD that distribute messages via official systems. In contrast, in Kenya, programmes are more likely to scale by collaborating with telecom providers or Agri-tech companies to disseminate the messages.

4.5 Socioeconomic and Cultural Factors Affecting Adoption

Several cross-cutting socioeconomic and cultural factors affect technology adoption in both India and Kenya, some of which we touched on earlier: literacy, gender norms, social structure (caste/ethnicity), and trust in information sources. Both

countries show that lower education can impede the benefits of text-based interventions. In Kenya, adult literacy ~78% is actually a bit higher than India's ~75%,[1] and English/Swahili proficiency is decent among many Kenyan farmers, yet the complexity of text messages can still alienate less educated farmers. In India's rural areas, literacy is low especially among women and older generations and many cannot read SMSs at all (MOSPI, 2016). Thus, the necessity of simplifying language and possibly using voice alongside text is common to both. However, cultural attitudes towards education differ: In Kenya, most farmers value formal schooling, and younger family members often assist elders with phones—rural youth act as intermediaries in ICT usage (Elliott, 2018; Lambrecht et al., 2023). In India, there is also a trend of youth helping elders, but where entire households are illiterate, an SMS campaign might totally miss impact. Both contexts highlight that education increases the likelihood of adoption, which is not surprising as it correlates with understanding and agency.

Gender roles in agriculture have similarities—women are crucial contributors in the production process but have less access to resources. In Kenya, women's land ownership is low and societal norms sometimes restrict women's use of phones. In India, many women farmers are not even recognised as "farmers" in official terms due to land being in men's names, and patriarchal norms can limit their decision-making. A difference might be in community organisation: Kenya has the concept of "chamas" (women's savings groups), which some interventions (like M-KOPA's initiative) leverage to reach women with technology and finance (Poole, 2024). India also has women's self-help groups (SHGs) and cooperatives that are used to disseminate agri-information via mobiles (e.g. community WhatsApp groups for women farmers). So culturally appropriate channels differ, but the underlying issue is the same—unless specifically targeted, women may be left behind by tech interventions. For instance, the Kenyan OFSP study and our Indian study both had to consider how women would receive the SMSs or be influenced by them, often concluding that supplementary approaches (like including nutrition messaging targeted at women or children) were needed. Household dynamics play a role: if a husband receives an SMS, will he convey it to his wife who does much of the farm work? Or if an SMS suggests a practice that increases women's labour (like hand-weeding), the household might be reluctant.

Social networks and trust (Caste and ethnicity): We discussed caste for India—it creates in-groups that trust each other and possibly mistrust outside advice. In Kenya, while there is no caste system, there are ethnic communities and local social networks that matter. Farmers often trust information shared by someone within their community or spoken in their mother tongue. For example, a Luo farmer might respond better to an audio message in Dholuo by a local expert than a Swahili text from Nairobi. In India, a lower-caste farmer might trust an NGO worker from their community more than a government officer from a higher-caste background. Social network effects on adoption have been documented: farmers observe their peers and

[1] Retrieved from https://countryeconomy.com/demography/literacy-rate.

emulate successful innovations. Local emulation: In Kenya, radio shows sometimes highlight local farmer champions.

Economic factors: Poverty and risk aversion are prevalent among smallholders in both countries, and these influence adoption. Even if information is provided, a farmer with tight finances may not adopt new tech without some guarantee or support. This is why adoption rates can be low if the tech requires upfront cost (like fertiliser or a new seed variety). Both governments and private initiatives have used subsidies or trial packs to reduce risk (e.g. giving free sample seeds along with SMS advice to try them). Without affordability, reminders alone might not tip the balance. The Kenyan integrated approach that combined credit via mobile and advice is one model to address this. In India, the government often subsidises the product and then uses SMS to instruct on its use—a synergy of economic and informational intervention.

Cultural attitudes towards change: Some farming communities have conservative attitudes, preferring traditional ways, while others are more open. Often this correlates with education and exposure. Kenyan farmers who are in areas with NGOs or projects might be more used to trying new things (Western Kenya, with many trials, vs. perhaps remote pastoral communities). Indian farmers in progressive states like Punjab or Maharashtra might be quick to adopt mechanisation or new hybrids, whereas more isolated tribal communities might stick to known varieties unless trust is built. Cultural receptiveness can affect how effective a generic SMS will be. If there is scepticism or superstition around a new technology, a simple message may not overcome that. Therefore, both cases highlight the need to build trust and demonstrate results in addition to messaging. One cultural aspect is the role of youth. In Kenya, a lot of rural youth are turning away from farming, but those who stay are often eager to use technology (smartphones, agribusiness ventures). They could be champions for digital adoption. In India, youth are also increasingly tech-savvy, and some are returning to or staying in agriculture with a business mindset, using apps and YouTube learning. Engaging these youth could accelerate adoption, and they can influence elders.

5 Discussion and Conclusion

The comparative analysis of mobile text reminder nudges in India and Kenya yields several important insights. Despite differences in context, a number of common threads emerge regarding what makes such interventions work (or not work), and what challenges must be overcome to scale them up effectively. In this concluding section, we discuss key themes including the role of trust, private sector contributions, environmental factors, scalability issues, and policy recommendations for the way forward.

Trust: Trust is a fundamental currency in the adoption of any new technology or practice. Farmers need to trust the information source and the recommended technology itself before they act on advice delivered via text. Both India and Kenya illustrate that digital messages do not exist in a vacuum—they are interpreted

through the lens of farmers' prior beliefs and experiences. If an SMS comes from a source perceived as credible, farmers are more likely to pay attention. In India, the official approval of the government or a known agricultural institute can lend credibility to an SMS advisory, but conversely, some farmers may distrust government messages due to past disappointments or a top-down tone. In Kenya, where much agricultural information has come through NGOs or private companies, building trust involves showing farmers that the service has their interests in mind. Empirical studies in other domains have found that trust moderates technology adoption—for instance, farmers adopt digital tools when they trust the performance of the technology and the adviser recommending it (Yeo & Keske, 2024). Our cases affirm this: the Kenya OFSP trial showed that text nudges alone, without an accompanying trusted educational component, did not yield adoption; but when mothers and children were engaged through a trustworthy educational narrative, the intervention clicked. Therefore, a key lesson is that interventions should cultivate trust, perhaps by involving local extension officers in follow-up (so farmers can verify messages with a person), or by sending occasional success stories of fellow farmers (peer endorsement). Designing messages that are empathetic and farmer-centric can also help. Over time, consistent, useful content will build credibility—if a few recommendations prove helpful, farmers will be more receptive to future messages.

Contribution of the Private Sector to Mobile-Based Agricultural Interventions: The private sector has emerged as a crucial player in advancing mobile agriculture interventions, as seen especially in Kenya but increasingly in India too. Private initiatives often bring in innovation, efficiency, and scalability, leveraging business models that can sustain the service. For example, Safaricom's *DigiFarm* in Kenya bundles advisory SMS with input sales and credit, aligning social impact with their revenue model—as a result, they have a stake in ensuring the advice leads to adoption (so farmers prosper and continue using their platform). The advantage of private sector involvement is the agility to iterate on services based on user response, the use of modern analytics (big data from mobile usage) to personalise content, and the deployment of marketing strategies to increase uptake (e.g. promotions, referral incentives, etc., which governments typically do not do). In India, while government dominates, private telecom operators like Reliance Jio have started investing in farmer-centric content (*JioKrishi app*) and could in the future send nudges to their large rural subscriber base (GRAIN, 2021). Agribusiness companies also have an interest—for instance, a fertiliser company might send SMS reminders to use their product correctly, which simultaneously serves the farmer (proper use) and the company (encouraging purchase/continuous use). We should acknowledge, however, that the private sector alone might not cater to all farmers. They will focus on areas and crops that are commercially viable. Resource-poor farmers or low-value crops might be neglected without public intervention. Therefore, public-private partnership (PPP) is an attractive model: the government or donors can fund the inclusion of marginal farmers and public good content, while private players execute and maintain the service. Another point on the private sector is the SMS as a gateway to other digital services—once farmers get comfortable with receiving texts, they might move up the digital ladder (to using apps, etc.). Private companies

often have the ecosystem (devices, network, apps) to support that journey. Policymakers should thus not view private tech companies warily, but as essential collaborators to achieve scale and innovation in delivering extension via mobiles.

Environmental and Climatic Factors Affecting Technology Adoption: Climate and environmental factors increasingly frame the context in which adoption decisions are made. As weather patterns become more erratic, the need for farmers to adopt climate-smart technologies (drought-tolerant varieties, water-saving methods, etc.) becomes urgent. Text message programmes can play a role in promoting these—for instance, sending weather forecasts and urging responsive actions (like early planting if rains come early, or water conservation measures in a drought). Both India and Kenya face climate-related agricultural risks; in Kenya, unpredictable weather was cited by 27% of farmers as a major challenge impacting yield (Elliott, 2018), and in India, drought or delayed monsoons frequently result in crop loss. These stresses can cut both ways for adoption. On the one hand, a farmer who has experienced climate shocks might be more open to new practices that promise resilience (e.g. trying a new drought-resistant crop if reminded and convinced). On the other hand, heightened risk may make farmers *more risk-averse*, clinging to old methods that they know, fearing that an untested technology might fail under harsh conditions. We saw hints of this in the Kenya case: even with messages, farmers hesitated to plant a new crop perhaps worrying about climate impacts. Interventions must therefore be climate-informed—timing messages to climatic events (for example, advisory before an expected flood) and convincing farmers how the advised action mitigates climate risk. Another environmental factor is degradation (soil fertility decline, etc.). Services that integrate real-time data (like weather, remote sensing for drought) to trigger appropriate messages will likely outperform static advice. Policymakers should integrate mobile advisory as part of their climate adaptation programmes—for example, India's climate-smart villages initiative could use SMS to disseminate adaptation practices.

Challenges in Scaling Text Message Interventions: While pilot projects and localised studies show promise, scaling up SMS reminder programmes nationally or across diverse regions presents several challenges. One major challenge is message fatigue and content relevance at scale. When sending millions of messages, it is easy to flood farmers with information that may not all be relevant to them, causing them to ignore or opt out over time. Maintaining a high signal-to-noise ratio is key. This requires robust farmer databases and segmentation so that farmers receive only pertinent messages (by crop, region, season). In India's *mKisan*, for example, farmers have complained at times of too many SMSs, some of which do not apply to their situation. Managing and updating these databases as farmers change crops or acquire new technology is a logistical challenge. Another scaling issue is localisation—India's multitude of languages and Kenya's multiple agroecological zones mean content must be localised at scale. Translation and customisation require coordination (e.g. a central team working with local agronomists in each state/county). Further, in the case of Kenya, agriculture was devolved to counties under the 2010 constitution. The usage of this intervention could be done at the county level because they have different crops and production challenges vary. This would ensure that the messaging is appropriate and relevant in content and context.

Signal to Noise Ratio
This refers to the balance between useful information (signal) and irrelevant or excessive messages (noise). A high signal-to-noise ratio means farmers receive clear, actionable messages. Too many messages or irrelevant content can overwhelm them, reducing the impact of important information.

Infrastructure on a Scale Can Be a Problem Too: Sending billions of SMSs can strain telecom networks or incur high costs unless special agreements are in place. In India, government has deals with operators for bulk SMS, but even then, during peak times (say before monsoon planting), delivery might lag. Ensuring last-mile delivery (phone is on, farmer's inbox not full, etc.) is another practical issue. Measuring impact at scale is also harder—when a programme is nationwide, running a control trial is infeasible; hence, impact may have to be inferred through observational data or periodic surveys, which can be confounded by other factors. It is also worth acknowledging the cost implications of conducting such experiments, particularly in light of the practical challenges involved. A reader or reviewer might reasonably contend that this further justifies the need for piloting the intervention, conducting a rigorous RCT, and then using the findings and extrapolated insights to inform decisions on scaling up, if deemed feasible.

There is also the question of sustained behaviour change. As the ATAI meta-study found, adoption gains from SMS were not always sustained beyond one season. This suggests that continuous engagement or repeated campaigns might be needed, which is fine but requires ongoing investment. Over multiple seasons, however, the novelty of SMS wears off, so programmes need to innovate content or add interactive elements to keep farmers engaged (for instance, two-way messaging where farmers can ask questions might be a next step on a scale). Privacy and data concerns become more pronounced at scale too—maintaining a database of millions of farmers raises questions of data protection (the Indian government is building a unified farmer database and assuring data will be used responsibly, but safeguards need to be clear). In scaling up, there is a risk of focusing on numbers reached rather than actual changes on farm; thus, continual refinement and support systems (like linking SMS with local extension workers who can follow up with those not responding) should be part of scaling strategies.

In addition to these challenges, it is also important to understand how to accurately measure the impact of text messages. To ensure credible causal inference from text message nudge programmes for agricultural technology adoption, it is essential to anticipate and address potential violations of the Stable Unit Treatment Value Assumption (SUTVA), particularly through spillover effects. Information-based interventions are inherently susceptible to contamination when treated farmers share messages or discuss promoted practices with non-treated peers, potentially diluting the estimated treatment effect. To mitigate such risks ex-ante, programme designers should consider spatially or socially clustered randomisation—assigning treatments at the village or farmer group level rather than to individuals. This

approach reduces the likelihood of cross-group contamination and allows for the estimation of both direct and indirect effects. Additionally, incorporating buffer zones between treatment and control units or using partial population designs, where only a subset of farmers within a cluster are treated, can help measure and adjust for spillovers analytically.

Beyond design-based strategies, implementing randomised saturation experiments—varying the intensity of treatment coverage across clusters—can help assess how impacts change with exposure levels in the surrounding environment. Furthermore, rigorous baseline data on social networks and farmer communication patterns can support post-hoc adjustments using spillover modelling techniques or instrumental variable approaches. Such strategies not only improve internal validity but also inform the scalability of these interventions by identifying the pathways through which behavioural spillovers propagate. Thus, future nudge programmes must strike a balance between maximising diffusion for real-world adoption and preserving evaluative clarity through thoughtful experimental designs.

6 Policy Recommendations and Way Forward

Both the Indian and Kenyan experiences point towards several recommendations for policymakers, practitioners, and private players aiming to harness mobile phone text messaging to spur agricultural innovation:

- Integrate SMS with Traditional Extension: Rather than viewing mobile messaging as a stand-alone solution, integrate it into the broader extension system. For instance, extension officers can use SMS to stay in touch with farmers between visits. In India, KVK agents could monitor who in their area is receiving what messages and follow up with demonstrations. In Kenya, county extension services can partner with platforms like *DigiFarm* to amplify reach. This hybrid approach leverages the strengths of both personal contact (trust, depth) and digital contact (breadth, frequency).
- Enhance Personalisation and Interactivity: To address message fatigue and relevance, investments should be made in ICT infrastructure that allows more fine-grained targeting. Governments and companies should collect data on farmers' crop cycles, preferences, and outcomes (perhaps via periodic surveys or feedback loops) to tailor advice. Incorporating interactive elements—for example, a system where farmers can text back simple codes if they have a question or want more information—can make the intervention more engaging and useful. Some projects have implemented a missed call system where farmers give a missed call to hear a voice message of detailed advice when they want; similar innovations can be scaled.
- Focus on Inclusivity: Special efforts are needed to include women farmers, marginal communities, and low-literacy users. This could mean creating women-only messaging groups or working through women's organisations to distribute information. Where phone ownership among women is low, one could explore

community-shared devices—for example, equipping women's cooperatives with a tablet or phone that receives messages and then the group meets to discuss them. For low-literacy audiences, sending audio clips or very pictorial MMS (for those with basic smartphones) might be more effective than text.

- Leverage Social Networks: Encourage the formation of peer-learning groups on messaging platforms. In India, many WhatsApp groups of farmers exist organically. Officials could support creating local language WhatsApp groups moderated by an expert who can disseminate the same info as SMS but allow discussion (since WhatsApp requires smartphones, this is supplementary). In Kenya, community leaders or lead farmers could be enlisted as "digital champions" who receive training and then serve as a bridge, possibly even being the sender of messages in their locality (to personalise the sender).
- Combine Nudges with Inputs and Incentives: Adoption is more likely when information is coupled with access to inputs and some incentives. Policymakers can design programmes where farmers who sign up for SMS advice also get vouchers or discounts for related inputs (seed, fertiliser)—this was effectively done by some seed companies and should be expanded. Similarly, outcome-based incentives (like "send us a picture of your new plot using technique X and get entered in a prize draw for farm tools") could spur farmers to implement what the messages say, adding a fun and rewarding element. Care is needed to keep such programmes fair and transparent.
- Continuous Monitoring and Adaptation: Treat large-scale SMS programmes as adaptive management exercises. Use analytics (delivery rates, response rates, perhaps satellite data on crop outcomes) to see what is working and where. If certain regions show low uptake despite messages, investigate and adjust the strategy there (maybe messages not in the right language or timing off with their micro-climate). Solicit farmer feedback regularly—even a simple poll via SMS ("Was this week's tip useful? Reply 1 for yes, 2 for no") can gauge reception. This feedback loop will help keep the content relevant and trust high.
- Infrastructure and Policy Support: Ensure supporting infrastructure—mobile network coverage in rural areas, and electricity for charging phones—continues to expand. Governments should possibly subsidise solar chargers or power banks for remote farmers, because a phone that is dead is an opportunity lost. On policy, regulators can facilitate such interventions by for example mandating a certain amount of SMS bandwidth for social messages at low cost from telecom operators (or encouraging it through CSR regulations). Data privacy laws should be crafted in a way that protects farmers but does not stifle innovation—farmers should have control of their data and opt-in choice, but responsible data sharing between government and service providers can allow better services (like sharing soil health data of regions to craft better advice messages).
- Scale Through Collaboration: Finally, scaling will require collaboration across stakeholders—government agencies, telecom companies, Agri-tech firms, research institutions, and farmer organisations. A coordinated approach can prevent duplication and conflicting messages. For instance, an advisory committee can oversee major campaigns (such as a campaign to monitor and manage

reduced pest outbreak via SMS in both countries, which could involve experts with message formulation and all other relevant agencies with consistent dissemination deciding the correct guidance, and all agencies pushing that out consistently).

Mobile phone-based text message reminder nudges represent a powerful tool in the toolkit for increasing agricultural technology adoption. The experiences from India and Kenya demonstrate that when executed thoughtfully, these nudges can positively influence farmer behaviour—from improving input use and practices in India's extensive farming system to integrating nutrition and agronomic gains in Kenya's smallholder context. They are not a silver bullet; the effectiveness of text reminders hinges on aligning with human factors (trust, literacy, social groups, gender roles, etc.) and being embedded in a supportive framework of services and policies. Yet, given the low cost and immense reach of mobile networks, even modest improvements per farmer can aggregate to large developmental impacts when millions are served. Going forward, a vision can be imagined where every farmer, no matter how remote, receives a timely reminder that helps them make a better decision—and those millions of better decisions translate into more food, income, and resilience. Achieving that will require continued commitment to innovation, inclusion, and inter-sectoral partnership. The path ahead for private players and policymakers is to build on what has been learned: scale up what works, redesign what has not worked, and always keep the farmer's needs and context at the centre of these digital interventions. With that approach, mobile reminder nudges could significantly contribute to accelerating Agri-tech adoption and improving livelihoods across the developing world.

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9 Agricultural Extension, Promoter Farmers, and Nudges to Encourage Technology Adoption Among Men and Women Smallholders in Sub-Saharan Africa

Janet M. Mutiso, Arjan Verschoor, and Julius J. Okello

Abstract

This chapter considers the use of information nudges to encourage smallholder farmers in sub-Saharan Africa to adopt new technologies. The use of these nudges takes place in a context of inadequate formal extension services, where promoter farmers frequently provide the advice that extension agents would normally provide. The limited evidence on the effectiveness of information nudges in this context suggests that they are promising in terms of their potential to encourage farmers to adopt new technologies. However, for understanding the effectiveness of information nudges, a triple interaction effect needs to be evaluated: the identity of the person doing the nudging (typically the promoter farmer or extension agent) interacts with the nudge, and these two together, as well as on their own, interact with the identity of the person being nudged (typically the smallholder farmer who is encouraged to adopt new technologies). The challenge to understand this triple interaction effect points to a new research agenda.

Keywords

Nudges · Promoter farmers · Agricultural extension · Technology adoption · Smallholder farmers

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1 Introduction

The provision of agricultural extension services in sub-Saharan Africa is inadequate due to insufficient resources and inefficient bureaucracy, which in turn limits smallholder farmers adoption of agricultural technologies that reduce risk, enhance productivity, or increase profitability (Wiggins et al., 2021; Kristin & Franzel, 2018). In an attempt to bolster formal extension services, progressive farmers from local communities (alternatively called lead farmers, model farmers, or promoter farmers) are often selected to provide, through a demonstration process, the type of information that extension officers would ordinarily provide (Khaila et al., 2015; Holden et al., 2018; Takahashi et al., 2019; Ragasa, 2020; and Ochieng et al., 2022). While promising, the promoter-farmer approach suffers from its own limitations, which relate in part to the loss or distortion of information that occurs when it is transmitted through unofficial channels. Information nudges may help overcome the imperfect transmission through promoter farmers (Kondylis et al., 2017; Holden et al., 2018; and Niu & Ragasa, 2018).

Information nudges are low-cost interventions based on insights from behavioural economics that can lead to behavioural change that is in the best interests of people.[1] For example, to encourage farmers to adopt a positive attitude towards quality seed, one can use posters that make farmers aware of the losses they could avoid by adopting the seed as an information nudge. It is a *nudge* because it evokes the feeling of loss aversion by making use of insights from behavioural economics indicating that farmers are loss averse. It is an *information* nudge because it combines this insight with the provision of information that helps farmers make the correct decision for their farms. Other examples of information nudges can be found in Textbox 9.1.

Textbox 9.1 Role, Impact, and Reach of Information Nudges

Information nudges have been used to encourage the adoption of water-saving technologies and innovative practices, with large effect sizes (Chabé-Ferret et al., 2019); nudge attendance to farmers markets, which was found to be ineffective (Didero et al., 2021); improve environmental and health outcomes by increasing compliance with pesticide use regulations (Buchholz & Musshoff, 2021; Michels et al., 2023); show how others change behaviour in order to influence uptake of eco-friendly practices (Boenke et al., 2022); provide price references to nudge commodity-traded produce (Belay & Ayalew, 2020); allow social comparison to encourage sustainable rice farming (Sasaki et al., 2024); and encourage investment in organic farming (Boun My et al., 2022).

(continued)

[1] In Thaler and Sunstein's (2008) account, nudging uses two fundamental principles, libertarian paternalism and choice architecture. Liberal paternalism supports people in making decisions they would make if they were fully informed and free of temptation, and choice architecture is the environment in which decisions are made. Thus, choice architects influence people's decisions and behaviours simply by leading them to better options for themselves (Sunstein & Thaler, 2003).

Textbox 9.1 (continued)

In developing countries, widespread initiatives primarily involve the use of information and communication technologies (ICT), especially short message service (SMS) and videos, with mixed results. The popularity of these two approaches can be attributed to their affordability and broad reach. An evidence synthesis of six SMS-based information campaigns in East African countries, designed to promote agricultural lime adoption, suggests that it is possible to influence farmer behaviour by delivering SMS reminders that encourage experimentation with certain fertilisers. These interventions have been shown to increase knowledge, though adoption is not sustained in subsequent seasons (Fabregas et al., 2025). Though the programmes differed in design, target populations, and information content, the meta-analysis yielded a modest effect size relative to intervention costs, with little evidence of fatigue or crowding out. Furthermore, the study found that the impact increases with the intensity of nudging but not with phone calls, more specific information, or the inclusion of behavioural framing.

Similarly, there is evidence of the positive effects of mobile phone-based information nudges, which have been shown to be effective in promoting new technology adoption in Burkina Faso compared to traditional extension methods, particularly among low-literate farmers (Maredia et al., 2018). Van Campenhout, Spielman, and Lecoutere (2021) provide evidence that information nudges in the form of videos increase maize farmers knowledge and adoption of recommended practices, with little indication that SMS reminders or interactive voice responses have an incremental effect.

In this chapter, the scope for information nudges to support smallholder farmers in SSA is assessed. The use of these nudges takes place in the context of inadequate formal extension services, where promoter farmers frequently provide the advice that extension agents would normally provide. We review the evidence on the effectiveness of information nudges in this context and conclude that they are promising in terms of their potential to encourage farmers to adopt new technologies. However, the effect of these nudges is heterogeneous and crucially depends on the identity of promoter farmers and receiving farmers, with gender being a key mediating factor. In Sect. 2, we review agricultural extension services in SSA and identify a potential role for information nudges. In Sect. 3, we review the influential promoter-farmer approach, focusing on those challenges that are likely to interact with nudges. In Sect. 4, we focus on farmer diversity and how that interacts with nudges. In Sect. 5, we conclude by highlighting the triple interaction that needs to be evaluated for better understanding of the effectiveness of information nudges, namely: the person doing the nudging (typically the promoter farmer or extension agent) *multiplied by* the nudge *and then by* the person being nudged (typically the smallholder farmer who is encouraged to adopt new technologies). In other words, the overall effect of the nudge can be understood as the combined influence of three factors: the characteristics and timing of the person delivering the nudge (typically the promoter

farmer or extension agent), the timing of the nudge itself, and the receptivity of the person being nudged (typically the smallholder farmer encouraged to adopt new technologies).

This points to an important new research agenda.

2 Information Nudges to Support Agricultural Extension Services

In this section, we review the difficulties with agricultural extension services in SSA and assess the scope for information nudges. Sub-Saharan Africa faces challenges in agricultural technology adoption in part due to farmers limited awareness of the benefits, profitability, and optimal utilisation of agricultural innovations (Wiggins et al., 2021). Farmers may fail to adopt productivity-enhancing, risk-reducing innovations when they are unaware of their existence, do not understand their benefits, or lack the knowledge and skills to use them (Magruder, 2018; Takahashi et al., 2020; Suri & Udry, 2022). For that reason, access to agricultural extension at the early stage of technology dissemination, which is characterised by information disequilibrium and high perception of risk, helps farmers adopt and better utilise agricultural technologies such as improved seeds (Kristin & Franzel, 2018). Yet, formal extension services face constraints arising from insufficient resources, bureaucratic inefficiencies, and a lack of responsiveness to evolving demands in the sector (Lecoutere et al., 2023). As a result, most farmers in SSA do not have access to sufficient relevant information and are slow to adopt innovations that could improve agricultural productivity and reduce risk (Magruder, 2018; Suri & Udry, 2022).

Not only are they inadequate, but extension services are also uneven and reach women ineffectively (Mudege et al., 2016). About half of the farmers without access to agricultural extension services in SSA are women from low-income households, restricting their ability to make informed decisions regarding crop selection, technology adoption, and farming practices (FAO, 2023). Women are also less likely to access and benefit from extension programs because they are designed for and targeted at male household heads (Ragasa et al., 2013). Extension services overlook the productive, reproductive responsibilities, and preferences due to gender roles (Diaz & Najjar, 2019), and view women as making a negligible contribution to farm activities (Lecoutere et al., 2019). Moreover, agricultural information received by men is not communicated to the women within their households (ibid.).

Extension services neglect gender-divided labour, women's mobility, time allocation, and norms that dictate the relationships they can form. Gender norms have an impact on women's capacity to pursue and apply agricultural training (Mudege et al., 2016, see Textbox 9.2 for details). Women farmers prefer certain channels or associations with female extensionists for enhanced communication and friendliness, or because they understand them better (Achandi et al., 2018). This creates differential access to extension, which may be an important cause of women's lower adoption rates of improved seed (Puskur et al., 2021). Further, women, compared to men, tend to have lower and impeded access to productive resources, including

Textbox 9.2 Gender Norms and Access to Extension Services and Training (Mudege et al., 2016)

Agricultural extension services provide a way to bridge the gap between science (global and local research) and practice (local farmer level), and are assumed to lead to better farmer decision-making, improved agricultural performance, and better outcomes. These services help farmers unpack the technical information about innovations, whether a technology—as in the case of an improved crop variety or livestock breed—or complementary practices required to optimise gains from their use. They also help reduce the risk and uncertainty associated with adopting innovations. In a study conducted in Malawi, the authors found that women and men differ significantly in their access to extension services and training. The study was conducted among potato farmers in the Southern region of Malawi, where the potato is ranked highly as a food and cash crop by both women and men. It also found that selection of the gender of farmers who participated in field days and workshops where agronomic training was provided was done by extension agents in collaboration with village headmen (both cases dominated by men). In addition, hosts of demonstration plots were lead farmers, and predominantly men. Thus, participation in training events, field days, and hosting of demos was skewed heavily towards men. The authors attributed this to gender norms. For instance, when invitations to the training events did not specify the number of women and men to attend, it was men who did so, in the guise of representing women. In some cases, women were forbidden by their husbands from attending training. Village headmen who oversaw the training recruitment did not want to inform women directly. They argued that "it was difficult [socially] to approach women to inform them about impending meetings and training opportunities without informing their husbands" (pg 298, paragraph 1, lines 6–7). Sometimes invitation to training events came at short notice, giving women no time to prepare (by rescheduling domestic chores) to attend. In other cases, gender and power relations worked against women, preventing them from being selected as information disseminators to other women, a practice that has been found more effective in reaching women with new information. Gender role expectations and gender stereotypes in communities reinforced these biases. Men, it was believed, understood new things better and are the "knowers", with women as recipients of knowledge from men. This, the authors argued, strengthened the stereotypic view that women are not intelligent and is "disempowering to women because it erodes their agency and self-esteem…" (pg 303, paragraph 3, line 5–6).

those that are required to obtain agricultural information, such as mobile phones (Burrell, 2010; Kotut & Alikhan, 2024). It has, for instance, been shown that if men and women had equal access to labour, land, and extension services, they would have an equal likelihood of adopting high-quality seeds (Doss, 2018). For instance,

according to Wahome et al. (2021), female farmers in Kenya are less likely to employ the tissue banana culture method; however, women would have an equal chance to adopt the invention if they were provided with sufficient information about it. Therefore, complementary extension channels have been explored from various angles to support the constrained systems and increase reach to marginalised groups, especially women.

One such approach involves leveraging promoter farmers to augment existing systems and broaden their scope (Kondylis et al., 2017). Extensions to agricultural extension systems that make use of promoter farmers are described as more inclusive, cost-effective, and involving a wider range of stakeholders (Wellard et al., 2013). Moreover, advocates of this model argue that peer learning can trigger significant social multiplier effects in the dissemination of agricultural technologies, which are essential complements to formal extension systems (Hogset & Barrett, 2010). In root and tuber crop projects like sweet potato, because of the low involvement of private actors, the use of promoter farmers is particularly popular—in various forms, such as community extension workers and decentralised vine multipliers (Adam et al., 2018). Information materials, new techniques, and tools are provided to promoter farmers to disseminate quality seeds and improved practices on a wide scale (Mandal, 2023). Promoter farmers host nutrition education sessions, demonstrate best practices, organise field days, and multiply and distribute high-quality seeds and improved varieties. However, despite the prevalence of promoter farmers in agricultural extension projects, insights into their comparison with adopting farmers and the associations of their characteristics with their performance in supporting quality inputs commercialisation are missing.

Relying solely on interpersonal interactions may limit the scalability and reach of commercial seed interventions, particularly in large or geographically dispersed communities. Akbarpour et al. (2020) emphasise the importance of simple contagion, a sufficiently long adoption period, and frequent social interaction within the social network of the promoter farmer relied on for diffusion. Integrating the efforts of promoters with information nudges is therefore seen as a promising way forward. For instance, when promoting high-quality seed, a poster showing its comparative advantage and placed in areas frequented by farmers can reinforce a message about the benefits of quality seeds, amplifying the effects of exposure to information about high-quality seeds provided by promoter farmers.

The transmission of information from promoter farmers to end-user farmers may introduce noise and imperfections, potentially exacerbating uncertainty regarding the benefits of adopting a new technology (Munshi, 2004). For promoters, information nudges can serve as reminders and reinforce the information conveyed during central training sessions, offering supplementary support to alleviate uncertainties and enhance the adoption of new agricultural practices. Information nudges may aid in mitigating the issue of information loss within promoter extension models, as highlighted by Kondylis et al. (2017), Holden et al. (2018), and Niu and Ragasa (2018). Kondylis et al. (2017) reveal substantial information loss from extension agents to both promoter farmers and other farmers in the community. These findings question the effectiveness of the promoter farmer approach in advocating specific

agricultural technologies, suggesting a significant gap in knowledge transfer despite training. Information nudges may potentially help bridge the gap.

Moreover, the promoter extension method often fails to account for the multifaceted dynamics of information diffusion in agriculture, where drawing from diverse sources is paramount (Beaman et al., 2015). To address this limitation, incorporating information nudges alongside traditional extension strategies can foster information dissemination. Empirical findings from Beaman et al. (2021) indicate that the conventional approach may suffer from limited effectiveness, as agricultural knowledge tends to remain localised and fails to extend significantly beyond the initially targeted individuals. Similarly, Berg et al. (2019) observed that health information shared by unincentivised agents tends to circulate primarily within specific social groups, such as castes. Information nudges serve as effective tools for reaching multiple audiences and enhancing the reach and impact of extension efforts.

Beaman et al. (2015) discovered that farmers in Malawi required information from diverse outlets before they were open to experimenting with techniques like pit planting. Genius et al. (2014) revealed that in the uptake of irrigation technology in Greece, the effect of extension services and social learning was more pronounced when combined. Information nudges complement these promoter-peer interactions by serving as conversation starters, reminders, or prompts for further dialogue among community members. There could be limitations to relying solely on interpersonal interactions in commercial seed interventions, particularly in large or geographically dispersed communities, which suggests considerable potential for integrating information nudges in agricultural extension services.[2]

3 Promoter Farmers Nudging and Being Nudged

As discussed in the previous section, promoter farmers are used to supplement agricultural extension. The use of this approach comes with its own challenges. In this section, we concentrate on the challenges that may interact with information-based nudges. It leads to the insight that the identity of promoter farmers becomes part of the nudge, which therefore requires explicit research attention when nudge effectiveness is evaluated.

Formal extension services have yielded unsatisfactory performance in sub-Saharan Africa, prompting the need for system restructuring and intensified efforts. An efficient agricultural extension program helps farmers make better decisions, increase their revenue, and ensure food security. It also helps farmers develop better technical habits, such as the use of quality inputs and seeds. However, formal

[2] Although outside the scope of this chapter, it is important to note that implementing information nudges in agricultural extension faces challenges related to: (i) access to mobile phones and network penetration (Aker et al., 2016; Fabregas et al., 2025), and (ii) the necessity of repetitive application and reinforcement to sustain impact, since a short-term effect on behaviour may not equate to habit formation and scalability (Jayanth et al., 2022; Fabregas et al., 2025).

extension services and outside assistance from development partners like NGOs and other international organisations have shown their limitations and need to be complemented to meet the challenges of the modern world (Amoussohoui et al., 2023). Despite considerable challenges (see Textbox 9.3), promoter farmer extension has the potential, through social learning, to harness the leadership existing in the farming community and networks to achieve and complement the goal of agricultural development.

Textbox 9.3 The Use of Promoter Farmers to Complement Agricultural Extension Services

The use of promoter farmers in agricultural extension within sub-Saharan Africa has been a topic of significant research and scrutiny. De Janvry et al. (2016) and Pamuk et al. (2014) have pointed out that this approach has yielded unsatisfactory results. One of the primary reasons cited for this is the presence of underfunded extension systems, which limit the effectiveness of the promoter farmer model. Additionally, the selection of inappropriate promoter farmers further exacerbates the issue, hindering the diffusion of agricultural technologies (de Janvry et al., 2016; Pamuk et al., 2014). For studies illuminating challenges of the promoter-farmer approach along these lines, see Khaila et al. (2015), Holden et al. (2018), Takahashi et al. (2019), Ragasa (2020) and Ochieng et al. (2022).

A strand of literature focuses on providing performance incentives to promoter farmers; see BenYishay and Mobarak (2019) for a representative example. In a recent study, Balew et al. (2023) shed light on the importance of incentivising group leaders within farmer communities to promote knowledge sharing. In their study on integrated pest management (IPM) in Ethiopia, incentivising group leaders with rewards and utilising loss-framed messaging increased the effort of knowledge dissemination among these leaders. However, despite this increased effort, the study observed a lack of significant experimentation with IPM among follower farmers. Similarly, Okello et al. (2023), using a field experiment, provide public recognition to promoter farmers for disseminating information about improved seeds and find that this does not affect receiving farmers knowledge or willingness to pay for improved seeds.

Motivational factors play a significant role in the engagement of promoter farmers, with challenges such as competing employment opportunities potentially leading to a loss of interest in their advisory roles (Ochieng et al., 2022). Studies emphasise the importance of providing performance-based incentives tailored to the specific motivations of promoter farmers, whether driven by a desire for knowledge enhancement or altruistic intentions (Fisher et al., 2018). Additionally, increased and targeted training of promoter farmers can help ensure they possess the necessary skills and knowledge to fulfil their roles (Khaila et al., 2015).

A discussion point is the suitability and credibility of promoter farmers, particularly regarding their social connections and representativeness of the farming community. To drive extension projects, promoter farmers are chosen with heterophilous ties, high status, influence, or leadership qualities, whereas at other times, homophilous representatives of the average farmer are preferred (Khaila et al., 2015; Ragasa, 2020; Beaman et al., 2021; Amadu, 2023).

The performance of the promoter farmers, besides the superiority of the technology, hinges on relationships between promoter farmers and their peers' ties, facilitating or impeding social learning (Shikuku, 2019). According to innovation diffusion theory, the relationship between a communicator and an information receiver can be one of homophily, where the similarity in characteristics with the average farmer exists for support, or heterophily, where the transmission of novel ideas occurs between dissimilar individuals (Rogers, 1995). Initially, promoter farmers were selected based on their connection to follower farmers, reflecting demographic and agricultural similarities. However, some projects also favour innovative promoters who are central to their networks to facilitate contagion or promoter farmers with slightly higher status (Nakano et al., 2015; Beaman et al., 2021). The inclination has provoked discussions regarding different modes of promoter selection and types of ties, namely homophily and heterophily, and their efficacy in technology diffusion.

A strand of literature argues for the superiority of homophily, centrally connected promoters and kinships. Beaman et al. (2021) emphasise that targeting farmers with high connections in their communities drives the adoption of new agricultural technologies. In their study, failure to engage central farmers resulted in limited diffusion. Over 3 years, it was found that pit planting increased significantly in villages where central farmers were involved and supported complex contagion with multiple exposures for adoption. BenYishay and Mobarak (2019) state that promoters' social identity affects other farmers learning and adoption behaviours. The authors also determine that similarity in farm size, input practices, and belonging to common social groups could be key to the high efficacy of promoters, in support of Wang et al. (2020). Beaman and Dillon (2018) contend that the vertical flow of information from the promoter farmer to peer farmers fails, and successful information exchange is likely to be based on horizontal, socially proximate relationships. In their study, Nakano et al. (2015) observed that ordinary farmers who maintained a kinship or residential connection with promoter farmers displayed a higher propensity to adopt new agricultural technologies. While the promoter farmers immediately experienced a surge in technology adoption following training, the non-trained ordinary farmers exhibited a delayed but eventual catch-up in their adoption rates.

Regarding heterophily, Maertens (2017) suggests that promoter farmers play a significant role in peer learning, while Holden et al. (2018) and Fisher et al. (2018) observe positive impacts of the promoter-farmer approach in sub-Saharan Africa. Nonetheless, BenYishay and Mobarak (2019) observe that ordinary farmers, especially when incentivised, may outperform promoter farmers as trainers in technology diffusion efforts. In support, Takahashi et al. (2019) demonstrate that rather

than promoter farmers, randomly selected training participants, representative of the majority in a community, effectively work as catalysts to disseminate information to non-training participants. Offering a compromise, Fisher et al. (2018) argue that an optimal approach is for promoter farmers to serve as initial conduits for disseminating new information, while the homophily positions promoter farmers to drive wider technology diffusion. Combining the ties entails training promoter farmers to introduce new technologies to socially proximate farmers who possess slightly higher capabilities than the average farmers.

Regarding social identity of promoter farmers, Shikuku (2019) and Kondylis et al. (2017) reveal that women trainers increase the intensity of reaching, translating to better awareness, adoption and mitigating gender bias. These findings underline the heterogeneous dynamics within farmer networks, with mixed empirical findings adding complexity to the promoter-farmer approach. Vasilaky and Leonard (2018) conducted a field experiment in Uganda aimed at establishing new information channels by pairing female cotton farmers who had not previously interacted. During training sessions, the authors encouraged these farmers to exchange technological insights in the production process. This intervention yielded a significant increase in productivity for the paired individuals, highlighting the value of connecting female farmers who typically operate outside traditional agricultural information networks. Furthermore, Mekonnen et al. (2018) found that network effects are pronounced among female farmers compared to their male counterparts.

Based on the above discussion, the ideal candidate for the promoter role is changeable. Should this individual be heterophilous, bringing diverse perspectives, or rather reflecting the ordinary characteristics of the majority within the community? Matching the characteristics of promoter farmers with those of peers can result in favourable outcomes following the homophily theory; in contexts of dissimilarity, mitigating cognitive dissonance is essential to prevent conflicting messages (Lazarsfeld & Merton, 1964).

Limited evidence exists on how the identity of promoter farmers, when these are involved in communicating information nudges to their fellow farmers with the aim of the latter to adopt new agricultural technology, interacts with (a) the identity of the farmer receiving the nudge and (b) the information nudges themselves. The study of Beaman and Dillon (2018) underlines the gender disparities that exist in information diffusion within social networks, indicating that women farmers are less likely to receive information when targeting strategies that prioritise central nodes based on betweenness centrality within village-level networks. Further, Lecoutere et al. (2023) show that involving women in receiving information improved their knowledge outcomes positively; nonetheless, men's knowledge outcomes suffered when information was solely provided to the female co-head. Their results suggest that women may not always share the information received with their spouses. Then Shikuku (2019) shows that information diffuses more if the disseminating farmer is female compared to male, as they are more dependable and apply more effort in reaching other farmers. The author concludes that training female promoters might increase competence and acceptance of messages. Pan et al. (2018) delved into comparable matters in Uganda, focusing on women

promoter farmers who facilitated training and access to hybrid maize seeds, especially for fellow women smallholder farmers. The study identified substantial positive effects of adopting recommended cost-effective agricultural practices and inputs within households and household food security.

For the peers, Kondylis et al. (2016) noted that providing information about sustainable land management practices to farmers in Mozambique had different effects on male and female farmers. The study found that female farmers were less effectively reached than their male counterparts, and a positive impact on awareness and adoption among female farmers was observed when additional female extension agents were introduced to engage with them in Mozambique. Lambrecht et al. (2016) explored the effectiveness of extension services based on whether information was provided jointly to both male and female co-heads, exclusively to the male co-head, or exclusively to the female co-head within households. Focused on integrated soil fertility management practices in eastern DR Congo, they discovered that when both male and female co-heads participated together in extension information events, the adoption rate increased the most.

4 Farmer Diversity and the Effectiveness of Information Nudges

The discussion so far suggests that the identity of promoter farmers is likely to matter when a nudge is being used alongside them to encourage farmers to adopt new technologies. We next focus on the identity of the farmers considering adoption, which leads to the insight that the nudge interacts not just with the identity of the person doing the nudging but also with that of the person being nudged.

The existing knowledge on smallholders' adoption of agricultural technology highlights four crucial conditions (FAO, 2018, 2024; Huyer et al., 2024). Firstly, the technology must be of high quality and cater to the specific needs and preferences of individuals from diverse demographic and socioeconomic backgrounds. Secondly, the technology should be readily available to all smallholder women and men farmers in the appropriate locations and at the right times. Thirdly, the accessibility of the technology is vital, meaning that farmers, irrespective of gender and socioeconomic characteristics, should have access to reliable information about the technology, be able to afford it, and physically obtain it. Lastly, both women and men must be able to use and control the technology, ensuring equity and empowerment. By meeting these conditions, agricultural technology can effectively contribute to overall food security and benefit all farmers.

However, an especially significant hindrance to the progress of farming in developing countries is the lack of gender equity, which poses a serious threat to the effectiveness of agricultural research at all levels, from seed delivery and livestock value chains to the management of rural landscapes (Tavenner & Crane, 2019; Harris-Fry et al., 2020; Njuki et al., 2023). Gender-based inequalities exist in access to and adoption of technology and are often attributed to differences in resource access between female and male farmers. For instance, women face challenges

accessing capital, credit, land, and extension services, creating a gender gap in agricultural technology adoption (Doss, 2018; Njuki et al., 2023).

Beyond gender, other factors associated with the adoption of technology are essential to explore in agricultural contexts. While gender dynamics undoubtedly influence decision-making, understanding additional factors such as farmers socioeconomic characteristics, access to credit, knowledge and awareness of the technology, and market conditions adds to the understanding of effective demand. We highlight next the particular factors that are relevant for understanding a potential role for information nudges.[3]

First and most obvious is the role of information provision (Bridle et al., 2020; Okumu et al., 2021; Mobarak & Saldanha, 2022). Limited access to information contributes to low agriculture technology adoption. When farmers have a limited desire to invest in agricultural innovations because they are unaware of their benefits, the adoption is low (Suri & Udry, 2022). Offering pertinent information about the innovations can increase the adoption rate (Fabregas et al., 2025). This information enables farmers to comprehend the advantages associated with using such innovations. Thus, there is an opportunity to use information nudges to influence farmers adoption of new technology.

Second, farmers are attentive to the physical attributes and appearance of inputs, especially of seed. Accordingly, in the case of incomplete and asymmetric information, a seed's visual appearance may be among the signals that farmers try and use to infer unobservable quality. Consequently, in such situations, farmers may misperceive input quality as a credence attribute despite sufficiency (Wossen et al., 2022; Michelson et al., 2021). Maredia and Bartle (2023) evidence this in a study that found that farmers bids for certified seeds increased by 8% in response to positive quality signals, while they decreased by 17% for ware potatoes in response to negative quality signals, indicating farmers probable quality misperceptions due to information asymmetry. Using information nudges can correct such misperceptions and perhaps increase the likelihood that a new technology is adopted.

Studies have shown that nudges may contribute to farmers behaviour change (Becchetti et al., 2020; Fabregas et al., 2019). In a framed experiment, Davidson and Goodrich (2023) show that information nudges motivate enrolment in index insurance covering pasture, forage, and rangeland. The authors conclude that providing enrolment recommendations may alleviate choice overload and increase the likelihood of enrolment. Belay and Ayalew (2020) nudged farmers in crop choice using price information. The authors argue that providing access to reference price information increases the average farm gate price, influencing farmers crop choice decisions. In Kenya, among sugarcane farmers, nudges were important in motivating fertiliser usage (Casaburi et al., 2014).

[3] Other factors important for technology adoption include farmers risk and ambiguity aversion (Holden & Quiggin, 2017; Crentsil et al., 2020; Chavas & Nauges, 2020), downside risk aversion (Mukasa, 2018), time inconsistency and self-control (Duflo et al., 2011), and locus of control (Abay et al., 2017). Potentially, these factors could interact with information nudges in complex ways; these are outside the scope of this chapter.

While encouraging, more attention needs to be paid in future research to farmer diversity, which is an insight that may be obtained from the literature on market segmentation. Müllensiefen et al. (2018) define market segmentation as identifying distinct groups of farmers with similar characteristics, explaining a phenomenon. This approach can help tailor information nudges to specific groups, ensuring they are effective and advantageous for particular groups of farmers. The importance of customer targeting and personalised approaches in agriculture is emphasised by Orr et al. (2021) and Kilwinger et al. (2021). Per Orr et al. (2021), customer segmentation forms the initial stage, followed by targeting, development and the dissemination of innovation. Kilwinger et al. (2021) argue that because farmers and their farms vary, implementing uniform interventions may only be effective for a specific group of farmers, leaving others disadvantaged. According to Frelat et al. (2016), the productivity of crops in sub-Saharan Africa can be significantly enhanced by considering the diversity within farming households, including variations in farm size and access to efficient markets. In Rwanda, Dawson et al. (2016) highlighted that green revolution interventions had unintended negative consequences, exacerbating social inequity by neglecting the impacts on local land tenure, agricultural practices, and the differing needs and preferences of diverse groups within local communities.

Hazell (2019) has contended that farming households are not the same and may require different technologies and delivery methods to suit their unique circumstances. The same applies, therefore, to information nudges too. Mausch et al. (2021) emphasise that treating farmers as homogeneous groups without considering these factors oversimplifies the relationship between technology adoption and their demographic profiles. While a one-size-fits-all approach may be easier to apply on a larger scale, it may not be as effective as nudging approaches, considering each farmers unique characteristics, their farm, and their practices.

5 Conclusion

Inadequate formal agricultural extension services limit the adoption of new agricultural technologies by smallholder farmers in sub-Saharan Africa. As a result, even when these technologies are risk-reducing, more productive and/or more profitable, adoption does not take place. Faced with this challenge, the use of promoter farmers (or model or lead farmers), who demonstrate to peer farmers that new technologies may be in their best interests, has become common. One limitation that arises, given the informal nature of the arrangement, is the loss and/or distortion of information. Information nudges have been proposed to help overcome the imperfect transmission of agricultural advice from promoters to other farmers. The evidence on the effectiveness of such nudges is, however, still limited.

The available evidence suggests that information nudges have potential when it comes to encouraging smallholder farmers in sub-Saharan Africa to adopt new technologies. An important insight that emerges from the literature is that the identity of the promoter farmer becomes part of the nudge when such farmers are instrumental

in administering it. Moreover, due to pervasive norms, female farmers face inequalities in accessing productive resources, including quality inputs, information, and extension services. In many farming communities, social interactions also follow gendered norms, which dictate who can associate with whom. Consequently, the effectiveness of nudges may be gendered, depending on whether the promoter farmer is male or female and whether the peer farmer is more likely to approach, trust, seek advice, and adopt recommendations from someone of the same gender. Furthermore, the effort exerted by the nudger may also be influenced by gender. It has been demonstrated in some contexts that male promoter farmers tend to put less effort into reaching out to peer farmers with agricultural information.

It follows, therefore, that for understanding the effectiveness of information nudges, a triple interaction effect needs to be evaluated: the identity of the person doing the nudging (typically the promoter farmer or extension agent), how this interacts with the nudge itself, and how these two factors independently and together interact with the identity of the person being nudged (typically the peer farmer who is encouraged to adopt new technologies). The challenge of understanding this triple interaction effect points to a new research agenda. Research should aim to unpack the role of gender in these interactions, particularly within dyadic relationships; assess the effectiveness of different types of nudges for men and women; and examine how the identity of the information recipient subsequently influences the adoption of the technology (i.e. improved varieties, in our case).

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Social Nudges for Stimulating Farmer Participation in Agricultural Information Crowdsourcing Initiatives

10

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Abstract

We implement a dryland information micro-tasking-based crowdsourcing initiative and generate exogenous variation in the expectations (high or low) held by "contributors" about the likelihood of continued payments in the future. A guaranteed monetary reward is provided to all contributors for an initial 3-month period and thereafter withdrawn for a random sub-sample. We make salient to the contributors the value of the information gathered for decision-making and designing of interventions for addressing drought impacts in the communities they represent. The study evaluates the responsiveness of effort provision to the monetary incentive by assessing the effect of reward withdrawal on the total tasks submitted. We do not find evidence of expectations-based reference dependence during the initial period when the monetary reward was guaranteed. While we find that guaranteeing continued reward correlates with increased

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effort provision after the initial period, this relationship is not statistically significant once we account for the role of expectations. In other words, withdrawing the monetary reward did not affect effort provision significantly when contributors were informed prior to starting the work. These findings suggest that making the value of the information collected salient and communicating to the contributors early about uncertainty in the future payments will likely minimise disappointment effects and sustain effort provision in agricultural information crowdsourcing initiatives.

Keywords

Expectations · Reference dependence · Information crowdsourcing · Incentives · Ethiopia

1 Introduction

Recent efforts and investments to inform policy decisions and timely intervention to address shocks in sub-Saharan Africa (SSA) increasingly promote data gathering through micro-tasking for near real-time monitoring of dynamic resilience indicators. These efforts are inspired by the substantial growth in the coverage and adoption of information and communication technologies (ICTs) in rural areas (Aker & Mbiti, 2010; Aker et al., 2016), by the rising interest in how crowdsourcing techniques can be used to facilitate information gathering (Adewopo et al., 2021; Solano-Hermosilla et al., 2022; Chelanga et al., 2022; Hasanain et al., 2023), and by the increasing recognition of the importance of indigenous knowledge in designing adaptation interventions (Makondo & Thomas, 2018). Crowdsourcing is commonly defined as a participatory method of obtaining information from several people who are not paid employees (the crowd) and using ICTs (Estellés-Arolas & González-Ladrón-de-Guevara, 2012).

It is implicitly assumed that the information provided through crowdsourcing initiatives is of high quality, meaning that the data gathered by individuals residing within the communities meet the agent's specific information needs in a timely manner (Aker et al., 2016). However, questions remain about individuals' motivation to contribute sustainably and whether the expectations they hold about future rewards for their efforts matter (Ziegler et al., 2017). Addressing these types of questions can be important for policy design as accurate and timely data are essential for informed decision-making, including anticipatory action and achievement of development goals aimed at improving the livelihoods of poor communities (World Bank, 2018; Bitso et al., 2020), and incentives have been shown to be important in nudging effort provision in information crowdsourcing initiatives (Solano-Hermosilla et al., 2022). Answers to these questions are particularly relevant for

understanding the sustainability and scalability of initiatives relying on voluntary contributions or which expect continued participation even after the funding source for rewards is withdrawn (Solano-Hermosilla et al., 2022).

The objectives of this study are twofold. The first objective is to assess the effect of expectations about future monetary rewards on participation in an agricultural information crowdsourcing initiative. Our experiment, therefore, studies expectation-based reference dependence as a social nudge for participation in agricultural information crowdsourcing initiatives. We define a social nudge as "any aspect of the choice architecture (i.e. the context in which people make decisions) that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives" (Nagatsu, 2015). Social nudges are used with the aim of influencing choice outcomes that generate higher benefits, not necessarily to each individual, but to society (or a group) as a whole. The second objective is to assess heterogeneous effects of expectations about future monetary rewards on participation in agricultural information crowdsourcing initiatives. We focus on heterogeneity by an individual's degree of altruism and loss aversion to understand the mechanism through which expectations affect participation. We expect that altruistic individuals, that is, those who exhibit preferences for other people's well-being, will be motivated to expend a costly effort to engage in crowdsourcing even in the absence of an extrinsic monetary reward. However, individuals with a high degree of loss aversion can be expected to dislike uncertainty about future income and may, therefore, participate less in the crowdsourcing initiative due to the disappointment effect.

To evaluate the causal effects of expectations about future rewards, we selected and randomly assigned 120 sub-locations *(kebeles)* from the Borena zone in pastoral southern Ethiopia to either the treatment or the control arm. A participatory exercise was conducted with community members before the baseline survey to recruit one pastoralist in each *kebele* full-time for 3 months in an agricultural information crowdsourcing initiative. Henceforth, we refer to these individuals as contributors. The experiment made salient to the contributors the value of the information gathered for decision-making and designing of interventions for addressing drought impacts in the communities they represented. Contributors in both treatment and control groups were informed that they would receive a small monetary reward (≈USD1) for each successfully submitted task during the first 3 months of the initiative. In the treatment group (high expectations), contributors were further told that they had a 90% chance of continuing to receive a monetary reward for their active participation in the assigned tasks after 3 months. Contributors in the control group (low expectations) were told that they had a 10% chance of continuing to receive a monetary reward for their active participation in submitting the assigned tasks after 3 months. Whether contributors continue to receive a reward or not was confirmed and communicated at the end of the 3 months. We assess the performance of the contributors during the initial 3 months when the reward was active for everyone and after the reward was withdrawn for a sub-sample of the contributors who were confirmed and communicated to at the end of the initial 3 months.

The first part of our empirical analysis shows that expectations about future monetary rewards did not affect participation in the information crowdsourcing initiative during the 3 months when the reward was guaranteed. The outcome variable measured the number of completed and acceptable submissions, that is, submissions that meet the quality threshold required. We find that guaranteeing continued reward correlates with increased effort provision after the initial period. However, this relationship is not statistically significant once we account for the role of expectations. The second part of the analysis shows null heterogeneous effects by loss aversion and altruism.

Our findings contribute to the growing literature on crowdsourcing in agricultural settings and to the nascent literature studying how to motivate individuals engaged in agricultural information crowdsourcing initiatives (Zeug et al., 2017; Graham et al., 2021; Adewopo et al., 2021; Chelanga et al., 2022; Solano-Hermosilla et al., 2022; Hasanain et al., 2023). Most of the related literature focuses on the ability of crowdsourcing initiatives in agricultural information gathering in remote settings at a high frequency. A few authors have examined how providing farmers with crowdsourced information about the quality of services offered and prices charged by agricultural input supplier affects the effort level chosen by the input suppliers (Hasanain et al., 2023). A few others have explicitly studied the incentives for participation in agricultural information crowdsourcing initiatives. A notable example is Solano-Hermosilla et al. (2022), who evaluate the effect of social norms and information disclosure, as nudges, on engagement in a food price crowdsourcing initiative in Nigeria and find a strong effect for social norms and no effect for information disclosure. In the context of this literature, our study provides new empirical evidence on the effect of expectations-based reference dependence (related to uncertainty about future income) on engagement in agricultural information crowdsourcing initiatives and the mechanism underlying such a relationship.

In what follows, the next section describes the pastoral context. We then explain the experimental design and data. The subsequent section discusses the empirical estimation, followed by a section that presents the findings. We conclude with the implications of our findings for policy and future research.

2 Pastoral Context

The experiment was conducted in the Borena zone of Oromia Region in southern Ethiopia. Borena is predominantly a pastoralist setting. While we selected Borena because of recent efforts to pilot an agricultural information crowdsourcing initiative in the zone, we view it as representative of the pastoralist settings and drylands in Ethiopia and the Horn of Africa. Ethiopia has a pastoralist population of 14.7 million people, representing 15% of the total national population (United Nations Economic Commission for Africa, 2017). Livestock contributes 16.5% to the country's gross domestic product (GDP) and 35.6% to the agricultural GDP (Guthiga et al., 2017). Ethiopia has the largest national livestock herd in Africa (comprising camels, cattle, sheep and goats) with an estimated 128.6 million head of animals in

2018 (Food and Agriculture Organization of the United Nations, 2020). Pastoralism is key for food security in Ethiopia: 80% of annual milk supply comes from pastoral systems (Malabo Montpellier Panel, 2020).

Following five consecutive rainy seasons that were relatively dry as compared to expectations, Ethiopia experienced the most severe and protracted drought in recent history during the period 2020–2022. The Borena zone multi-agency rapid assessment report indicates that more than 2.3 million heads of livestock died due to the prolonged drought of 2020–2022, leaving 67,000 households with no livestock and compromising efforts to improve food and nutrition security.

The International Livestock Research Institute (ILRI) and partners have been implementing index-based livestock insurance (IBLI) in Borena since 2012 to address drought impacts. To monitor drought impacts and provide ground truthing data for the normalised difference vegetation index (NDVI), which is used to assess forage conditions and determine payouts for IBLI, ILRI established a "sentinel zones" approach of gathering information in the drylands in Borena zone (Ethiopia) and Marsabit county (Kenya), in 2021 through the Drought Index Insurance for Resilience in the Sahel and Horn of Africa (DIRISHA) project. The sentinel zone was set up to allow monitoring of livestock markets, rangeland transects and pasture availability, and household food security and health. Monitoring is conducted by collecting weekly data using KAZNET—a smartphone application implemented using crowdsourcing techniques (see Chelanga et al., 2022 for a detailed description of KAZNET). ILRI works with community members and uses a participatory approach to select contributors. Selection criteria for the contributors include residence in the identified location for monitoring, availability for the completion of task, knowledge about the use of a smartphone, a good reputation, an ability to communicate with community members in the local language, basic literacy levels, and a general interest in interventions and efforts aimed at supporting the community against drought and related shocks. In addition, contributors are recruited to be people who already have another source of income and therefore do not rely fully on the crowdsourcing initiative. At the market level, contributors collect information about livestock prices, animal body condition, numbers of livestock by species, and prices of basic food commodities. At the rangelands level, information is collected on forage availability and suitability from carefully identified transects. At the household level, the task involved surveying households and recording their food consumption patterns, coping strategies to shocks, milk production and consumption, and livestock production, sales, child health indicator-mid upper arm circumference, and livestock mortality. Contributors receive a small monetary reward (≈USD1) for each successfully submitted task. A contributor is expected to complete nine tasks weekly.

The experiment was embedded in the sentinel zones programme. Scaling efforts for the sentinel zones programme started in August 2022. During scaling, the sentinel zone was expanded to cover all unit areas of insurance (UAIs) in Borena. UAIs are geographical areas defined to be homogeneous in vegetation cover, pastoral experiences, and risk profile, and within which the NDVI is calculated for IBLI payouts.

3 Experimental Design and Description of the Intervention

3.1 Recruiting Contributors

We randomly selected 120 sub-locations *(kebeles)* in Borena and worked with the community leaders to recruit 120 new contributors, one in each *kebele*, in an agricultural information crowdsourcing initiative. We conducted power calculation to obtain an appropriate sample size.[1] We followed the selection criteria developed by ILRI as described in sect. 2, but also required that contributors must own a smartphone. Selected contributors were contacted to confirm their interest in participating in the crowdsourcing initiative. They were then invited to a three-day training course at a specified venue. None of the identified contributors declined the invitation.

3.2 Randomisation

The study implements a randomised controlled trial (RCT) design in which the 120 *kebeles* are randomly assigned to either treatment or control. Contributors in both the treatment and control groups receive training and a guaranteed monetary reward, paid every 2 weeks, for successfully completed tasks during the first 3 months after the initiative is launched. We then generate exogeneous variation in the expectations that contributors hold about the chance of continuing to receive a monetary reward beyond the initial 3 months. Treatment group contributors (high expectations) have a high chance (90%), while the control group contributors (low expectations) have a low chance (10%). It is possible that recruiting contributors who already have another source of income can be a further motivation to participate in the crowdsourcing initiative. However, in our experiment, the same recruitment criteria were applied in both the treatment and control arms. We only varied expectations about future income.

3.3 Expectations Intervention

Training sessions were organised separately for the high and low expectations groups to minimise contamination. We provided both classroom training and practical skills in the markets, rangelands, and household tasks. Practical sessions

[1] We use data from a study that was piloted in the sentinel zones, providing useful summary statistics for a power calculation. Using these, we set the mean total weekly submissions by a contributor at 26, the standard deviation at 11, the number of clusters in one experimental arm at 60, intra-cluster correlation (ICC) at 0.15. We set the significance level at 0.05 and the power of test at 0.8. Under these settings, the sample size of 1 *kebele* in each cluster generates the minimum detectable effect (MDE) of submission by 10%. Our target sample size in each cluster was set at 1 *kebele*.

followed the classroom sessions and involved visiting the contributors in their respective *kebeles* to help them set up transect sites for monitoring rangeland condition.

We implemented expectation manipulation at the end of the classroom training and before the contributors travelled back to their communities for the practical sessions. Contributors were reminded about the job. We emphasised the usefulness of their work and the information that they were being asked to collect, both for their own households and the communities they represented, in terms of informing timely and accurate decision-making and interventions for addressing drought impacts. We used combinations of coloured balls (orange and white balls) to explain the concept of chance. An orange ball represented the chance of not receiving a monetary reward in the future, whereas a white ball represented the chance of continuing to receive a monetary reward in the future. In the high expectations treatment, we presented a combination of one orange ball and nine white balls. Conversely, in the low expectations control group, we presented a combination of nine orange balls and one white ball. Participants were informed that the research team would return at the end of the first 3 months of the information crowdsourcing initiative and that they would be invited to a meeting. We informed them that the combination of balls would be put in a bag and that each contributor would be asked to draw one ball from the bag without looking. Contributors drawing a white ball would continue to receive a monetary reward, and those drawing an orange ball would not continue to receive a monetary reward after the specified 3-month period.

3.4 Chance Confirmation

As promised, contributors were invited to a meeting at the end of the first 3 months. Again, we held separate meetings for the treatment and control groups. During the meeting, balls of different colours corresponding to the combination they had been shown in the first meeting were put in a bag. We used the same balls that had been used to explain the chance earlier; hence, the probability of each person winning or losing was not affected. We shook the bag to mix the balls, then each contributor drew one without looking. Depending on the draw, rewards were either continued or discontinued.

4 Data, Summary Statistics, and Balance

4.1 Data

Data came from a weekly frequency survey implemented in the sentinel site. The surveys were implemented during the period from January 2023 to September 2023. We focus on data submissions over a period of 24 weeks, split into 12 weeks before the monetary reward was withdrawn and another 12 weeks after the reward was withdrawn. We use information from the household, rangeland, and market-level

tasks. The remaining 3 months were not considered because the smartphone application was not functioning properly during that period, while the issue was being addressed by the software developer. In our analysis, the outcome variable measures participation in the agricultural information crowdsourcing initiative using a continuous variable representing the total number of successful submissions by a contributor. This variable, therefore, aggregates submissions across household, rangeland, and market tasks. A task comprises several questions. In case any of the responses to the questions is rejected, the entire task is also rejected. This is because all the questions in a task are related. This means that an error in one question will likely cause an error in another question. The average number of accepted submissions is 48 and 151, in the initial 3 months and after the reward was discontinued for a sub-sample of the contributors, respectively. In addition to the outcome variable, we collected data on the socioeconomic profile of the contributors. This information was collected at baseline. We asked about the sex, age, and education of the contributor. Further questions probed the distance from the contributor's homestead to the nearest market and to the nearest household he or she had been assigned.[2] Data were also collected about the contributor's membership in an association and experience in the use of digital platforms for information gathering. We use these variables to conduct the balancing test to assess if our randomisation worked.

Finally, we measured contributors' degrees of loss aversion and altruism. In the loss aversion game, we asked each contributor to make six choices between a binary lottery and a fixed payment of zero. In each choice, with a 50/50 chance, the lottery paid either 250 Birr or x Birr with $x \in \{-50, -100, -150, -200, -250, -300\}$ in decreasing order.[3] For example, in round one, a contributor was presented with a lottery that gives 250 Birr if lucky but if unlucky the contributor gives 50 Birr instead. The contributor was asked to indicate whether they preferred the lottery over an amount of zero with certainty (i.e. not trying their luck in the lottery). The cutoff value where a subject switches from favouring the lottery to preferring the fixed payment of zero was used to elicit a measure of loss aversion (see also Abeler et al., 2011; Wenner, 2015). The higher the number of safe choices means that the individual prefers the amount of zero with certainty, that is, is unwilling to take the lottery, thereby exhibiting a higher degree of loss aversion. Altruism was measured using an adapted dictator game. Each contributor received 200 Birr, of which a fraction could be donated to a charity organisation helping pastoralists to cope with climatic shocks and improve their livelihoods. We interpret the amount donated as a proxy for the contributor's intrinsic motivation for the cause (see also Shikuku et al., 2019; Carpenter & Myers, 2010). The altruism game preceded the loss aversion

[2] We matched each contributor with six other households.

[3] To ensure that each contributor had money for the loss aversion game, they were invited to participate in a real effort task. Each contributor was provided a printed list of 200 names. Against each name there was a unique identification number that was supposed to contain 11 digits. However, some numbers had errors and contributors were therefore asked to carefully review their lists and identify all the numbers with errors by placing a mark (X) against the number. Contributors received 200 Birr for performing this task. The exercise was aimed at endowing the contributors with cash to ensure they could effectively participate in the loss aversion game.

game, and both were non-hypothetical. We used the loss aversion and altruism variables to assess the heterogeneous effects of expectations about future rewards.

4.2 Sample Characteristics

Table 10.1 presents summary statistics for our sample. Most of the contributors are male (94%); their average age is 31 years, and about 66% have completed college education, while 32% have completed university education. Forty-three per cent of the contributors have conducted a survey using a smartphone. Only 15% of our sample contributors have membership in a livestock marketing group, environmental group, or savings and lending group. The average distance from a contributor's homestead to the livestock market is 27 kilometres. Contributors were residents in the sampled kebeles.

4.3 Balance Checks

To verify that the randomisation resulted in comparable groups of contributors between the treatment and control groups, we conducted balance tests by regressing baseline data on the treatment dummy. According to these balance tests, for all variables, the treatment does not differ significantly from the control group, that is, the group that was assigned low chance of receiving a monetary reward in the future (Table 10.1). A joint significance test between treatment and the control (shown at the bottom of the table) was not statistically significant.

5 Estimation Strategy

Estimation of the effects of expectations about future rewards on participation in the agricultural information crowdsourcing initiative relies on the exogeneous variation generated in the assignment of contributors to high or low expectations. When the stable unit treatment value assumption (SUTVA) is satisfied, random assignment eliminates systematic differences between contributors in the high and low expectations groups and permits unbiased causal inferences based on post-intervention outcomes.

We first examine the effect of expectations on the number of successful submissions during the initial period when the monetary reward was guaranteed. Our regression takes the form:

$$Y_{ik} = \alpha + \beta \text{Expect}_{ik} + C_c + \varepsilon_{ik} \tag{10.1}$$

where Y_{ik} represents the outcome of interest (a continuous variable for the total number of successful submissions) for contributor i in *kebele* k, Expect_{ik} is a dummy variable equal to one if the contributor is located in a *kebele* assigned to the high expectations treatment group and zero if otherwise, C_c represent region fixed effects,

Table 10.1 Randomisation balance on observables

Variable	Whole sample	High expectations	Low expectations	*p*-value of *t*-test
Age (years)	31.02 (6.38)	29.70 (5.48)	31.95 (6.87)	0.164
Contributor is male (1 = yes; 0 = otherwise)	0.94 (0.24)	0.93 (0.27)	0.95 (0.22)	0.670
Contributor's education level is university (1 = yes; 0 = otherwise)	0.32 (0.47)	0.30 (0.47)	0.34 (0.48)	0.702
Contributor's education level is college (1 = yes; 0 = otherwise)	0.66 (0.48)	0.70 (0.47)	0.63 (0.49)	0.560
Contributor's education level is primary (1 = yes; 0 = otherwise)	0.01 (0.12)	0.00 (0.00)	0.02 (0.16)	0.421
Distance to nearest household assigned (minutes)	39.94 (33.63)	28.85 (17.66)	47.24 (39.42)	0.026
Distance to nearest market (km)	26.82 (27.99)	23.96 (25.11)	28.71 (29.88)	0.498
Membership to a group (1 = yes; 0 = otherwise)	0.15 (0.36)	0.07 (0.27)	0.20 (0.40)	0.173
Experience with digital surveys (1 = yes; 0 = otherwise)	0.43 (0.50)	0.33 (0.48)	0.49 (0.51)	0.213
Score in real effort task (%)	64.72 (25.40)	61.73 (26.23)	67.11 (3.06)	0.260
Donation in altruism game (ETB)	64.49 (38.01)	58.17 (35.13)	69.54 (39.70)	0.104
Loss aversion (number of safe choices)	2.73 (1.56)	2.67 (1.70)	2.77 (1.44)	0.746
Observations	117	52	65	
p-value of joint orthogonality test				0.339

Note: In parentheses are standard deviations

and ε_{ik} is the random error term. We use OLS to explain variation in the number of submissions. Throughout, we cluster standard errors at the *kebele* level. We calculate intent-to-treat (ITT) estimates. The coefficient β in Eq. (10.1) measures the causal effect of expectations about future rewards on participation in the agricultural information crowdsourcing initiative under the identifying assumption that Expect_{ik} is orthogonal to ε_{ik}.

Next, we assess the local average treatment effect (LATE), the effort provision effect of continuing to receive a monetary reward for those contributors that were induced to form high expectations by our intervention. We calculate this effect by estimating:

$$Y_{ik} = \alpha + \beta \text{Reward}_{ik} + C_c + \varepsilon_{ik} \tag{10.2}$$

where Reward_{ik} is a binary variable equal to 1 if the contributor was confirmed to continue receiving a monetary reward after the initial period and 0 otherwise. The rest of the variables are as defined in Eq. (10.1). The endogenous decision to continue or discontinue the reward is instrumented with whether or not a contributor was randomly placed in the high expectations group:

$$\text{Reward}_{ik} = \lambda + \rho \text{Expect}_{k} + \upsilon_{ik} \tag{10.3}$$

where the instrument Expect_k is an indicator for the random assignment at the *kebele* level into the treatment (high expectations) or control group (low expectations). First-stage results in Table 10.A1 (in the appendix) verify that the random assignment to high expectations treatment is a powerful predictor of the decision to continue or discontinue the reward.

6 Spillovers and Attrition

Random assignment to treatment implies that identification is satisfied unless there are substantial spillover effects (so the SUTVA is violated). This might happen if contributors in the control group changed their behaviour because of knowing that others had been provided a higher chance of continuing to receive a monetary reward. Yet, spillover effects are shown not to pose a serious threat to our identification strategy. First, several design features help to minimise this risk: (1) we selected only one contributor from each *kebele*, and hence there was only one treatment per *kebele*; (2) contributors attended the training with others who were assigned to the same experimental arm (even if this was not announced to the contributors before the training); and (3) training sessions for different treatment arms were organised at different venues. Second, we formally test for evidence of spillovers. To check whether the submissions by the control group contributors were affected by spillovers, we compare the submissions by the control group contributors who share a common livestock market with a treated contributor and control group contributors who do not share a common market with treated units. Using a border-to-treatment dummy variable, a *t*-test indicates that control group contributors' submissions were not significantly affected by the presence of a neighbour from the treatment arm (Table 10.A2 in the appendix).

Attrition is low (4%) in our study and is not concentrated in a particular treatment arm. The main reason for attrition was that some of the contributors who had attained diploma-level education joined a summer programme that provides opportunities to government employees to advance their studies. A formal test further shows that attrition is not related to the treatment assignment (Table 10.A3 in the appendix).

7 Results

In this section, we present the results. First, we present treatment effects for our experiment. Second, we explore the possible channels of our treatment effects through heterogeneity analyses.

7.1 Effect of Expectations About Future Rewards on Participation in Agricultural Information Crowdsourcing

We now turn to our key regression results. Table 10.2 presents OLS regression estimates to examine the effect of expectations about future rewards on participation in the agricultural information crowdsourcing initiative. We start by looking at participation during the first 3 months when all contributors were guaranteed a monetary reward for their effort, and the value of the information both for themselves and the communities that they represented was made salient to them. Results in Table 10.2 show that expectations about future rewards did not affect data submissions by the contributors (column 1). The estimated coefficients of the expectations variable are small and not statistically significant. A possible explanation for the null expectations effects is that providing an extrinsic reward during the 3 months may have dampened the effect of expectations. While individuals might think and be concerned about the consequences of the withdrawal of the extrinsic rewards, they also know that the discontinuation is not immediate. We speculate that the guaranteed high frequency of payments, that is, every 2 weeks for 3 months, may expand the planning horizon in the minds of the contributors, consequently reducing their discount rates for the future. Therefore, it is possible that guaranteeing the provision of the extrinsic rewards attenuated the effect of expectations.

Next, we examine the effects of expectations about future rewards on participation in the agricultural information crowdsourcing during the phase after the monetary reward was discontinued for a random sub-sample of the contributors, depending on the outcome of chance confirmation. Results are presented in column 2 of Table 10.2. Although the effect is larger relative to that observed in the initial period, it is not statistically significant at the 10% level. This finding suggests that explaining to the contributors about the value of the data for the communities they represented could be more valuable than the short-term monetary gain. In Table 10.3, OLS regression estimates show a positive and statistically significant relationship between confirmed continued reward and effort provision in the crowdsourcing initiative. This is consistent with literature examining the role of extrinsic rewards in labour supply in agriculture (see, for example, BenYishay & Mobarak, 2019; Balew et al., 2023; Shikuku et al., 2019). However, this variable is endogenous, and we interpret the relationship as a correlation. To assess the causal effect of confirmed continued reward on effort provision, we estimate an instrumental variables regression and report LATE estimates. The results are presented in Table 10.4. The estimated effects are slightly larger than those reported in Table 10.2, but not statistically significant at the 10% level. Our findings are consistent with a narrow but rapidly growing literature on the role of expectations-based reference dependence on choice behaviour in agricultural settings. For example, Shikuku et al. (2023) found that while expectations affected bidding behaviour for subjects "trading up" to obtain a high-quality food product, they did not affect bids for subjects "trading down" to give up the novel food item. More broadly, our results align with those of studies seeking to understand the sustainability of agricultural information crowdsourcing

Table 10.2 OLS estimates of the effects of expectations about future rewards on participation in the agricultural information crowdsourcing initiative

	Before reward is withdrawn	After reward is withdrawn
	(1)	(2)
Treatment	7.20 (12.44)	20.93 (40.27)
Region fixed effects	Yes	Yes
Constant	43.08*** (9.45)	140.17*** (29.62)
Control group mean	44.54 [53.64]	142.05 [169.67]
R^2	0.004	0.003
Observations	117	117

Notes: In parentheses, there are robust standard errors clustered at the *kebele* level. In square parentheses are standard deviations of the control group. ***$p < 0.01$. Dependent variable measures the number of successful submissions by the contributors

Table 10.3 Continued monetary reward and contributors' effort

	Dependent variable: total accepted submissions
	(1)
Continued monetary reward	111.30** (48.10)
Region fixed effects	Yes
Constant	111.76*** (28.29)
R^2	0.06
Observations	117

Notes: OLS regression estimates. In parentheses are robust standard errors clustered at the *kebele* level. ***$p<0.01$, **$p<0.05$. The explanatory variable is a dummy variable equal to 1 if the contributor was confirmed to continue receiving a monetary reward after the initial period and 0 otherwise

Table 10.4 2SLS Regression estimates of the effect of expectations about future rewards on participation in the agricultural information crowdsourcing initiative

	Period = After reward is withdrawn
	(1)
Continued monetary reward	37.80 (70.50)
Region fixed effects	Yes
Constant	136.69*** (32.21)
Control group mean	142.05 [169.67]
R^2	0.37
Observations	117

Notes: 2SLS regression estimates. In parentheses are robust standard errors clustered at the *kebele* level. In square parentheses are standard deviations of the control group. ***$p < 0.01$. The dependent variable (number of submissions) is regressed on a binary variable equal to 1 if the contributor was confirmed to continue receiving a monetary reward after the initial period and 0 otherwise. The instrument measures the random assignment to either high or low expectations group

initiatives (e.g. Solano-Hermosilla et al., 2022), indicating the need for considering contributors' expectations when designing such initiatives.

7.2 Heterogeneous Effects

We hypothesised that a contributor's degree of loss aversion and altruism would mediate the effect of expectations about future rewards on participation in the agricultural information crowdsourcing initiative. We divide the sample into two groups based on the median value of the contributors' degree of loss aversion (median = 3) and generate the ITT and LATE estimates using different sub-samples (low and high loss aversion). Similarly, we generate a dummy variable equal to 1 if the contributor donated above the median amount in the dictator game (median = 50) and 0 otherwise. Using this variable, we split the sample into two sub-samples (high and low altruism) for our analysis of the heterogeneous effects of altruism. We conduct the analysis looking at both the initial period during which the material reward was guaranteed and the period after the reward was withdrawn. We report OLS estimates for the former and 2SLS estimates for the latter.

The results of OLS regression estimates are presented in Table 10.5. Columns (1)–(2) present results of heterogeneity by loss aversion, while columns (3)–(4) focus on altruism. We found no differential effects associated with either loss aversion or altruism. The results of 2SLS estimates for the period after the material reward was withdrawn also show null effects of both loss aversion and altruism (Table 10.6).

Table 10.5 Heterogeneous effects of expectations about future rewards by contributors' degree of loss aversion and altruism (prior to the withdrawal of reward)

	Loss aversion		Altruism	
	Low (1)	High (2)	Low (3)	High (4)
Treatment	7.78 (15.43)	5.39 (20.47)	13.60 (16.49)	−10.99 (16.01)
Region fixed effects	18.55 (14.86)	−22.97 (19.60)	−1.52 (16.46)	21.42 (13.54)
Constant	30.92*** (11.74)	62.28*** (15.95)	47.64*** (12.23)	26.71** (10.55)
Control group mean	40.88 [53.48]	50.79 [54.47]	47.03 [53.31]	41.25 [47.61]
R^2	0.03	0.03	0.01	0.06
Observations	74	43	74	43

Notes: OLS estimates. In parentheses are robust standard errors clustered at the *kebele* level. In square parentheses are standard deviations of the control group. ***$p < 0.01$. The dependent variable measures the number of accepted submissions

Table 10.6 Heterogeneous effects of expectations about future rewards by contributors' loss aversion and altruism (after reward was withdrawn)

	Loss aversion		Altruism	
	Low	High	Low	High
Continued monetary reward	37.26 (94.63)	34.00 (101.55)	115.94 (92.67)	−97.47 (86.77)
Region fixed effects	54.03 (48.08)	−75.83 (60.65)	1.03 (47.89)	35.59 (58.40)
Constant	106.92*** (38.86)	184.50*** (53.96)	127.02*** (37.59)	135.88** (61.02)
Control group mean	40.88 [53.48]	50.79 [54.47]	47.03 [53.31]	41.25 [47.61]
R^2	0.36	0.44	0.63	0.32
Observations	74	43	74	43

Notes: 2SLS estimates. In parentheses are robust standard errors clustered at the *kebele* level. In square parentheses are standard deviations of the control group. $^{**}p < 0.05$, $^{***}p < 0.1$. The dependent variable (number of accepted submissions) is regressed on a binary variable equal to 1 if the contributor was confirmed to continue receiving a monetary reward after the initial period and 0 otherwise. The instrument measures the random assignment to either high or low expectations group

8 Conclusion

Agricultural information crowdsourcing initiatives have recently received considerable attention for data gathering in remote settings that tend to be underrepresented in national surveys. The desirability of such initiatives is associated with their ability to collect high-frequency data necessary for the dynamic monitoring of resilience indicators. Agricultural information crowdsourcing initiatives are, therefore, important for informing timely and accurate interventions to address the adverse impacts of shocks and improve livelihoods. However, questions remain about the sustainability of such initiatives. Understanding the responsiveness of effort provision in agricultural crowdsourcing initiatives to extrinsic monetary rewards is a fundamental first step towards identifying scaling pathways.

This study conducts a field experiment to examine the effect of expectations about future rewards as reference points for effort provision in an agricultural information crowdsourcing initiative in southern Ethiopia. The study further probes the mediating role of loss aversion and altruism. Our results show that expectations about future monetary rewards did not affect participation in the information crowdsourcing initiative, both during the 3 months when the reward was guaranteed and after the reward was withdrawn for a random sub-sample of the contributors. Guaranteeing continued reward correlated with increased effort provision by the contributors after the initial period. However, this relationship disappeared after the role of expectations was considered. Our findings suggest that when contributors are informed in advance, before starting work, about uncertainty about future rewards, and if the value of the information collected is made salient, effort

provision in an agricultural crowdsourcing initiative will not be influenced by expectations-based reference dependence.

Finally, a few points warrant consideration. The contributors in our study were nominated by community members and may not be a typical representation of pastoralists in the Horn of Africa. For example, our contributors are better educated than a typical pastoralist. As such, while the internal validity of our findings holds, the results particularly on observed behaviour and participation may not be generalisable to a wider context in SSA. Second, the requirement that the contributors must have smartphones may attract relatively wealthier people in the communities. In that case, the motivation for 1 USD every 2 weeks may not have been significant. Third, we did not communicate the value of the data to the contributors personally. Therefore, the implications of that on effort provision are not known. Fourth, there is a need for a long-term impact assessment study to assess whether effort provision is sustainable in the long term.

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Appendices

Table 10.A1 First-stage regression: continued monetary reward as a function of treatment assignment

	Dependent variable: dummy variable equal to one if contributor was confirmed to continue receiving a monetary reward
	(1)
High expectations	0.55***
	(0.07)
Region fixed effects	Yes
Constant	0.09**
	(0.04)
R^2	0.56
Observations	117

Notes: In parentheses are robust standard errors clustered at the *kebele* level. ***p<0.01, **p<0.05. Table displays first-stage results for the regressions displayed in Tables 10.4 and 10.6

Table 10.A2 Test for spillover effects: T-test using a border-to-treatment dummy variable

	Without potential spillover	With potential spillover	*p*-value of difference in means
	(1)	(2)	(3)
Total number of accepted submissions	79.67 (51.22)	81.76 (52.33)	0.914

Notes: Results of a *t*-test. In parentheses are standard deviations

Table 10.A3 Relationship between attrition and treatment assignment

	Dependent variable = 1 if attrition is present and 0 otherwise
	(1)
Treatment assignment	−0.09 (0.42)
Constant	−1.68*** (0.27)
R^2	0.001
Observations	117

Notes: Probit regression. In parentheses are robust standard errors. ***p<10.0.01

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11 Behavioural Nudges and Farmers' Demand and Diffusion of Agricultural Innovations in Urban and Peri-Urban Food Systems

Julius J. Okello, Carl-Johan Lagerkvist, Sylvester O. Ojwang, and Jens Rommel

Abstract

Urban and peri-urban food systems in developing countries can strengthen household resilience and improve access to fresh produce, yet productivity is often limited by weak extension services and low adoption of quality seed. This study investigates whether social incentive nudges—public recognition—combined with goal setting influence demand for improved sweetpotato seed and knowledge diffusion among model farmers in the Katakwi district of Uganda. A cluster-randomised controlled trial (RCT) was conducted in 17 villages (184 farmers), with treatment farmers receiving both agronomic training and social nudges while control farmers received agronomic training only. Experimental auctions revealed that nudges unexpectedly reduced willingness to pay for the locally widely grown Ejumula variety and had negative, though insignificant, effects on other varieties, suggesting an over-justification effect. However, nudges substantially enhanced knowledge sharing, secondary diffusion, and information-seeking. Findings highlight the context-dependent nature of behavioural nudges and underscore the value of farmer training for informal farmer-farmer extension to be effective in a resource-constrained urban food systems environment.

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Keywords

Behavioural nudges · Social incentives · Urban and peri-urban agriculture · Adoption of quality seed · Knowledge diffusion · Uganda

1 Introduction

The urban and peri-urban food environment in developing countries is undergoing rapid changes (Ruel et al., 2020). In larger cities, these changes are being driven by urbanisation, shifts in consumption patterns caused by lifestyle changes, and income growth among the middle-class population (Fanzo & Davis, 2021). In the smaller urban centres and settlements, the changes are driven by increasing population caused by, among others, urbanisation and migration (De Bruin et al., 2021). The changes are increasing the demand for food commodities.

Traditionally, however, the urban and peri-urban food (UPF) system environment has been characterised by the trade of food produced in rural farming areas. Thus, changes in demand imply that tons of fresh/raw food are hauled over long distances to the urban centres at high transportation costs and increased damage to the environment from greenhouse gas emissions (Li et al., 2022). The bulkiness and perishability of raw/fresh foods also increase transaction costs.

UPF production has the advantage of reducing the cost of supplying food to urban consumers because of the lower haul distance, hence reduced transportation and transaction costs. In addition, food arrives in fresh form onto the market, which increases its appeal to consumers. Lagerkvist et al. (2012), for instance, found that urban consumers prefer fresh, good-looking vegetables. Further, studies indicate that UPF strengthens the resilience of low-income households to cope with food price changes driven by seasonality as demonstrated by Sabiiti et al. (2014) for Kampala city in Uganda.

Interest in urban food production gained momentum in the early 2000s with the launch of a global effort to strengthen agriculture in urban spaces. This coalesced into the creation of a Consultative Group for International Agricultural Research (CGIAR) Initiative known as the Urban Harvest. The goal of the initiative was, among others, to establish 'a more adequate food supply and increase the value of agricultural production' (King'ori, 2004). It aimed to increase the productivity and sustainability of urban and peri-urban food production systems by customising agricultural production technologies for application to different urban and peri-urban environments. Uganda was among the countries that participated in this initiative. The initiative's major outcome was to be the reduction in food insecurity and poverty. With more than two decades of effort, a recent meta-analysis by Payen et al. (2022) indicates that a majority of research on crop productivity in the UPF systems has focused on vegetables and neglected caloric staples that are also widely grown in the same environment.

At least two key factors are driving the prominence of vegetables in urban and peri-urban food environments. Firstly, vegetables have higher market value, hence attracting many farmers as a source of both food and income (Drechsel & Dongus, 2010; Badami & Ramankutty, 2015). Secondly, vegetables tend to sell much faster but are also much more perishable than other crops.

Although the UPF system is generally viewed as being important in addressing food security and poverty challenges of poor urban households, government investment in promoting it has been rather dismal (Frayne et al., 2014). Most developing-country governments are, however, still ambivalent about full support for farming in the urban and peri-urban environments (Dixon & Richards, 2016). This ambivalence stems from at least three reasons. First is the conflict in land use between farming and other economic uses with higher value than agriculture (Drechsel & Dongus, 2010). Second, there is often the feeling among high- and middle-high income urban dwellers that agriculture is a rural practice and has a negative image that lowers property values (Bouvier, 2014; Battersby, 2016). Third, some studies suggest that urban farming has negative hygiene and health effects, resulting from the use of unsafe water in food production and providing a habitat for mosquitoes to breed (Matthys et al., 2010; De Silva & Marshall, 2012; Mattah et al., 2017). Thus, some countries treat UPF production as 'de jure and de facto illegal' (Davies et al., 2021).

The above factors have contributed to lack of support for UPF production through investment in productive inputs needed to intensify production, given the limited space by governments. This includes the lack of extension services and poor access to other productivity-enhancing agricultural inputs. Mkwambisi et al. (2011), for instance, argue that the lack of agricultural extension services is a major constraint to UPF production, especially among low-income women farmers, and recommend the need to provide it. Frayne et al. (2014) also emphasise the importance of ensuring access to inputs and extension services by urban and peri-urban farmers. Moreover, despite its importance in creating awareness and communicating the benefits of agricultural innovations, public extension systems have remained weak in most developing countries (Takahashi et al., 2020).

To address the above weakness, focus has been directed, in recent years, to the role incentivised model/progressive farmers can play in disseminating knowledge about agricultural innovations to other farmers in their network. For instance, Shikuku and Melesse (2020) examined the role trained peer farmers can play in diffusing knowledge about climate-smart agriculture when provided with incentives framed as nudges. That is, incentives are benignly framed to influence choice decisions in a predictable way without significantly changing economic incentives (Thaler & Sunstein, 2009, p. 6). Okello et al. (2023) assessed the effect of nudging model farmers already involved in technology transfer activities on demand for improved crop varieties. Like Shikuku and Melesse (2020), their study used social incentives as the nudge. Balew et al. (2023) examine the effect of loss-framed nudges (i.e. loss aversion) and targeting leaders of farmer groups on the diffusion of integrated pest management practices. Beaman et al. (2021), on the other hand,

investigated the role central farmers in social networks can play in diffusing agricultural information. These authors, except for Okello et al. (2023), found that providing incentives in form of nudges influences the effort applied by these non-governmental extensionists in disseminating knowledge and technology. They examined economic and social forms of incentives.

In this chapter, we use data collected from farmers in UPF production environments to explore how behavioural nudges can be used to spur the adoption and diffusion of agricultural innovations among urban and peri-urban farmers. This chapter addresses two research questions:

1. What is the effect of social incentive nudges on the adoption of quality seed of improved crop varieties by urban and peri-urban farmers?
2. What role can social incentive nudges play in the farmer-to-farmer exchange of knowledge and good agricultural practices in the UPF production environment?

This chapter draws data from a study implemented in the Katakwi district of the Eastern region of Uganda and involved smallholder sweetpotato farmers. It uses a subsample of the data collected by Okello et al. (2023) and was used to assess the role of social incentives and goal setting on willingness to pay for quality seed of improved sweetpotato varieties. The subsample used in this chapter focused on households residing and farming in urban and peri-urban farming environments of the district and who grow sweetpotato in such environments. This chapter therefore builds on the findings of Okello et al. (2023) by identifying factors, in addition to social incentive nudges, that affect demand for quality seed. It also examines the diffusion of knowledge within a social network activated by participation in the initial activities of the project.

The study focuses on sweetpotato farmers because sweetpotato is a major food staple in Uganda. It is consumed by households across the country, including urban areas, with annual per capita consumption estimated to be 85 kg (Low et al., 2009). It was chosen for three reasons. First, it is widely grown as a cultural crop, with most households in the study district using it to make cultural food known as *amukeke*, which is stored and consumed during the dry period. Second, farmers grow sweetpotato also as a commercial crop, especially during the first season during which it is either consumed fresh or sold to local and long-distance traders, making it a food and income security crop. Third, a recent meta-analysis by Payen et al. (2022) found that very few past studies on crop production within the UPF production environment have focused on other staple food crops such as sweetpotato, with a majority focusing on vegetables.

The rest of this chapter is organised as follows. The next section describes the study context relating to urban and peri-urban farming and sweetpotato farming in Katakwi. This is followed by a description of the study methods and data used to address the two research questions above. Next, we present the findings and finally provide conclusions.

2 Definitions and Study Background

2.1 Urban and Peri-Urban Agriculture

While the literature on urban peri-urban food production is recent, farming in cities is a very old phenomenon (Gallaher et al., 2013). Archaeological evidence suggests that urban agriculture probably originated in Egypt (Janick, 2010). One of the simplest definitions of urban and peri-urban agriculture describes it 'as agriculture in and around cities' (FAO, 1996). The definition recognises that UPF production competes with other industries for resources (land, water, energy, labour) while meeting the requirements of the urban populations. Drechsel and Dongus (2010) distinguish two forms of urban and peri-urban agriculture, namely, (i) open-space production of high-value products on undeveloped urban land and (ii) mostly subsistence gardening in backyards. However, this classification of the UPF production system into two groups masks the various other forms urban and peri-urban farming take. For instance, one would expect to find several farmers who grow crops in open spaces that are undeveloped purely for household subsistence needs and not necessarily for sale. Similarly, with intensive use of inputs, backyard farms can generate more produce than can be absorbed by a household, resulting in sales. A more encompassing definition by Davies et al. (2021) states that UPF production is the 'growing of crops and raising small livestock on land within the urban boundaries of cities and towns (e.g., home gardens, vacant lots, roadsides, and balconies) for household consumption or sale in urban markets' (p. 1). In this chapter, we adopt Davies' definition and focus on farmers who live within delineated areas in and around the UPF production environment. Specifically, following the literature, we define a UPF production environment as farming occurring in or within 3–5 kilometres of urban centres (Simon, 2008; Tacoli, 1998; Kombe, 2005; Lwasa, 2012). Urban centres, in our case, include the district town, county, sub-county, and parish.

Most of the existing studies on urban and peri-urban agriculture have been conducted in large cities (Obudho & Foeken, 1999; Omondi et al., 2017). There is much less literature and evidence on urban and peri-urban farming in smaller urban centres. For instance, Urban Harvest, the CGIAR Initiative, focused on major cities, including Kampala in Uganda; Nairobi, Kisumu, and Nakuru in Kenya; Yaoundé in Cameroon; Dhaka in Bangladesh; and Bogota in Columbia (Prain et al., 2010; Amin & Rahman, 2014; Moustier & Renting, 2015). The study reported in this chapter was conducted in urban and peri-urban areas of Katakwi district. Katakwi is in the Teso sub-region of Eastern Uganda. The district borders Karamoja region and lies in the transition zone of dry and slightly wetter part of eastern Uganda. It suffered from political unrest that displaced many families, forcing some to settle in urban centres. It has the lowest population density in Teso region, estimated at 109 persons/sq. km by the 2024 population census.[1] Farming is openly and widely practised in all the urban centres of the district, including the district headquarters. Households

[1] https://www.ubos.org/explore-statistics/

practise crop, livestock, and even fisheries[2] production. Kitchen gardens and small crop plots are commonplace in all urban centres, with vegetables, sweetpotato, and maize dominating. Field crops grown in the peri-urban areas include cereals (maize, millet, sorghum), root and tuber crops (sweetpotato, cassava), and legumes (especially groundnuts and soybean). Sweetpotato, as the second most important food staple after cassava in the district, is widely grown in both the urban and peri-urban areas.

2.2 Behavioural Nudges

There are multiple definitions of behavioural nudges in literature. Congiu and Moscati (2022) define nudges as 'an intervention in the decisional context that steers people's decisions by acting on their cognitive biases'. More specifically, they state, following Thaler and Sunstein (2009, p. 9) that a nudge is any 'intervention in the "choice architecture," that is, in the structure of the decision context, that "alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives," with the intervention remaining "easy and cheap to avoid" (Congiu and Moscati, 2022, p. 189–190). In their simplest form, behavioural nudges refer to the alteration of the choice environment to influence/direct choices in a predictable direction. The application of the nudge theory in agriculture dates to the seminal study in Kenya by Duflo (2011). The study tested the effect of present bias nudges on the purchase and application of fertiliser on maize in Kenya. Since then, the application of the nudge theory in agriculture has been growing, albeit slowly and mostly in developed countries (Wuepper et al., 2023). For instance, Wuepper et al. (2023) report that farmers in Germany, France, and the USA responded to nudges of different forms. Khanna et al. (2017), in their US study, indicate that loss-framed nudges induce loss aversion that in turn increases the use of efficient water management techniques. Chabé-Ferret et al. (2019) find that social comparison nudges reduce water consumption of the heaviest water users in southwest France. Peth et al. (2018) demonstrated that bundled nudges combining information and picture-based social comparison induce compliance with environmental restrictions relating to water quality protection from non-point source farm-fertiliser-based pollution among farmers in Germany. While testing the likelihood of the crowding-out effect of using multiple nudges in tandem in a UK farm environment, Howley and Ocean (2022) find that a combination of social norm and status signalling nudges increases the intention among farm managers to adopt ICT-based agricultural technologies. Their study focused on social (injunctive) norm nudges. Davidson and Goodrich (2023) examine the role of information nudges in the adoption of farm insurance in the northeast and southeast USA and find that framing insurance as a risk management strategy increased uptake. Notably, most studies on nudges in agriculture have been conducted in developed countries. Our

[2] Fish farming is one of the activities being promoted by the national government as income and food security venture.

study therefore is among the few that focus on the application of behavioural nudges in developing-country agriculture.

3 Study Area, Sampling, and Data

This chapter draws data from a study implemented as a cluster randomised controlled trial with two study groups, henceforth referred to as treatment and control. Clustering was done at the village level. The study targeted all the counties and sub-counties. In each sub-county, 61 parishes/wards[3] were randomly selected from the 20 sub-counties proportionate to the size of the sub-county. Within each parish/ward, one village was randomly selected and assigned to the treatment arm. Lastly, 11 households were sampled in each village, and the member responsible for sweetpotato production decisions in each of the sampled households was invited to participate in the auction event. In addition, one model farmer was selected in each village with the help of local government staff to act as the disseminating farmer (DF). The criteria used for the selection of the DF are outlined in Okello et al. (2023). The DFs were offered a one-day in-class and field training on sweetpotato vine production, broadly covering agronomic, marketing, and utilisation aspects. Agronomic training emphasised the use and sources of quality sweetpotato seed; yield advantage associated with planting quality seed; quality seed production specifications and growth monitoring; moisture and nutrient management; harvesting and postharvest management; diagnosis and control of pests and diseases, especially weevils and sweetpotato virus diseases (SPVD); the health benefits of the biofortified orange-fleshed sweetpotato (OFSP); and the costs and expected payoffs of planting improved variety compared with the local varieties. The seed production practices were practically demonstrated in the field.

At the end of field training, every DF from each treatment and control village was matched with the 11 randomly selected farmers in their village (i.e. their co-villagers) and asked to share the knowledge obtained during in-class and field training with them. After matching with their co-villagers, the DFs from treatment villages received social incentives while those in control did not. Specifically, the treatment DFs were as follows: i) promised a reward if they put effort into reaching 11 co-villagers, and ii) asked to set a goal (i.e. write down) on how they would reach their co-villagers. The reward/social incentive comprised a handshake by the top-ranking government official in the district in recognition of effort and having photos of the highest performers mounted in the district agricultural office. The DFs from the treatment and control groups were trained on separate days to avoid contamination. Each DF received a small amount of money to cover the costs of transportation to the training venue. The study team met the costs of field visits (transport, snacks

[3] In Uganda, parishes and wards are the same administratively. The former is used for rural areas while the latter is for urban areas. Data used in this chapter were drawn from wards but included parishes within 5 km radius from urban centers to serve as peri-urban.

and meals). After about three weeks, DFs and co-villagers were then invited to participate in an auction event held in their village.

Data were collected in three survey rounds. The first round was a survey administered to each auction participant before the auction event using a pre-auction questionnaire. It included modules about farmer and household characteristics, membership to farmer groups, social networks, preferences for sweetpotato planting materials, household income and assets, knowledge about sweetpotato farming, and risk preferences. The second round of data collection involved administering a post-auction questionnaire after the auction event. The questionnaire collected data about sweetpotato farming practices, farmer perceptions of production constraints, pest and disease incidence, trust, and information about the interaction between the DFs and other farmers. The first two rounds of data collection were implemented in April 2023. Four sweetpotato varieties (products) were used in the study, namely, Ejumula, NASPOT 13, Tanzania, and NAROSPOT 1. These varieties are described in Chap. 6 of this volume. During each auction event, the auction team presented a detailed description of the seed of each variety and its quality/health status and showed visuals of some of the pests and diseases and quality characteristics found in seed from local sources.

The auctions were conducted at the beginning of the season to enable farmers to plant the vines purchased immediately during that season. The third round of data collection was, on the other hand, implemented in November/December of 2023, that is, after 6 months, and after two seasons of sweetpotato production. It aimed to assess the diffusion of information about the quality seed and agronomic practices farmers obtained during the auction. Thus, data captured knowledge-sharing, information-seeking behaviour, and farmer characteristics in terms of prosocial behaviour.

In addition to participating in auction events, all the respondents also participated in a dictator game designed to measure their altruistic behaviour. The game asked farmers to donate to a charitable initiative that would support other farmers in need. The procedure used is outlined in Box 11.1.

Box 11.1 Measuring Altruism—The Dictator Game

The dictator game is used to assess an individual's prosocial behaviour. Accounting for this aspect is especially important because sharing knowledge with other farmers, as anticipated by the treatment in this study, requires farmers to be social and philanthropic with their time. This study designed a game that asked respondents to voluntarily donate towards a charitable venture. Each respondent was given Uganda Shillings (UGX) 5000 as an appreciation for the effort in completing the auction surveys. They were asked to choose how much of the sum received they would donate and informed that they had the liberty to keep whatever they decided for themselves, including the whole amount. Donations were to go to charity organisations such as Welt Hunger Life, World Vision, and the Soroti Catholic Diocese Development Organisation (SOCADIDO), which works with farmers to train them about new farming methods. SOCADIDO is a local charity run by the

(continued)

Box 11.1 (continued)

Catholic Church and has supported crop and livestock production projects in the district, hence well known to farmers.

Donating was made confidentially in a provided envelope with a number reflecting the farmers' identification known only to the research team. These data on altruism (based on amounts donated) were collected separately six months after participation in the auction.

The data used for the analysis in this chapter are a subsample of data collection in the three phases described above and are limited to farmers that live and grow sweetpotato in UPF production environment.

3.1 Analytical Approach

Four different varieties of sweetpotato were presented for bidding to farmers. The demand for these varieties can be assessed by fitting individual regression models for each and applying the appropriate econometric technique to estimate the effect of treatment (social nudge incentives) on the bid. Since the dependent variable is continuous, an Ordinary Least Squares (OLS) regression technique can be applied. However, the auction participants' knowledge that four different varieties are to be presented for the bidding process is likely to influence bidding decisions. Thus, the bid price of one variety is likely to be correlated with that of another. In other words, error terms of the different regression equations for the different varieties are likely to be correlated, making the coefficient estimates imprecise. Therefore, following Mwiti et al. (2020), a seemingly unrelated regression (SURE) model was fitted to account for and address such correlations. The general model fitted is specified as:

$$WTPi = X\beta + \mu$$

where WTP_i for $i = 1, 2, 3, 4$ are the willingness to pay bids for four varieties in the estimated equations, one for each variety, X is a vector of explanatory variables, which can differ for the different equations, β is a vector of coefficients, and μ are the error terms.

The variables entering the estimated regression model are presented in Table 11.1.

3.2 Characteristics of Study Farmers and Farm Settings

Table 11.2 presents the characteristics of the respondents and farm, and the demand for various varieties measured in terms of willingness to pay. It also presents the institutional factors and production practices relating to sweetpotato production. Notably, the only significant difference in willingness to pay (WTP) for quality seed between treatment and control groups is found in Ejumula, a variety that is native to

Table 11.1 Definitions of variables used in the empirical estimations

Variable name	Description
Dependent variable	
WTPejumula	Willingness to pay for a bundle of 200 vine cuttings of the Ejumula variety in UGX
WTPtanzania	Willingness to pay for a bundle of 200 vine cuttings of the Tanzania variety in UGX
WTPnarospot1	Willingness to pay for a bundle of 200 vine cuttings of the Narospot 1 variety in UGX
WTPnaspot13	Willingness to pay for a bundle of 200 vine cuttings of the Naspot 13 variety in UGX
Location	
county	Categorical variable for counties: 1 = Ngariam county; 2 = Toroma county; 3 = Usuk county
Socio-demographics	
sex	A dummy variable equal to 1 if the respondent is male; 0 if female
age	Age of the respondent in years
educ	Number of years of formal education
hhdsize	Total number of individuals who lived in the household consecutively in the last 6 months
mjr_above5yr	Dummy variable with 1 if most of the household members are aged 5 years and older; 0 otherwise
under2yr	Dummy variable with 1 if a household member has a member aged under 2 years old; 0 otherwise
assets	Asset wealth status categories are computed by generating quintiles from the first principal component resulting from principal component analysis of 12 indicator variables measuring on-farm and off-farm asset ownership by the household as: 1 = Very poor; 2 = Poor; 3 = Middle; 4 = Rich; 5 = Very rich.
Farm production practices	
rentland	Dummy variable equal to 1 if the household rents land for sweetpotato farming; 0 otherwise
varsplanted	Count of sweetpotato varieties planted in the last 2 years
seedreplace	Categorical variable for frequency of seed/vine replacement measured as 1 = At most every other season; 2 = Every 2 seasons; 3 = Every 3–4 seasons; 4 = Every 5 and more seasons; 5 = Never.
growseason	Binary variable for the primary season in which household engaged in sweetpotato production 1 = first season (March/May); 2 = second season (July/September)
Capacity and institutional factors	
knowdvm	Dummy variable with 1 if the respondent is aware of a trained sweetpotato vine multiplier; 0 otherwise
lndistmaket	Natural log of distance to nearest market measured in walking minutes
agronotrain	Dummy variable with 1 if the farmer has ever received agronomic and/or agricultural training; 0 otherwise
groupmember	Dummy variable with 1 if the respondent is a member of a farmer group; 0 otherwise

(continued)

Table 11.1 (continued)

Variable name	Description
creditaccess	Dummy variable with 1 if the respondent had access to a savings and credit scheme in the last 2 years; 0 otherwise
adopbehav	Categorical variable capturing innovation adoption behaviour measured as 1 = innovator, 2 = early adopter, 3 = early majority, 4 = late majority, 5 = laggards
trustagroinfo	Categorical variable capturing the degree of trust in agronomic information given at the auction event and measured on a 5-point Likert scale as 1 = strongly distrust; 2 = distrust; 3 = neither trust nor distrust; 4 = trust; 5 = strongly trust
trustpestinfo	Categorical variable capturing the degree of trust in pest and disease resistance information given at the auction event and measured on a 5-point Likert scale as 1 = strongly distrust; 2 = distrust; 3 = neither trust nor distrust; 4 = trust; 5 = strongly trust
altruism	Indicator of the farmers' prosocial (altruistic) behaviour, measured by their donation in a Dictator game with an endowment of UGX 5000. Coded 1 if the respondent's donation equals or exceeds the median amount (UGX 2000), thus altruistic; 0 otherwise.

UGX Uganda Shillings; The exchange rate was UGX 3500 = 1 US Dollar at the time of the survey

the district. The results however show, contrary to expectations, that farmers in the control group had higher demand (WTP) for quality seed of Ejumula varieties than their treatment counterparts. Differences between treatment and control group are also observed regarding location, socio-demographic factors, production practices, and capacity and institutional factors. In terms of socio-demographic characteristics, the results show that the treatment group had, on average, higher age and fewer women than the control group. The treatment group differed from the control regarding production practices but only in replacing seed. The former replaced their seed after 3–4 cropping seasons, while the latter did so after only about two cropping seasons. There were larger differences between the treatment and control groups with respect to capacity and institutional variables. The two groups differed in distance to market from the farm, participation in farmer groups, access to credit, and altruism, that is, prosocial behaviour. They did not differ with respect to the other variables in the table.

3.3 Findings

Drivers of Demand for Quality Seed

The results of the econometric model estimated to assess the factors driving the demand for quality seed of the four improved sweetpotato varieties are presented in Table 11.3. The very low *p*-values (0.000) across all the estimated equations indicate that there are indeed correlations in willingness to pay bid/values among the four varieties. Turning to demand, Table 11.3 shows that the only variety for which there is a different and statistically significant demand between the treatment and

Table 11.2 Characteristics of the urban and peri-urban farmers who participated in auction events, by study group

	Control (n = 83)	Treatment (n = 101)	Mean difference (control − treatment)	t-statistic
Dependent variables				
WTPejumula	4221.69	3397.03	824.66*	1.80
WTPtanzania	4283.13	3667.33	615.81	1.27
WTPnarospot 1	4219.28	3666.34	552.94	0.87
WTPnaspot13	4768.07	3903.96	864.11	1.59
Location variable				
County—Ngariam	0.47	0.25	0.22***	3.18
Toroma	0.21	0.48	−0.27***	−4.04
Usuk	0.33	0.28	0.05	0.70
Socio-demographics				
sex	0.77	0.59	0.18***	2.62
age	40.96	45.27	−4.30*	−1.88
educ	6.36	5.99	0.37	0.60
hhdsize	7.98	7.61	0.36	0.69
mjr_above5yr	0.84	0.88	−0.04	−0.73
under2yr	0.58	0.52	0.05	0.72
assets	2.99	3.01	−0.02	−0.11
Farm production practices				
rentland	0.10	0.11	−0.01	−0.28
varsplanted	1.78	1.67	0.11	0.64
seedreplace	2.57	2.91	−0.35*	−1.66
growseason	1.36	1.32	0.045	0.63
Capacity and institutional factors				
knowdvm	0.23	0.17	0.061	1.02
lndistmaket	3.91	3.56	0.343***	2.63
agronotrain	0.13	0.16	−0.03	−0.50
groupmember	0.25	0.14	0.11*	1.93
creditaccess	0.74	0.58	0.15**	2.18
adopbehav	1.47	1.36	0.11	1.06
auction_order	8.30	9.55	−1.25*	−1.71
trustagroinfo	4.31	4.34	−0.02	−0.21
trustpestinfo	4.21	4.25	−0.04	−0.30
altruism	0.36	0.50	−0.13*	−1.83

The exchange rate was UGX 3500 = 1 US Dollar at the time of the survey; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

control groups is *Ejumula*. The coefficient is negative, indicating that the nudges reduced willingness to pay.

The treatment group paid, on average, UGX 945 less than the control group for the bundle of 200 vine cuttings (each 30 centimetres long). The finding suggests that the nudge, rather than increasing demand, actually served to decrease it. Okello et al. (2023) found the same result using the larger dataset from which our sample

Table 11.3 Factors driving willingness to pay for quality seed of improved sweetpotato varieties auctioned in urban and peri-urban environment

	(1)	(2)	(3)	(4)
	Ejumula	Tanzania	NAROSPOT 1	NASPOT 13
treatment	−945.3** (458.8)	−303.2 (485.5)	−225.6 (664.0)	−549.1 (543.6)
County[a]: Toroma	564.7 (543.5)	−636.8 (567.5)	226.0 (789.2)	−74.12 (633.4)
Usuk	−1486.5*** (542.6)	−1921.0*** (564.9)	−1924.8** (781.4)	−1267.3** (631.2)
sex	−209.6 (491.0)	−101.4 (501.2)	460.4 (719.9)	214.4 (584.4)
age		−14.54 (11.51)	−16.35 (19.02)	
educ	55.63 (44.71)		61.04 (68.65)	105.2* (54.01)
hhdsize	60.55 (48.27)	15.25 (52.81)	37.55 (81.80)	
mjr_above5yr	464.7 (619.6)	913.0 (649.7)	703.6 (895.5)	676.4 (738.0)
assets				−103.2 (147.0)
rentland		−305.8 (524.9)		
varsplanted	424.8*** (138.4)			
seedreplace	151.6 (153.0)	−137.3 (159.2)	−22.92 (219.4)	−339.4* (178.6)
growseason	259.1 (368.9)			−941.0** (439.7)
knowdvm	−494.6 (467.3)	910.1* (466.1)		
lndistmaket		−205.5 (180.1)		
agronotrain	968.5* (497.6)	815.4* (494.3)		
groupmember	828.8 (549.3)	479.1 (523.4)		1381.4** (602.8)
creditaccess	368.6 (455.0)	869.3* (478.2)	1403.2** (656.6)	658.1 (541.8)
adopbehav			−218.2 (384.3)	
trustagroinfo			480.9 (366.0)	
trustpestinfo			130.3 (289.6)	128.1 (199.7)
altruism	−106.6 (441.5)	−124.0 (462.0)	−1059.4* (637.3)	184.1 (521.4)
_cons	1565.8 (1171.8)	4973.2*** (1362.7)	941.4 (2775.7)	4812.6*** (1597.0)
Observations	184	184	184	184
Parameters	15	15	14	13
F	3.395	2.807	1.788	2.567
P-value	0.000	0.000	0.037	0.002
RMSE	2893.4	3043.9	4207.2	3404.0
R-squared	0.175	0.176	0.111	0.135
AIC	13847.5			
BIC	14043.6			

[a]Ngariam county was treated as the base county in the model. Standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

is drawn. They attribute the finding to the principle of over-justification, which refers to the tendency of individuals to withhold effort when they feel that their prosocial behaviour is being over-justified. The study used model farmers who already enjoyed a lot of publicity from the local government for their support in deploying public and NGO-funded development programmes. Therefore, the promise of public recognition may not have been a sufficient incentive for them to invest

their effort in sharing knowledge obtained from the training with their co-villagers. Demand (willingness to pay) for Tanzania, Narospot 1, and Naspot 13 also decreased, signalling the same effect, but the coefficients are not statistically significant.

Several factors influenced the demand for quality seeds of the Ejumula variety. They include the location of the farmer, number of varieties planted (*varsplanted*), participation in farmer group activities, and having received agronomic training. Other things constant, being in Usuk and not Ngariam county, reduced the willingness to pay by UGX 1487 (i.e. 50 US cents). Usuk county was the closest in proximity to the district headquarters and probably benefited from government programmes, including those involving seed distribution, because of the tendency of such activities to target farmers that are closer to main towns with better infrastructure. Chambers (1983) highlighted this bias in development targeting in his famous book, *Rural Development: Putting the Last First*. Additionally, this study was conducted one season after the World Bank had distributed vines of orange-fleshed sweetpotato varieties in the neighbouring Kapelebyong district. This may have had a dampening effect on demand for the improved varieties presented at the auction.

The factors driving demand for quality seed of the Tanzania variety are presented in the third column. As in the case of Ejumula, being located in Usuk, reduced farmers' bid for Tanzania, but by an even bigger amount (UGX 1921). Demand for quality seed was also influenced by training in agronomy, access to credit, and awareness of a vine multiplier (i.e. source of vines). Holding other factors constant, agronomic training, access to credit, and awareness of vine source increased demand by UGX 815, UGX 869 and UGX 910, respectively. It is noteworthy that credit access increases demand for quality seed of this variety. Bayiyana et al. (2024) and Okello et al. (forthcoming in this book) discuss the difficulty farmers face in purchasing quality seed due to liquidity constraints. Further, this significance of agronomic training highlights the need for farmers to learn about production practices that accompany the use of improved varieties. This especially relates to the strategies for maintaining seed quality on the farm.

The fourth column presents the factors affecting willingness to pay for quality seed of Narospot 1. Unlike the first two varieties, Narospot 1 was a new introduction in the district, hence a priori unfamiliar to farmers. It, too, has a lower demand among farmers living in Usuk than those in Ngariam, a reduction in willingness to pay by UGX 1925. Holding other factors constant, access to credit increased demand for quality seed of this variety by UGX 1403 while trust in information provided during the auction increased demand by UGX 480. This finding that credit access results in an increased likelihood of purchase of this crop variety corroborates the results of Bayiyana et al. (2024), who argue that farmers often use poor-quality seed because of liquidity constraints.

Lastly, the last column presents the drivers of demand for quality seed of Naspot 13. Just like Narospot 1, Naspot 13 was a new introduction to the study area. Farmers, therefore, encountered these varieties for the first time at the auction event. As in the first three cases, being in Usuk rather than Ngariam county reduced the willingness to pay bids for Naspot 13. In this case, the reduction was by UGX 1267.

Results also show that an additional year of formal education increases willingness to pay by about UGX 105, other things constant. This finding is in line with a priori expectation. Given that the bids were based on information received from DF and/or during the auction, more educated farmers are likely to understand the benefits of using quality seed of this variety better, hence bid higher. As expected, the variable *seedreplace* is negative and statistically significant, indicating that the longer a farmer takes to replace seed, the lower the bid. The results specifically show that an increase in the number of seasons taken before the decision to replace seed by one unit reduces the willingness to pay bid for Naspot 13 by UGX 339 (i.e. about 0.1 USD), other things constant. The results further show that variable *growseason* is negative and statistically significant, implying that planting sweetpotato in the second season reduces the willingness to pay for Naspot 13. This finding is also in line with a priori expectation. In the study district, farmers, in the second season, typically grow white or cream-fleshed sweetpotato varieties that are typically chipped, dried and stored for later use. The fact that Naspot 13 is orange-fleshed and therefore does not fit in with the local food system for farmers who plant sweetpotato in the second season may, therefore, have contributed to this penalisation of its seed.

Role of Social Incentive Nudges in Farmer-Farmer Knowledge-Sharing

The pathway by which demand for quality seed in this study was to be activated was via sharing of information learned from the training (by DFs). The DFs were to reach out to co-villagers with information based on the knowledge gained from the training they received. Additionally, during auction events, information about the superior attributes of the varieties presented over the local counterparts was provided to both DF and co-villagers. Therefore, the study activated a network of farmers' knowledge and information-sharing about quality seed of improved sweetpotato varieties. In this section, we explore how knowledge and information were transmitted by the study participants and the differences between farmers in the treatment and control groups in doing so.

Figure 11.1 shows the different methods used by the DFs to reach out to co-villagers in the UPF production environment with agricultural information, as well as the proportion of farmers reached through those means. Most of the DFs passed information mainly through in-person meetings either at their homes or farmers' homes. A few DFs took advantage of chance meetings in the market, church, or mosque to pass information to co-villagers. These methods of information transfer are the most frequently used channels for the diffusion of knowledge in social networks (Zheng et al., 2019; Roo et al., 2023). Notably, a higher proportion of farmers in the treatment group in our sample was reached with information through individual in-person interactions at their homes or farms. On the contrary, a larger percentage of control group farmers obtained information from their DFs in group settings.

Among the different aspects of training covered during the DF training, the most transmitted information was agronomic in nature, as shown by the top five topics discussed by the DFs. Market and nutrition information came next. Surprisingly,

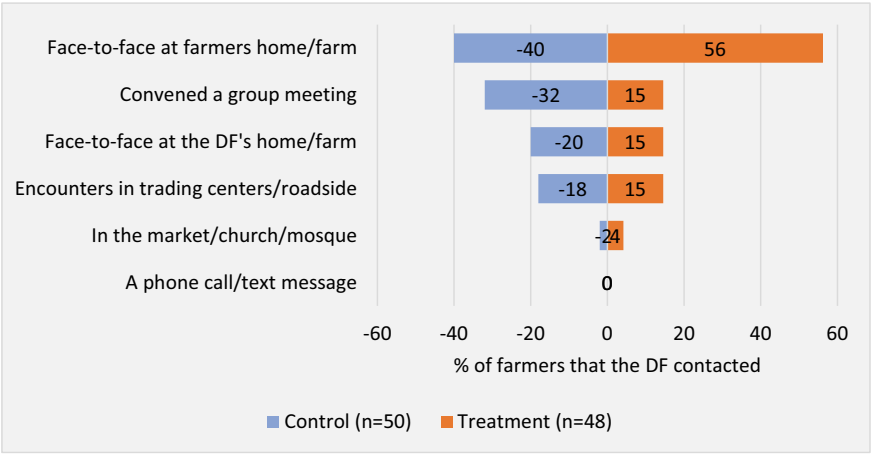


Fig. 11.1 Information-sharing methods among study farmers

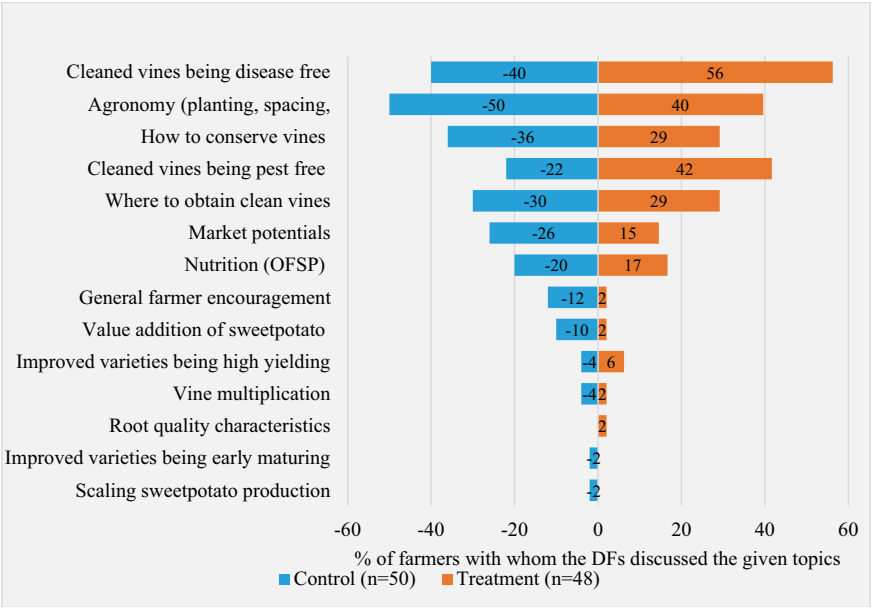


Fig. 11.2 Information farmers could recall from discussions with DFs

only a small proportion of farmers in both treatment and control groups mentioned the higher-yielding ability of quality seed. Figure 11.2 further indicates that there were differences between the treatment and control groups in what was learned from the interaction with DFs. While a higher proportion of the treatment group learned about quality seed being disease and pest free, it was the opposite for the case of agronomy and vine conservation.

Did farmers share the knowledge obtained from the DFs with other farmers? That is, was there a secondary wave of knowledge diffusion kicked off by interaction with the DFs? If so, were there differences in knowledge dissemination between treatment and control groups? The results in Table 11.4 address these questions. They show that co-villagers indeed shared information with other farmers. In addition, a higher proportion of co-villagers in the treatment group shared knowledge learned from DF with other farmers in their network. As shown by the p-value of the test of difference in proportions, the dissemination effort by the treatment group co-villagers was higher and statistically significantly different from the control group. The number of other farmers reached by each co-villager through this secondary wave of information dissemination averaged four persons for both treatment and control groups. Hence, while more treatment group co-villagers disseminated knowledge obtained, the dissemination effort (in terms of people reached) was the same for both groups.

Of interest, also, in this study was whether farmers sought information from the DF or other auction participants after the auction event, and if there were differences in information-seeking behaviour. That is, what was the source of information shared? As shown in Table 11.5, more than 60% of the farmers in both the treatment and control groups sought farming information from about two people. There are no statistical differences in information-seeking behaviour between the treatment and control groups. That is, social incentive nudges did not induce differences in information-seeking behaviour between farmers in the treatment and control villages of the urban and peri-urban production environments. Further, there are no differences in information-seeking behaviour relating to sweetpotato farming between the two groups.

Table 11.4 Proportion (%) of farmers who shared what they learned from the DFs with other farmers

	Control (n = 83)	Treatment (n = 101)	p-value
Farmer shared what was learned from DF with other farmers	28.0	47.9	0.04
Number of other farmers with whom knowledge learned from DF was shared	4.00 (1.71)	4.39 (3.60)	0.71

Table 11.5 Farmers who sought information from other farmers after the auction events

	Control (n = 83)	Treatment (n = 101)	p-value
Farmer sought agricultural information from others (1 = yes)	68.7	60.4	0.24
Number of people from whom agricultural information was sought (count)	1.66 (1.91)	1.53 (1.65)	0.63
Farmer sought agricultural information specific to sweetpotato farming (n = 118; 1 = yes)	87.8	83.1	0.27
DF sought agricultural information from others (n = 17; 1 = yes)	42.9	90.0	0.04

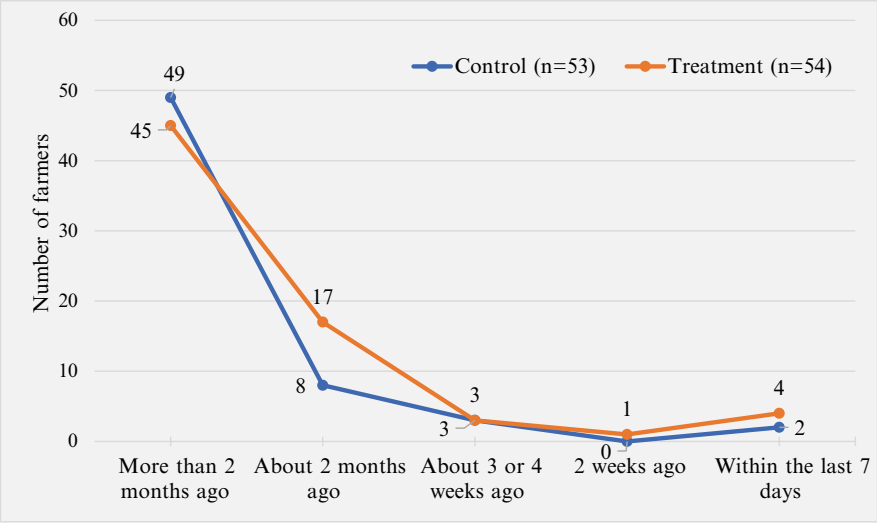


Fig. 11.3 Trends in information-seeking behaviour among auction participants

There was, however, a statistically significant difference in information-seeking behaviour among the DFs in the treatment and control villages. Ninety per cent of the DFs in the treatment group sought information about quality seed after the auction event compared to less than half of those in the control group. DFs sought information from multiple sources, including fellow DFs, agricultural extension staff, and the research team.

Information-seeking behaviour was high in the months immediately following the auctions but declined quite steadily after. As shown in Fig. 11.3, the proportion of farmers who sought information about sweetpotato more than 2 months prior to the follow-up study (i.e. about 4 months after auction) was much higher than those who did so at or just before the follow-up study. This suggests a tendency for decline in interest with time. However, the high interest 2 months prior to the follow-up study could be because this period covers the second planting season when interest in and demand for vines is expected to be high.

4 Summary, Conclusions, and Implications

This chapter examined the effect of social incentive nudges on demand for quality seed of four improved sweetpotato varieties and on information and knowledge diffusion. It finds that social incentives had a rather unexpected effect on willingness to pay for seeds of the improved varieties. The incentives reduced demand for all the varieties. However, it is only in the case of *Ejumula*, a variety native to the study district, that this effect was statistically significant. This chapter further finds that training the model farmers and asking them to reach out and train co-villagers, in

turn, may have activated a secondary wave of information-sharing by the co-villagers with other farmers. Moreover, co-villagers and the trained model farmers, the DFs, actively sought information about agriculture in general, and sweetpotato production as well. Based on these findings, the study concludes that social incentives failed to increase demand for quality seed. However, this failure is likely because the reward did not provide a sufficiently high incentive to motivate participating model farmers to perform assigned tasks, because they already enjoyed significant social recognition from the government. This finding implies the need for further studies to understand the nature of social nudge incentives required to motivate model farmers, especially those who already enjoy a significant level of recognition and status with the government, to disseminate agricultural innovations. More importantly, the findings imply that the outcome of social nudge incentives is influenced by the context in which they are applied.

This study also concludes that social incentive nudges may be useful in inducing information-sharing behaviour among farmers. Two important implications arise from the findings about information-seeking and -sharing behaviours. Specifically, the finding that social incentive nudges induced differential effects on knowledge-sharing has significant implications for policy and practice. In terms of policy, the finding implies that investment in training model farmers on new agricultural innovations has a positive multiplier effect regarding outreach efforts. This effect can then be amplified with well-designed social incentive nudges. In terms of practice, the finding suggests the importance of targeted social incentive nudges that are sufficiently rewarding to motivate the desired level of effort needed to perform assigned tasks.

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Part IV

Synthesis and Future Directions



12 Planning, Aggregating, and Generalising Experimental Nudging Evidence in Agricultural Impact Evaluation

Jens Rommel

Abstract

This chapter investigates the potential of nudging for agricultural development from a meta-science perspective. We start by exploring the available evidence on nudging in non-agricultural domains. Modest effect sizes of nudging interventions are found in academic studies, but even more so if applied by practitioners at scale. We continue by scrutinising nudging interventions for promoting agricultural development from this perspective and derive three main conclusions. First, academic nudging studies in the domain of agricultural development should expect small effect sizes, implying that sample sizes should be large, and designs should be well documented and replicable to allow for an aggregation of evidence. Second, under high fixed cost, nudging studies for agricultural development, from the outset, must consider how interventions would scale up. Third, nudging studies should evaluate cost-effectiveness: for low-cost interventions, even small effects can add up at scale, while non-scalable interventions may not pass cost-effectiveness thresholds. Newly emerging digital platforms are a promising area for nudging interventions, ensuring that behavioural interventions benefit farmers and society rather than private sector providers of digital platforms is a key task for the regulator.

Keywords

Randomised controlled trials (RCT) · Meta-science · Experimental design · Power analysis

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1 Introduction

There is growing recognition that behavioural factors are important drivers of farmers' behaviour (Colen et al., 2016, 2024; Dessart et al., 2019; Palm-Forster & Messer, 2021; Shukla et al., 2023; Wuepper et al., 2023). Yet, the use of these insights for agricultural policymaking and practice is limited. While there are hundreds of behaviourally informed interventions by academics and international organisations in various domains (Lourenço et al., 2016; OECD, 2017; Mertens et al., 2022), there are only a few studies addressing the causal impact of behaviourally informed interventions in agricultural policy (Dessart et al., 2019; Čop & Njavro, 2024).

Effect sizes of behaviourally informed interventions tend to be very small (Hummel & Maedche, 2019; DellaVigna & Linos, 2022) to a degree where they cannot be distinguished from zero (Maier et al., 2022). This does not imply, however, that behaviourally informed interventions are generally not cost-effective. Unlike traditional policy instruments such as taxes and subsidies (which need authorities to implement them) or regulation (which has to be monitored and enforced), the cost of implementing behaviourally informed interventions is oftentimes small. As argued and evidenced for instance by Chabé-Ferret et al. (2023), even small positive individual effects can add up, achieving a net-positive benefit-to-cost ratio for behaviourally informed low-cost interventions. Behaviourally informed interventions may sometimes have a high fixed cost component of developing the interventions, but they are usually marked by very low or zero marginal cost. For instance, printing information on a package or changing the default setting in a form can be achieved at very low or even zero marginal cost.

The objective of this chapter is to discuss several challenges that emerge from small effect sizes and a heterogeneous and scattered literature on behaviourally informed interventions for agricultural policymaking. Behaviourally informed interventions include all efforts to promote a certain outcome behaviour without altering incentives substantially. They, hence, include nudges, but also information provision studies. Potential remedies and best practices are offered to address these challenges. The examples will refer to behaviourally informed interventions that address farmers in low-income countries and lower-middle-income countries. While the issues discussed in this chapter may be more generally applicable, focusing on a specific field allows me to work with examples.

In Sect. 2, I will start by reviewing the evidence as presented in a recent review by Čop and Njavro (2024). I will then discuss two critical general points. First, I will argue that we must think more about the statistical power of experimental designs at the outset when designing behavioural interventions. This allows for future evaluations. I will then offer a primer to power calculations and some reflections on how to improve statistical power when designing a study (Sect. 3). This section will also argue that pre-registration of research designs can facilitate early feedback and enhance the quality of research. Second, I will discuss how we, as researchers, must think more critically about generalisation and aggregation of evidence (Sect. 4). Without sharing data and documenting materials, it will be difficult to critically

assess how a given finding would generalise. The main point of this section is that for many studies we lack important contextual details. Both sections provide references and practical guidance. In Sect. 5, I will draw conclusions.

2 What Do We Know About Nudging Farmers in Low- and Middle-Income Countries?

Nudges build on behavioural economics insights. They exploit well-known human heuristics and biases, such as the endowment effect or status quo bias, to steer people's decisions in a direction that may be generally and socially perceived as positive, such as healthy or pro-environmental behaviours (Thaler & Sunstein, 2008). A key principle of nudging is that the available options are not reduced and that the cost of choosing a particular option is not substantially altered, thus maintaining the original choice set of the targeted behaviour. Nudging has gained traction in policy circles, with the UK establishing a Behavioural Insights Team in 2010, followed by other governments and institutions, including the United States of America and Germany. Applications cover a wide range of domains and include programmes to address malnutrition in school canteens, enrolment into retirement plans, or the adoption of environmentally friendly practices. While many see nudges as cost-effective tools for lasting behaviour change (Brandon et al., 2017), critics question their effectiveness when they go against one's preferences (Lorko et al., 2025) and worry they might overshadow more impactful policies (Hagmann et al., 2019). Concerns also include democratic legitimacy and the risk of manipulation (Lepenies & Małecka, 2015; Lusk, 2014; Sugden, 2017). Yet, behaviourally informed policy interventions are increasingly applied, often in tandem with traditional policy instruments (Bowles & Polania-Reyes, 2012; Rode et al., 2015).

A recent review by Čop and Njavro (2024) systematically investigated the academic literature on nudge interventions among farmers. The review was rather narrowly focused on nudges and nudging in the keyword search. It may therefore have missed behaviourally informed interventions that do not subscribe to this label, but the arguments in this chapter are broad enough to apply also to other studies. Čop and Njavro (2024) identified only 53 studies applying nudging in the field of food and agriculture in the *Web of Science* database for the period 2003 to 2023. Out of these, 31 studies were dealing with farmers and their decisions, whereas the remaining 22 dealt with consumer and food choices. A majority of the 33 farmer studies focus on high-income countries and upper middle-income countries. Notably, only six studies with farmers took place in low or lower middle-income countries (Meemken et al., 2017; Belay & Ayalew, 2020; My et al., 2022; Solano-Hermosilla et al., 2022; Lopes et al., 2023; Balew et al., 2023; Okello et al., 2023). Two studies took place in Asia (Lopes et al., 2023 study rice straw burning as a cause of air pollution in India; My et al., 2022 study network effects in organic farming adoption in Vietnam). The remaining studies all took place in Africa, with Solano-Hermosilla et al. (2022) focusing on market pricing in Nigeria and all remaining studies having

a regional focus in East Africa. The studies span from agricultural training and technology adoption to market price information and environmental awareness.

For this chapter, we are only concerned with experimental studies, using an experimental design with randomly assigned treatments to study real-world outcomes of a behaviourally informed intervention. This excludes studies based on naturally occurring variation in observational data, stated preferences studies, and framed field experiments. In particular, Meemken et al. (2017) who use a stated preferences approach (a Discrete Choice Experiment), Belay and Ayalew (2020) who exploit a natural experiment, and My et al. (2022) using a framed field experiments are not considered in the overview of studies using an experimental intervention and real-world outcome in Table 12.1.

Although the number of studies is limited, they illustrate how nudges can steer decisions in various settings, serving as valuable examples for the points discussed. However, the limited scope and geographical concentration of these studies suggest the need for broader research to fully understand nudging's impact across diverse environments.

Table 12.1 Overview of experimental nudging studies with farmers

References	Main research question	Nudge	Main finding	Sample size
Balew et al. (2023)	How does message framing affect information spread on new agricultural technologies in social networks among Ethiopian farmers?	Framing of information	Statistically significant positive effect on learning; no statistically significant effect on uptake	1684 follow farmers
Lopes et al. (2023)	How does information framing of information affect rice straw burning among Indian farmers?	Framing of information (social norms and gain-loss frame)	Complementarity between cash compensation and information nudges	300 farmers
Solano-Hermosilla et al. (2022)	How can Nigerian farmers be nudged to use more price information?	Social norm-based nudge and informational nudge	Positive statistically significant effect of social-norm nudge	377 farmers for the main phase
Okello et al. (2023)	Do social incentives for disseminating farmers encourage uptake of improved seeds among farmers in Uganda?	Social recognition and goal setting for disseminating farmers	No statistically significant positive impact of the nudge	586 follow farmers

Adapted from Čop and Njavro (2024)

Note: Sample sizes are reported for the main analysis, that is, attrition or missing values are considered. Some studies include additional treatments with financial incentives; these are not discussed in the table, as the focus is on the behaviourally informed interventions here

3 Statistical Power and Its Experimental Design Implications

Power calculations estimate the probability that a statistical test will correctly detect a true effect, assuming one exists. For a given test or model, the key inputs are the expected effect size, sample size, and the chosen significance level (α). Statistical power reflects how sensitive a test is at distinguishing the null from the alternative hypothesis. When standard formulas are not feasible—due to complex designs or assumptions—simulation-based approaches allow researchers to empirically estimate power by repeatedly generating data under specified conditions.

Low statistical power increases the risk of a type II error—that is, failing to detect an effect that actually exists. While a type II error rate (β) of 20% is commonly accepted, this threshold should be context-dependent. For example, consider testing an intervention that adds warning labels to pesticide packaging. If this intervention reduces harmful exposure, failing to detect its benefit (a type II error) could carry serious health consequences. In such cases, the cost of missing a real effect—known as the loss function—can inform how much power (and thus sample size or study budget) is justified. The higher the potential cost of a missed effect, the greater the value in designing a study capable of detecting even small but important effects.

Reviews of the general economics literature (McCloskey & Ziliak, 1996; Ziliak & McCloskey, 2004) and the agricultural economics literature (Rommel & Weltin, 2021; Ferraro & Shukla, 2023) show that empirical studies rarely engage in a discussion of statistical power or type II error. Partly this may be explained by a lack of knowledge in the Agricultural Economics community (Heckelei et al., 2023) and established routines and support for open science practices in journals (Finger et al., 2025). Hence, I shortly review some basics here.

Power calculations for simple tests can be easily performed. They rely on four key inputs: the statistical test or model the researcher plans to apply, alpha (the type I error rate), typically set to 5%, the expected effect size or the minimum detectable effect that is meaningful from a policy perspective, and the sample size. If power is set to 80%, any of the other parameters can be the outcome of a power calculation. For instance, one could calculate the alpha error or the minimum detectable effect size.

A very common problem is to calculate the necessary sample given a test, alpha, beta, and effect size. For instance, consider the simple example of a two-sided t-test for unpaired data and a small assumed standardised effect size of Cohen's d of 0.1.[1] In a between-subjects treatment-control experiment (participants are either assigned to treatment or control) with a metric and normally distributed outcome, the required sample size for a type I error rate of 5% and a power of 80% is already 1571 per group, that is, a total of 3142.[2]

[1] Cohen's d is a measure of a difference between treatment and control divided by the variability in the data. It is hence a normalised measure of an effect size.

[2] To run this calculation (for a two-sided t-test for unpaired data) in Stata use *power two means 1 1.1, sd (1)*. For understanding the non-linearity, try the same with half the effect size (of $d = 0.05$) by using *power two means 1 1.05, sd (1)* which leads to a four-fold increase in the required sample size of 6281 per treatment.

Even such simple calculations can be useful to understand that detecting small effects needs large samples. While in some instances, it may be possible to work with one-sided hypothesis tests (assuming the treatment improves the outcome), thereby increasing the statistical power, there are many practical complications, such as oddly shaped outcome variable distributions, multiple hypothesis testing, or clustered randomisation (e.g. Hemming et al., 2011; List et al., 2019), that *decrease* the statistical power. Furthermore, it should be clear that all the studies presented in Table 12.1 would not have sufficient statistical power (80%) to detect small effects of $d = 0.1$ or below, which is roughly in line with some of the meta-analytical estimates that correct for publication bias (Maier et al., 2022).

The book of Ellis (2010) discusses many of the basic principles of statistical power analysis and meta-analysis. Tools like G*Power (Faul et al., 2007) help with calculations of intermediate complexity for instance for various types of regression models. Simulations offer the estimation of power for more complex designs by generating synthetic datasets under an assumed data-generating process (Arnold et al., 2011; Bellemare et al., 2016). A summary of the approach when simulating power is provided in the box (Box 12.1).

Box 12.1: Steps in Setting Up Power Simulations

1. Define your statistical test or model. What is being tested (e.g. *t*-test, regression)?
2. Specify assumptions: Effect size, sample size per group, standard deviation, α level, (joint) distributions of outcome variables and relevant co-variates.
3. Simulate data under your assumptions: Generate many random samples for each group/treatment based on expected distributions.
4. Run the test on each of the many simulated datasets and count the number of significant results with $p < \alpha$.
5. Approximate power by calculating the number of significant tests divided by the total number of simulations.
6. Vary assumptions to check robustness, such as different effect sizes, variances, distributional assumptions of outcomes and co-variates, or sample sizes.

Several factors that can influence statistical power are under the control of the researcher. First, the number of treatments can often be reduced. Other things being equal, in a between-subjects experimental design, having fewer treatments will result in a larger sample size per treatment and hence in larger statistical power. Removing intermediate levels in favour of having polarised treatments with sharp contrast is one way to achieve this goal. Second, sharply contrasted treatments also have the largest chance of resulting in a large effect size. Hence, selecting the most powerful treatment-control combinations is important under sample size budget

constraints. Thirdly, other things being equal, less noise in the data increases effect sizes. Using a more homogenous sample or improving instructions and measurement instruments to avoid confusion can then lead to an increase in statistical power.

Finally, researchers should consider collaboration with partners to obtain large samples for the study of behaviourally informed interventions. For instance, Milkman et al. (2022) collaborate with Walmart to estimate the impact of text messages on Covid-19 vaccine uptake. This collaboration gives the authors access to 680,000 respondents. Such a "mega-study" approach (Milkman et al., 2021) substantially boosts the statistical power and allows researchers to test several interventions with potentially small, yet cost-effective, effect sizes. Another example is the study of List et al. (2023) who show that exploiting a left-digit bias in the pricing of ride shares on the Lyft platform can save the company millions of dollars every year, showing that seemingly small behavioural biases can aggregate at large scales. While, as of now, such applications in the field of agricultural development may be difficult to run, collaborating with authorities can lead to reasonably large samples (e.g. Chabé-Ferret et al., 2023). Furthermore, with the increasing adoption of information and communication technology, larger and high-resolution datasets will become more widely available, offering new opportunities for testing behaviourally informed interventions in large samples with repeated observations. An obvious risk is that these studies will only happen when the collaborating organisation has a stake in the study and that experimental designs will be driven by the organisation's interest. Building trustful relationships and establishing a culture of experimentation in organisations is therefore crucial (Ferraro et al., 2023).

Adaptive experimental designs can be a useful tool to reduce the number of treatments in large and long-term-oriented experiments or in online experiments with larger samples and frequent outcome measures. In such designs, the assignment of experimental treatments is not static but depends on the estimated treatment effect gathered *during* the experiment. As new information from the experiment becomes available either continuously or as part of a multi-stage trial design, the probability to assign a treatment changes (Kasy & Sautmann, 2021; Jobjörnsson et al., 2023). One idea for policy experiments is to start from many potential treatments and to decrease the probability of being sampled for a treatment (potentially to zero) when treatments do not prove sufficiently effective given their estimated effect or benefit-to-cost ratio. This helps the researcher to develop statistically more powerful designs, that is, there is a higher chance of finding an effect or a lower cost of collecting data.

Pre-analysis plans and pre-registration—although part of the broader open science movement—are increasingly used to commit to good research practices, ensure transparency, and avoid specifying models and tests with the goal of obtaining statistically significant results—so-called p-hacking (Arpinon & Espinosa, 2023). Specifying, before data are being collected, the hypotheses, sample size, effect size, and analysis methods can improve the credibility and reproducibility of research (Heckelei et al., 2023; Arpinon & Lefebvre, 2025). Notably, some of the studies presented in Table 12.1 are not pre-registered, and few of them discuss their statistical power.

4 Aggregation and Generalisation of Nudging Evidence

One of the goals of an experimental impact evaluation is to generalise beyond the context of a single study. When we, as researchers, find an effective behaviourally informed intervention for a given context, we want to know whether the intervention also works elsewhere and whether the effect sizes are of similar size. This allows us to assess the upscaling potential. It is especially important for implementors of development interventions, such as non-governmental organisations, farm advisors, and other practitioners, who might want to apply outcomes of such behavioural interventions in other contexts. However, it is often difficult to draw these conclusions from published literature. To begin with, researchers may intentionally or unintentionally set up their studies with participants who show a strong response to the treatment. Further, researchers may collaborate with partners that are unusually committed, creating success stories that cannot be replicated or up-scaled (List, 2022). While these practices can be useful to explore the upper bound of the potential impact of a behaviourally informed intervention, they also limit the generalisability of the published evidence. Publication bias—the selection for large and statistically significant effects—may further aggravate the upward bias of effect size estimates, and, indeed, there is increasing evidence that academic studies show smaller effects when implemented in the real world at scale (DellaVigna & Linos, 2022).

An important implication of the lack of generalisation is for researchers to discuss and document the idiosyncrasies of a specific study design. For instance, Peters et al. (2018) make this point for the broader experimental literature in development economics. By asking seven yes-or-no-questions (Box 12.2) to 54 studies, they find major shortcomings and room for improvement in documenting study designs.

Box 12.2: Seven Questions on Generalisability, Directly Quoted from Peters et al. (2018, pp. 42–43)

1. Does the paper explicitly say whether participants are aware (or not) of being part of an experiment or a study?
2. If people are aware of being part of an experiment or a study, does the paper (try to) account for Hawthorne or John Henry effects[3] (in the design of the study, in the interpretation of the treatment/mechanisms, or in the interpretation of the size of the impact)?
3. Does the paper explicitly discuss what might happen if the program is scaled up?
4. Does the paper explicitly discuss if and how the treatment effect might change in the long run?

(continued)

Box 12.2 (continued)

5. Does the paper explicitly discuss the policy population (to which the findings are generalised) or potential restrictions on generalising results from the study population?[3]
6. Does the paper discuss particularities of how the randomised treatment was provided in demarcation to a (potential) real-world intervention?
7. Who is the implementation partner of the RCT[**]?

The first two questions refer to participant awareness and its consequences. Only if this question is answered, can readers and others assess to what extent a specific effect size estimate may be an artefact of an idiosyncratic design or subtle biases that would not be present when interventions are scaled up. For instance, the Hawthorne effect is a change in behaviour in response to awareness of being studied as a research participant. Being aware of the experimental treatments can lead to experimenter demand effects of various kinds (Zizzo, 2010). Likewise, the so-called John Henry effect refers to unusual changes in behaviour when becoming aware of being assigned to a control group in an experiment.

The third and fourth questions refer to the paper discussing how the intervention may scale up, such as long-term or general equilibrium effects. For instance, an intervention may have short-lived initial success, but in the long run, the effects may wane off. A training programme may increase incomes in a small-scale trial, but if the intervention is scaled up, part of the positive effect for the targeted group could be eaten up by increased competition in general equilibrium.

The fifth question refers to the potential differences between the study and the policy population. For instance, an intervention may be implemented in collaboration with an NGO that builds on an established network of partners for conducting the study, but the policy population may be a broader and more general population for which some of the impacts may differ.

The sixth question refers to the way the intervention is implemented in a trial. For instance, special training or advice may be part of an experimental impact evaluation of a new agricultural technology, but the same training or advice may not be part of an up-scaled programme.

[3] *Hawthorne effects* refer to the phenomenon that participants in an experiment sometimes alter their behaviour when being observed. *John Henry effects* occur when participants' knowledge of being assigned to an experimental control group affects the behavioural outcome under investigation. [**] RCT = randomised controlled trial, that is, an experiment that studies real-world behavioural outcomes under randomly assigned treatments.

Finally, the seventh question refers to the partners that help implement an intervention in a trial. For example, randomised impact evaluations are often performed in close collaboration with NGOs, but these NGOs may not work across a region or country. Hence, if up-scaled interventions would potentially involve a different set of partners, this should be reflected upon.

Summing up, it is important to provide a thorough discussion and transparent documentation of how the estimation of the impact of behaviourally informed interventions comes about. A related issue is the overall assessment of costs and benefits of an impact assessment. To estimate an intervention's cost-effectiveness, researchers should discuss the individual economic benefits associated with an intervention as well as the fixed and variable (per participant) costs in implementing the intervention. A positive example is Chabé-Ferret et al. (2023), who discuss the cost-effectiveness of social norm-based nudging in information letters to French farmers.

5 Conclusion

This chapter has made two major points. First, researchers should engage more with statistical power and open research practices. Low statistical power increases the likelihood of missing out on important effects, which can be particularly costly for interventions that would successfully scale up. Researchers can mitigate this risk by optimising study designs, such as reducing treatment groups, improving measurement precision, or collaborating with partners to achieve larger sample sizes. Notably, researchers, when starting from economic theory, are often interested in singling out the effects of smaller interventions or studying the interaction of interventions, potentially leading to many treatments with small effects. In contrast, practitioners are often interested in the aggregate effect of complex bundled and supposedly more impactful interventions. Being aware of these trade-offs that also impact the statistical power and identification of causal effects is crucial, as the failure to consider statistical power can lead to studies that overlook important findings (type II error) or that find non-existing effects (type I error), ultimately affecting the validity and impact of the research. Tools like adaptive experimental designs can help improve power, and pre-analysis plans can ensure that studies produce credible results.

Second, the generalisability of behaviourally informed interventions is often limited by study-specific factors, such as participant selection, committed partners, and publication bias, which can lead to inflated effect sizes. The ideal situation would be that outcomes of such interventions can and should be scaled up by development practitioners, for which a priori consideration is required during design. To address this, researchers should thoroughly document study designs and consider factors like participant awareness, scalability, and the differences between study and policy populations. Transparent reporting, including cost-effectiveness assessments, is crucial for understanding the true impact of these interventions.

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From Evidence to Action: Synthesis of Behavioural Insights for Agricultural Innovation in Low- and Middle-Income Countries

13

Julius J. Okello, Hugo Campos, David R. Just, and Carl-Johan Lagerkvist

Abstract

There is growing anxiety over global food security, akin to that of the 1960s, driven by predictions that food demand will rise 35%–50% by 2050. Despite significant investments in the CGIAR and related agricultural research organisations estimated at $60 billion between 1970 and 2020, adoption rates for innovations—like improved seeds and vaccines, among others—remain stubbornly low, often below 40%. This dismal performance is attributed to the failure of traditional "rational" economic models to account for the human element that dictate farmer behaviour and hence innovation uptake such as the psychological biases, social norms, and cultural contexts. In this book, we demonstrate the role that behavioural science interventions can play in stimulating adoption of best-bet agricultural innovations. The book argues that the application of nudge theory—a behavioural science approach that uses low-cost, subtle cues to influence decision-making without restricting choice—can significantly contribute to increased innovation use and adoption among smallholder farmers in low- and middle-income countries. While successfully applied in health and finance and developed countries, its use in developing-country agriculture is nascent but promising. By shifting focus from purely technical solutions to behavioural "nudges" like text message reminders or social signalling, the book aims to

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provide a framework for jumpstarting productivity. Its main premise is that understanding the cognitive and social processes of smallholder farmers is essential to achieving inclusive, sustainable, and equitable global agrifood systems.

Keywords

Behavioural sciences · Nudges · Innovation · Technology Adoption · Agricultural research

1 Introduction

This final chapter provides a synopsis of the evidence and the lessons from preceding individual chapters. While each chapter has focused on particular aspects of behavioural interventions in agriculture, here we highlight cross-cutting themes, identify overarching lessons, and articulate these within the broader landscape of agricultural innovation. The aim here is not only to review what has been established but also to highlight key lessons for policy, practice, and future research.

The underlying thesis of this chapter, as also outlined by Zilberman et al. in Chap. 2, is that behavioural interventions can drive the use of agricultural innovation by recognising the human dimensions of decision-making processes. Agricultural innovations—whether products such as improved seed varieties, livestock vaccines, or services such as digital advisory platforms—do not operate in a vacuum. Their diffusion and uptake are shaped by farmers' perceptions, biases, social networks, cultural norms, and the context in which everyday decisions are made. As widely acknowledged, the classical economic theory of rational behaviour is inadequate in explaining why promising innovations sometimes fail to be adopted or why adoption proceeds unevenly across communities (Rogers, 2003; Kremer et al., 2019). By integrating the tools of behavioural economics, psychology, and sociology, researchers and practitioners can better account for these dynamics and design interventions that are more context-sensitive, equitable, and effective and have greater odds of being adopted (Thaler & Sunstein, 2008; Duflo et al., 2011).

This chapter speaks directly to three key audiences: policymakers, development practitioners, and academia. For policymakers, including politicians and senior government officers, the synthesis demonstrates how behavioural approaches can inform cost-effective, politically feasible, and highly effective agricultural strategies. For development practitioners—NGOs, donor agencies, and project implementers—it offers practical lessons grounded in evidence about embedding behavioural interventions into programme design, monitoring, and scaling. For the academic community, including students, scholars, and faculty, this chapter highlights theoretical contributions, methodological challenges, and opportunities for interdisciplinary research at the intersection of behavioural and agricultural sciences (Kremer et al., 2019; BenYishay & Mobarak, 2019).

This chapter is organised as follows. First, we present a high-level synthesis of the overarching lessons that emerge from the book as a whole, drawing on the

foundational frameworks presented in Part I. Second, we highlight three key domains—livestock systems, crop systems, and extension or digital platforms—covered in the book and illustrate how behavioural insights operate differently across these domains. Third, we present the implications of our findings for each of the three main audiences, namely, policymakers, practitioners, and academics. Finally, we conclude this chapter by revisiting the importance of behavioural interventions in driving inclusive adoption of innovations and promoting sustainable and equitable food systems. By structuring the synthesis in this way, this chapter seeks to balance breadth and depth: offering a panoramic view of the insights while also providing concrete and actionable lessons to the targeted audience. The goal is to equip diverse audiences to implement the lessons, thereby ensuring that behavioural insights contribute meaningfully to the design and delivery of agricultural innovation.

2 Behavioural Interventions: The Big Picture

2.1 Foundations in Behavioural Economics

Part I of this volume, comprising Chap. 1 by the editors, Chap. 2 by Zilberman et al., and Chap. 3 also by Just and Jiao, establishes the conceptual foundations upon which the subsequent chapters build. It demonstrates that farmer decision-making cannot be adequately explained through classical economic assumptions of perfect rationality, complete information, and stable preferences. Behavioural economics instead provides a framework for integrating insights from psychology, sociology, and cognitive science into economic models of choice (Laibson, 1997; O'Donoghue & Rabin, 1999). Farmers, as economic agents, are subject to heuristics, cognitive biases, and procrastination, and are influenced by social norms. These factors mean that decisions about whether to adopt agricultural innovations (e.g. seed/variety, livestock vaccination, or participate in extension services) may diverge significantly from what classical models would predict as rational utility-maximising behaviour.

Evidence presented in these earlier chapters systematically categorises these dynamics. Biases, specifically present biased preferences, which undervalue future benefits in favour of immediate ones, and status quo bias, which fosters preference for existing practices even in the face of superior alternatives, are endemic in agricultural contexts (Madrian & Shea, 2001). Similarly, heuristics—mental models that simplify decision-making—can produce outcomes that induce seemingly irrational behaviour, which are, in fact, adaptive responses to uncertainty and complexity. The analytical framework for understanding behavioural mapping presented in preceding chapters therefore provides practitioners and scholars with a toolkit for diagnosing the types of biases at play and for designing interventions—or "nudges"—to counteract or redirect them (Thaler & Sunstein, 2008).

2.2 Why Nudges Matter

The rationale for behavioural interventions in agriculture is not merely theoretical. When properly designed and ethically applied, nudges offer a low-cost, context-sensitive complement to more traditional policy instruments such as subsidies, regulations, or large-scale infrastructure investments. Whereas conventional policies often assume that financial incentives or material rewards are sufficient to induce behaviour change, nudges recognise that adoption decisions are shaped by subtle cues, defaults, reminders, and framing effects (Cialdini, 2007; Duflo et al., 2011).

Evidence from multiple contexts illustrates the potential of such approaches. Mobile phone-based short messaging system (SMS) reminders, for instance, improve timely uptake of fertiliser or attendance at vaccination campaigns by overcoming forgetfulness or procrastination (Fafchamps & Minten, 2012; Fabregas et al., 2019). Altering the default option in seed distribution schemes—such that farmers must opt out of receiving improved varieties rather than actively opting in—increases adoption rates (Bold et al., 2017). Social nudges, which leverage peer influence or community identity, reduce resistance to innovations that might otherwise be perceived as risky or alien (Bandiera & Rasul, 2006; Beaman & Dillon, 2018). In all these instances, the key strength of nudges is their capacity to work with, rather than contrary to, human behaviour, thereby enhancing policy effectiveness without imposing heavy-handed measures, and doing so at lower cost.

In resource-constrained settings, this low-cost feature of nudges is particularly important. Governments and NGOs often operate with limited budgets and competing priorities. Nudges, by resolving behavioural bottlenecks, can spur greater returns on existing investments. Here is a case in point. The distribution of livestock vaccines is only as effective as farmers' willingness to present animals for treatment. If behavioural barriers such as mistrust of veterinary officers or competing household priorities prevent uptake, then the vaccines themselves achieve little impact. A modest nudge—such as trusted local promoters or reminder systems—can substantially increase coverage, thereby protecting both livelihoods and public health (Coyne et al., 2019; WHO et al., 2019).

2.3 Behaviour and Context

A key insight from the evidence presented in this volume is that behaviour cannot be meaningfully separated from its context. Agricultural decisions are not made in a vacuum. Rather, they are made within cultural, social, institutional, and ecological environments (Conley & Udry, 2010; BenYishay & Mobarak, 2019). Thus, nudges that work well in one setting may fail in another if they do not align with local norms or if institutional arrangements undermine their effectiveness. For example, evidence emerging from this volume is that culture, traditions, and social expectations strongly influence the adoption of quality seed of improved varieties. Trust in neighbours or customary practices outweighs trust in formal certification systems (Louwaars & de Boef, 2012). Thus, designing nudges that merely emphasise

scientific superiority defeats the purpose and is unlikely to succeed unless they do not address these relational dynamics. Similarly, diffusion of improved varieties is less likely to be driven by the inherent characteristics of the seed than by social learning processes (Bandiera & Rasul, 2006). As Rogers (2003) demonstrated, years ago, farmers looked to peers for evidence of success before deciding to adopt new technology. Hence, interventions that create visible early adopters and accelerate diffusion far more effectively than technical leaflets alone.

Institutional context also matters. Where extension systems are weak or under-resourced, digital nudges such as mobile reminders may serve as substitutes (Aker, 2010; Fafchamps & Minten, 2012). However, in areas with high illiteracy or limited phone penetration, such nudges will be ineffective unless coupled with trusted intermediaries. Therefore, policymakers and practitioners need to understand that nudges need to be tailored and adapted to the context for them to be effective.

2.4 Implications for Agricultural Development

The insights emerging from behavioural interventions presented in this volume have major implications for global agricultural development. First, they challenge the assumption that innovation bottlenecks are primarily technical or financial. Instead, they highlight the fact that human factors—beliefs, norms, attention, and trust—are equally significant drivers (Suri, 2011; Spielman & Smale, 2017). Addressing these requires investment not only in technologies themselves but also in accompanying behavioural tweaks that address behavioural biases. Second, they suggest that development programmes should incorporate behavioural diagnostics at the outset to better understand the behavioural levers that must be pulled to deliver the desired outcomes optimally. Just as agronomists conduct soil tests before recommending fertiliser regimes, development practitioners should clearly understand the behavioural barriers at play before prescribing interventions (Kremer et al., 2019). Third, behavioural interventions offer a means of enhancing equity and inclusion. Poorer households, women farmers, and marginalised groups often face distinctive behavioural barriers, such as reduced confidence in their own agency or exclusion from social learning networks (Beaman & Dillon, 2018). Nudges that are sensitive to these dynamics—such as targeted reminders, inclusive extension methods, or interventions that shift social norms—can contribute to more equitable adoption patterns. Finally, behavioural insights carry particular relevance for the emerging paradigm of One Health, which recognises the interconnectedness of human, animal, and environmental health. Many of the most pressing challenges in this space—zoonotic disease control, antimicrobial resistance, and food safety—depend on farmer behaviour (O'Neill, 2016; WHO et al., 2019). Encouraging vaccination, prudent antibiotic use, or safe handling practices cannot be achieved by technical solutions alone. Behavioural nudges that address mistrust, habits, or social influence are essential complements to biomedical interventions. The broader lesson, therefore, is that agricultural innovation must be understood at both technical and behavioural levels.

3 Synthesis by Domain

3.1 Livestock Systems

In this section, we distil the evidence presented in this volume and its implications for livestock sub-sector development. Livestock systems occupy a critical place in agricultural economies, food security strategies, and rural livelihoods. They contribute not only to household nutrition and income but also to broader economic and ecological systems. However, livestock systems are particularly vulnerable to disease outbreaks, which may have devastating consequences for farmers and communities, and in many cases carry implications for public health. Classical epidemiological models have traditionally provided the primary framework for understanding and managing these risks. They emphasise transmission dynamics, biological susceptibility, and technical interventions such as vaccination, quarantine, or treatment. While these models are indispensable, Chap. 4 of this volume underscores a fundamental point: livestock disease dynamics are not solely a biological phenomenon but are deeply intertwined with human behaviour.

Farmers' decisions—whether to vaccinate, to report an outbreak, or to adopt preventive measures—are as consequential as the virulency of pathogens. Yet conventional approaches have often treated farmers' behaviour as an exogenous factor. In other instances, such approaches have assumed that farmers will naturally comply with veterinary advice once technical solutions are available. Behavioural economics challenges this assumption by demonstrating that decisions are shaped by heuristics, biases, social norms, and context-specific constraints (Thaler & Sunstein, 2008; Coyne et al., 2019). Integrating these behavioural insights into epidemiological models allows for more robust and accurate predictions and more effective interventions.

Vaccination is among the most effective, cost-effective tools for controlling livestock diseases, from foot-and-mouth disease in cattle to Newcastle disease in poultry. Yet uptake is often low and inconsistent, even when vaccines are subsidised or made widely available (WHO et al., 2019). Behavioural interventions presented in Chap. 4 shed light on this puzzle. Farmers may undervalue the future benefits of vaccination due to present bias, focusing instead on the immediate cost or the inconvenience of accessing the service (O'Donoghue & Rabin, 1999). Others may perceive vaccination as unnecessary if disease outbreaks are not immediately visible, reflecting availability bias. Trust also plays a significant role. In communities where veterinary officers are perceived as outsiders, or where previous interventions were mishandled, farmers may hesitate to participate even in the well-designed campaigns (Coyne et al., 2019).

Behavioural nudges can help address these barriers. Simple reminders—through local promoters, SMS messages, or community meetings—counteract forgetfulness and procrastination (Fabregas et al., 2019). Changing the framing of vaccination campaigns from "optional" to "standard practice" from which people choose to "opt out" can alter perceptions of norms and increase uptake (Cialdini, 2007). Social proof, or aspirational characters/role modelling, whereby respected opinion leaders

or local champions/respected farmers publicly vaccinate their herds or flocks, may reduce uncertainty and signal that participation is both safe and expected (Bandiera & Rasul, 2006). Importantly, these nudges complement rather than replace technical interventions. They address the behavioural bottlenecks that often undermine otherwise sound veterinary strategies.

Disease reporting is another domain where behavioural factors can play a significant role. Early detection is critical for containing outbreaks, yet underreporting remains a persistent problem across many livestock systems (WHO et al., 2019). Some farmers may fear that reporting an outbreak may result in culling without compensation, leading to economic loss. Others may hesitate to engage with authorities due to mistrust, bureaucratic barriers, or social stigma (Coyne et al., 2019). From a behavioural perspective, these decisions are not irrational: they reflect risk aversion and the weighing of immediate, visible costs against uncertain, future benefits. Nudges can resolve this behavioural inertia and increase farmers' benefits and incomes.

Providing small social incentives for timely reporting, such as preferential access to veterinary services, can shift the cost–benefit calculation. Equally, emphasising the collective benefits of early reporting—through community meetings or trusted intermediaries—can activate pro-social motivations (Cialdini, 2007). Behavioural interventions can also be applied to reporting systems themselves. For example, simplifying reporting procedures, reducing paperwork, or introducing anonymous hotline (phone) numbers for consultation lowers the otherwise costly frictions that discourage participation. Moreover, trust is central: the more the authorities are seen as responsive and fair, the more likely farmers will be to cooperate and engage in timely reporting (Coyne et al., 2019).

The significance of behavioural interventions in livestock systems extends well beyond farm-level outcomes to encompass the broader One Health agenda. Livestock diseases often have zoonotic potential, posing risks to human populations (O'Neill, 2016). Antimicrobial resistance, foodborne pathogens, and transboundary diseases such as avian influenza exemplify the interconnectedness of animal, human, and environmental health. In such contexts, technical solutions alone are insufficient. Successful control depends on understanding and exploiting human behaviour. It requires that attention is given to how farmers use antibiotics, how they handle animal products, and whether they comply with biosecurity protocols (WHO et al., 2019).

Integrating behavioural insights into One Health frameworks allows policymakers and practitioners to better anticipate points of resistance and design interventions that address both technical and behavioural dimensions. For instance, campaigns promoting prudent antibiotic use must not only supply alternatives to disease management practices and training but also address cognitive biases. Farmers may overuse antibiotics as a form of risk minimisation, believing that "more is better", even when evidence suggests otherwise (Coyne et al., 2019). Behavioural nudges—such as default prescriptions that are in appropriate dosages, providing visual reminders about withdrawal periods, or highlighting peer practices—can promote more rational use.

For policymakers, the integration of behavioural and epidemiological models has several important implications. First, it enhances predictive capacity. Models that account for likely behavioural responses to interventions can provide more realistic projections of disease dynamics and control strategies (WHO et al., 2019). Second, it improves cost-effectiveness. Resources are often wasted when vaccines remain unused, extension campaigns are ignored, or reporting systems go underutilised. Behavioural interventions, typically low-cost, can maximise the returns on these investments (Thaler & Sunstein, 2008). Third, it strengthens resilience. By fostering trust, encouraging compliance, and embedding preventive behaviours, policies informed by behavioural insights build stronger relationships between farmers, veterinary service providers, and the state (Coyne et al., 2019).

There are also important political economy dimensions to the behavioural interventions in the livestock sub-sector. Outbreaks of livestock disease can quickly escalate into crises that attract public attention and do not recognise borders between countries. Policymakers are judged not only on their technical responses, readiness, and speed of execution but also on their ability to mobilise cooperation and/or buy-in. Behavioural strategies—by tackling mistrust, reducing barriers, and aligning interventions with local norms—can enhance legitimacy and ensure smoother implementation.

For development practitioners, NGOs, and veterinary service providers, the take-home message is that technical tools need to be combined with behavioural tweaks that address biases to be more effective. Efforts—such as vaccine delivery, diagnostic tests, or extension advice—that neglect behavioural barriers risk low adoption and suboptimal impact. Practitioners should therefore invest in understanding behavioural aspects—mapping out the cognitive, social, and cultural factors—that shape farmer decisions in each context (Franzel & Kiptot, 2014).

Practical steps towards achieving this include the following: (i) embedding reminders into service delivery (e.g. SMS alerts for vaccination days), (ii) engaging trusted local intermediaries to promote reporting and uptake, (iii) designing campaigns that highlight community-wide benefits—thus appealing to social norms—rather than individual costs, and (iv) simplifying procedures to reduce friction in reporting or compliance.

Equally important is the issue of designing the evaluation of projects and programmes that explicitly embody behavioural interventions. Practitioners should monitor and report not only the technical outcomes (e.g. vaccination coverage) but also behavioural indicators such as trust, perceptions of risk, and norms (BenYishay & Mobarak, 2019). Iterative learning—testing different nudges, adapting to feedback, and scaling successful approaches—ensures that interventions remain responsive and contextually grounded.

In sum, livestock systems demonstrate how paying attention to behavioural aspects of the farmer and production environment is important in the use of agricultural innovations. Disease dynamics are inseparable from human decision-making, and technical tools alone cannot secure effective and sustainable outcomes. Vaccination uptake, disease reporting, and prudent antimicrobial use all hinge on behavioural factors such as trust, norms, and cognitive biases. Integrating these

insights into epidemiological models enriches predictive power, improves cost-effectiveness, and advances the One Health agenda.

3.2 Crop Systems

We now turn our attention to the crop sub-sector. Crop systems represent one of the most critical arenas for agricultural innovation, food security, and nutrition. The adoption of improved crop varieties has been a key focus of research and policy interventions over the past decades. Yet, as Chaps. 5, 6, and 7 have shown, behavioural barriers frequently undermine the effectiveness of these efforts, which in turn diminishes the return on investments in research. Farmers may delay, resist, or selectively adopt innovations not because of technical shortcomings but due to psychosocial, cultural, and social learning dynamics (Duflo et al., 2011; Bandiera & Rasul, 2006).

Chapter 5 analyses the role that procrastination and psychosocial factors play in shaping the adoption of improved crop varieties. Procrastination is a common behavioural pattern in which individuals postpone actions despite intending to undertake them. In agricultural contexts, this tendency is particularly costly. Delaying the purchase or planting of improved seed varieties early may result in late planting, thereby reducing yields and discouraging future adoption (Duflo et al., 2011).

Psychosocial factors also play a role. Farmers may doubt their own capacity to use a new technology effectively, especially if they lack prior exposure or training. Feelings of low agency or mistrust in formal seed systems may exacerbate reluctance (Meenakshi et al., 2010). These insights underscore the fact that providing improved seed alone is insufficient. They suggest that adoption depends on addressing behavioural bottlenecks that lead to procrastination, self-doubt, and mistrust. Indeed, behavioural interventions can counteract these dynamics in multiple ways. Commitment devices, such as pre-ordering schemes or group pledges, help farmers lock in intentions before procrastination sets in (O'Donoghue & Rabin, 1999). Timely reminders—whether through SMS, radio broadcasts, or local extension meetings—can prompt action at critical moments and improve timely planting (Fafchamps & Minten, 2012). Social recognition of early adopters can increase confidence among hesitant farmers, by signalling appreciation of efforts and that adoption of new innovations is feasible and beneficial (Beaman & Dillon, 2018).

Chapter 6 of this volume highlights how cultural and social norms influence the purchase and use of quality seed. Farmers are embedded within communities where traditions, reciprocity, and trust networks strongly influence decision-making (Louwaars & de Boef, 2012). In such contexts, innovations are not evaluated based solely on technical merits but also on their perceived alignment with cultural identity, sense of belonging and social norms in general. For example, reliance on landraces or farmer-saved seed may reflect not just economic necessity but also cultural continuity/preservation. Certified seed may be seen as "foreign" or disconnected from local values. In some cases, adoption of improved varieties can be interpreted

as disloyalty to cultural norms, especially if neighbours view it as rejecting shared practices (Spielman & Smale, 2017).

These dynamics explain why information campaigns purely focused on yields or nutrition may fail to persuade. Farmers often prefer to conform to norms rather than risk social sanctions/ostracisation, even if innovation use promises higher returns (Conley & Udry, 2010). Yet norms are not immutable. When champions/respected leaders or influential peers adopt improved seed, community perceptions can shift. Nudges that leverage reciprocity, trust, and pride can reduce resistance. For instance, distributing seed through farmer cooperatives/groups reinforces existing trust and social structures, while public recognition of adopters (a form of social incentive) reframes innovation as prestigious rather than deviant (Bandiera & Rasul, 2006).

Chapter 7 underscores the importance of social learning in the diffusion of crop innovations. Farmers rarely adopt technologies in isolation. They observe neighbours, share experiences, and wait for proof of success before committing. This reliance on peer influence is a rational response to uncertainty in high-risk environments (BenYishay & Mobarak, 2019).

Interventions that strategically support early adopters and amplify their odds of success can therefore accelerate diffusion. Demonstration plots, farmer field days, and participatory trials allow farmers to observe the outcomes in real time. Providing small starter packs reduces the cost of experimentation and risk aversion, thus encouraging trial (Bold et al., 2017). Nudges that encourage discussion—such as small rewards for sharing results/knowledge with neighbours—can expedite diffusion of innovations through farmer networks (Beaman & Dillon, 2018).

However, diffusion can stall if early adopters fail or if information is poorly transmitted. This implies that practitioners need to ensure that experimentation/early trials are well supported and that outcomes are effectively communicated. Digital tools and participatory platforms can complement traditional mechanisms by widening the circle of influence (Aker, 2010).

Several crop systems development implications can be drawn from the evidence presented in this volume. First, for policymakers, the evidence presented in this volume highlights the need to integrate behavioural science into seed system development. Subsidies, certification, and distribution mechanisms will be ineffective unless measures to address procrastination, cultural norms, and social learning are embedded in the interventions (Louwaars & de Boef, 2012; Spielman & Smale, 2017). For instance, opt-out enrolment in subsidy programmes targeting seed delivery and distribution can improve farmer participation in programmes and adoption rates (Madrian & Shea, 2001). Policies that invest in intermediaries that promote trust and social norms, such as cooperatives and farmer groups (or farmer organisations in general), are more likely to overcome resistance than top-down directives.

Second, for practitioners, the major implication is that technical interventions can be more effective if complemented with behavioural interventions such as nudges. Accompanying technical interventions such as a promotion of improved seed or agronomic practices with reminders, pre-commitments, cultural reframing, and peer influence strategies can greatly enhance adoption. Further, as argued by Rommel in Chap. 12, project and programme monitoring should track not only the

progress made in promoting technical innovation but also the embedded behavioural indicators (e.g. trust, risk perception, reminders).

Third, for academics, the evidence presented in this volume highlights research gaps and opportunities for future research. Some of the research questions that emerge include: How durable are behavioural effects over time? How do nudges interact with poverty and structural constraints? What ethical boundaries must be observed to avoid manipulation? Addressing these questions requires mixed methods and participatory research that encompass rigorous quantitative research such as randomised controlled trials (Kremer et al., 2019).

3.3 Extension and Digital Platforms

Extension and communication systems are essential for bridging research and practice in agriculture. In developing-country agriculture, however, these systems tend to be weak, under-resourced and poorly managed. From early models of diffusion to the more recent participatory and digital approaches, extension services can greatly influence how innovations spread and ultimate adoption. Behavioural dynamics play a major role in this process. Farmers unconsciously filter advice through behavioural lenses that include biases, social norms, and cultural contexts (Rogers, 2003).

The explosive digital revolution in developing countries has multiplied opportunities for farmer outreach under human and financial resource constraints. Mobile phones, internet connectivity, and digital platforms extend reach at reduced costs. SMS reminders, voice response systems, and crowd-sourced data platforms exemplify new modes of extension as shown in this volume. The evidence we present further indicates that success in digital interventions is influenced by farmers' and messenger's behaviour, not technology/innovation characteristics alone (Aker, 2010; Fabregas et al., 2019).

In Chap. 8, Jayanth et al. illustrate how SMS/text message reminders counteract forgetfulness and procrastination. Farmers often intend to apply fertiliser or vaccinate animals but fail to do so due to competing demands or present bias. Timely reminders can therefore reorient attention and spur action as documented by Duflo et al. (2011). There is indeed evidence from past literature that behavioural nudges such as text message reminders improve fertiliser use and vaccination uptake (Fafchamps & Minten, 2012; Fabregas et al., 2019). Messages that frame behaviours as urgent or normative—such as "Most farmers in your area are applying fertiliser this week"—further increase impact (Cialdini, 2007). Costs are low, making this tool attractive for governments and NGOs. Yet context matters. Literacy, phone ownership, and trust in digital messages vary widely. What this means is that messages need to be culturally tailored and linguistically appropriate (Cole & Fernando, 2016). Moreover, overuse of text message reminders risks inducing fatigue as Okello et al. document in Chap. 11 of this volume. Thus, scalability requires sensitivity to social and cultural realities.

Chapter 9 explores the role of promoter farmers, local champions who embody behavioural principles of social proof and peer learning. Farmers are more likely to adopt practices demonstrated by trusted peers than by distant officials (Franzel & Kiptot, 2014; Bandiera & Rasul, 2006). Promoter farmers address multiple barriers simultaneously: they reduce uncertainty by providing visible evidence, lower transaction costs by being readily accessible, and confer social legitimacy by modelling adoption. Incentives—financial or reputational—strengthen their effectiveness. The chapter, however, highlights challenges in this approach that are noteworthy. They include elite capture, jealousy, and gender bias. Careful selection of project and programme participants, keen attention to diversity and equity, and support for men and women farmers likely to be excluded are essential. Here, public recognition nudges designed to reward effort and training to ensure technical accuracy and accessibility of training materials can be essential in ensuring diversity, equity and inclusion and in sustaining promoters' motivation (Beaman & Dillon, 2018).

In Chap. 10, Shikuku et al. examine nudges in the context of participatory digital platforms designed to encourage farmers to contribute data on pests, weather, or crop performance. They find, using rigorous quantitative methods, that participation in digital platforms is influenced by behavioural incentives. Their findings suggest that farmers may be reluctant to volunteer information/data unless they perceive fairness, immediate benefit, or collective good. Thus, nudges such as airtime credits, leader boards, and recognition appeal to fairness and status motivations and are needed to spur participation (BenYishay & Mobarak, 2019). Specifically, the nudge messaging needs to emphasise collective benefits, which encourage pro-social behaviour (Cialdini, 2007). In addition, ensuring that farmers have trust in the platform is vital. Without transparency and feedback, platforms risk low participation (Fabregas et al., 2019).

Chapter 11 extends behavioural analysis to urban and peri-urban agriculture. Urban farmers face higher opportunity cost of time and operate in different social networks from their rural counterparts (Zezza & Tasciotti, 2010). Successful introduction of innovations in this context therefore requires careful attention to the drivers of decision-making. The authors thus examine nudges designed to invoke and influence pro-social behaviour, namely outreach and knowledge sharing and adoption of improved varieties. They find that such nudges dampened the incentive to adopt new innovations. Nonetheless, the nudges activated information and knowledge-sharing waves.

The chapters in this section provide valuable lessons that can be applied to design more effective behavioural interventions for extension and digital platforms. For policymakers, these lessons include how to: (i) embed behavioural design into farmer extension/outreach strategies, (ii) institutionalise promoter farmer models, and (iii) target digital platforms as farmer outreach platforms (Fabregas et al., 2019). For practitioners, the lessons emerging from this section relate to how to effectively design behavioural interventions that promote effective delivery of extension messages. First, the section suggests that SMS campaigns need to be well-timed, accessible, and contextual. Second, promoter farmer approach can be an effective strategy for farmer outreach but requires support and recognition. Third, crowdsourcing

platforms need embedded behavioural incentives that promote transparency and trust to be more effective in driving participation.

The section also provides valuable lessons for academia. It highlights opportunities for further research to address lingering questions. These questions include: How sustainable are nudges at scale? What behavioural models can be built into digital platforms to make them effective, inclusive, equitable, and sustainable? How can behavioural models be designed to increase rather than decrease demand for agricultural innovations?

4 Implications for Key Audiences

The preceding synthesis across livestock, crop, and extension/digital platforms highlights a consistent message: the behaviour of agricultural actors (i.e. farmers, promoters) influences the adoption and diffusion of agricultural innovations. These insights have significant implications for development programming and practice (i.e. outreach) and for academia (research, training). This section therefore highlights the key implications for major key audiences targeted by this book, namely, policymakers, development practitioners, and the academic community.

4.1 Policymakers

For policymakers, the implications of the insights from this synthesis fall under three themes: cost-effectiveness, political feasibility, and alignment with broader development agendas (e.g. food and nutrition security, climate resilience). Nudges offer cost-effective complements to other agricultural interventions such as subsidies and regulations (Thaler & Sunstein, 2008). They preserve freedom of choice, reduce perceptions of coercion used under command-and-control approaches, and explicitly incorporate behaviour. Consequently, behavioural interventions such as nudges present policymakers with less expensive levers to pull in pursuit of accelerated development of the agricultural sector. This implies the need to explicitly incorporate, where feasible, behavioural aspects in policy design.

From a political economy standpoint, the appeal of behavioural interventions is that they are supportive rather than punitive. For instance, as reported in this volume, reminders improve the timeliness of fertiliser application and vaccination uptake (Duflo et al., 2011; Fafchamps & Minten, 2012), default enrolment in seed subsidy programmes increased adoption (Madrian & Shea, 2001), and public recognition nudges enhance reporting of livestock diseases by reframing participation as pro-social (Coyne et al., 2019). Thus, incorporating behavioural aspects in policy design can facilitate and accelerate, rather than hinder, the achievement of policy goals.

Behavioural insights also align with broader policy agenda for improving food and nutrition security, poverty eradication and One Health. For instance, nudges addressing antibiotic misuse in livestock contribute to global antimicrobial

resistance strategies, seek to arrest the decline in productivity, and therefore contribute to food security (O'Neill, 2016; WHO et al., 2019). Similarly, behavioural interventions that promote the adoption of biofortified crops directly enhance nutrition security (Hotz et al., 2012). Therefore, and as intimated above, incorporating behavioural insights into policy making contributes to the realisation of national and international development goals, including the Sustainable Development Goals.

The overall implication of the insights from this book, relating to policy making, is that governments should actively embed behavioural insights into the overall agricultural sector development strategies. This can be done by establishing behavioural/nudge units whose responsibility would be to identify behavioural bottlenecks, testing different behavioural interventions and deploying novel ones, and then monitoring the outcomes (Kremer et al., 2019). Embedding behavioural insights into the agricultural sector development strategies has the advantage of ensuring that proven/effective behavioural interventions and insights move from pilots to mainstream policy.

4.2 Development Practitioners

Development practitioners, including NGOs, donor agencies, and project/programme implementers, are often responsible for delivering innovations to intermediate- and end-users, namely processors, farmers, traders, and consumers. The major practical implications of the insights from the evidence presented in this volume for this audience are as follows: First, provision of technical interventions (i.e. innovations) alone, while neglecting behavioural and contextual issues, is not sufficient to promote adoption. Understanding the behavioural aspects of the actors targeted by such interventions will, on the other hand, greatly improve the desired development outcomes. Thus, development practitioners need to be intentional in incorporating behavioural aspects in the design of their outreach actors.

Second, introduction to the end-users of interventions that have been piloted/tested and shown to be novel needs to address behavioural constraints that can impede their uptake. It would greatly help if such novel innovations could be introduced to farmers through farm demonstrations by trained promoter/champion/model farmers who can build trust and confidence of the farmers in the new technology while addressing perceived risks and uncertainty. It is worth noting, in particular, that behavioural interventions are influenced by the context in which they are deployed and therefore what works in one community may fail in another (BenYishay & Mobarak, 2019).

Third, behavioural interventions need to be deployed in a conducive socioeconomic environment to be more effective. For instance, they cannot compensate for poor infrastructure, market failures, or political instability. Behavioural innovations will be more effective if introduced in a conducing environment and appropriate context. Fourth, monitoring of projects and programmes that embody behavioural interventions should necessarily go beyond the technical metrics to including behavioural indicators. Defining and tracking such indicators as trust, nostalgia, and social norms can greatly

enrich understanding about why some innovations spread faster and are more highly adopted than others (Bandiera & Rasul, 2006). Overall, the insights from this book imply the need to embed behavioural insights in project and programme outreach, monitoring and evaluation and make it an integral part of the project/programme cycle.

4.3 Academia

For academia, behavioural science in agriculture represents a new but rapidly growing frontier of applied science in developing countries, but with a lot of unknowns. Undoubtedly, behavioural science enriches the understanding of predictions of classical economic theories relating to technology adoption by explaining why farmers resist seemingly profitable innovations (Laibson, 1997; Kremer et al., 2019). That is, it helps understand what is perceived as irrational behaviour in agricultural development. While building on the now widely accepted new institutional economics, behavioural science expands the horizon by exploring and bringing into the analytical toolkit the other fields of human behaviour, including psychology, economic psychology, sociology, cognitive science, neuroscience, anthropology, and political science. The insights presented in this volume draw from many of these fields. However, several research gaps remain. First, the durability of nudges over time. Do SMS reminders or peer influence sustain behaviour beyond a season? The insights presented in this volume lend support to the hypothesis that nudges, when deployed under certain conditions, can have a sustained effect. This finding needs to be tested further under different contexts.

Second, there is a need to understand how behavioural interventions interact with structural barriers such as food and nutrition insecurity, poverty, and fragility resulting from political instability. For instance, can behavioural interventions be effective under extreme poverty or systemic market failure? Does food and nutrition security influence the outcome of such interventions? The latter question stems from the findings of a study conducted in Ethiopia several years ago by some of the editors of this volume (see Okello et al. (2022)). It was a field experiment that embedded nudge interventions in a school lunch programme in a context characterised by extreme food insecurity (famine). The study implementers observed that food choices were strongly influenced by hunger and had to increase food rations substantially to detect effects. Further studies are needed to validate these kinds of outcomes.

Third, there are ethical concerns about behavioural interventions. Critics of behavioural interventions point to the potential for analysts to manipulate subjects towards a desired outcome. Thus, students of behavioural science and future researchers must address the questions of how nudges, and behavioural interventions in general, can be deployed in ways that respect the autonomy of subjects and avoid manipulation (Thaler & Sunstein, 2008). Fourth, for students, behavioural agricultural science offers new opportunities for study, research and career. For faculty, in developing countries, behavioural research provides a new field for teaching, research and outreach. While university curricula in agricultural economics

now include new institutional economics as a taught course, unfortunately nudge science remains largely untouched. It also means that university faculty interested in this field will need to develop and/or adapt their own training materials, methods, and metrics used in developed countries to their context. To sum up, the insights from this volume imply for academia that there is a need to integrate behavioural science into agricultural economics, development studies, and One Health curricula, and invest in developing and adapting interdisciplinary methods that blend quantitative experiments with qualitative inquiry.

5 Conclusion

This chapter has drawn together the insights of the volume and the implications of these insights for policy making, development practice, academic research, training and outreach. Our central thesis is that behavioural science can enhance agricultural innovation and hence contribute to improving the standard of living of agricultural actors by considering human behaviour dimensions. It suggests that innovations are less likely to be successful based purely on technical merits alone but are likely to achieve desired outcomes if the design and delivery explicitly take into account the behavioural aspects of the users. Thus, innovation design and delivery for both products and services need to pay attention to how such innovations intersect with behavioural aspects (such as biases, norms) and perform in different contexts. Three key major lessons arising from this volume are as follows:

1. Behavioural factors—procrastination, norms, trust—shape adoption.
2. Nudges present low-cost interventions for addressing behavioural bottlenecks that impede innovation use in agriculture.
3. Context matters. Cultural and institutional settings determine whether nudges succeed.

Implications are clear. Policymakers should embed behavioural units within agricultural strategies. Practitioners should integrate nudges into programme cycles and track behavioural indicators. Academics should expand research on durability, ethics, and interdisciplinary collaboration.

Ethical reflection is also essential. Nudges must respect autonomy, transparency, and fairness (Thaler & Sunstein, 2008). Without this, interventions risk eroding trust.

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