Improving Agricultural Policy and Programming through Data-Driven Adoption Prediction

Asian Productivity Organization

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IMPROVING AGRICULTURAL POLICY AND PROGRAMMING THROUGH DATA-DRIVEN ADOPTION PREDICTION

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Improving Agricultural Policy and Programming through Data-Driven Adoption Prediction

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FOREWORD

Agriculture remains a cornerstone of economic development and sustainability across APO member economies. In an era marked by rapid technological progress and increasing demands on food systems, it is essential that agricultural policies and programs are informed by robust predictions and analyses. Understanding the speed and extent of adoption of new practices and technologies in agriculture is critical for shaping effective strategies that enhance productivity and resilience.

This research report on *Improving Agricultural Policy and Programming through Data-Driven Adoption Prediction* provides valuable insights into the processes of adoption and diffusion using the Adoption and Diffusion Outcome Prediction Tool (ADOPT), with a focus on informed decision-making for policy and programming. It documents a series of validations of ADOPT prediction in APO members such as Bangladesh, India, and Lao PDR as examples. The findings also underline the importance of data-driven approaches to refine predictions and optimize the outcomes of agricultural interventions in terms of programs and policies in the public domain.

The APO extends gratitude and appreciation to Dr. Brendan Brown and Dr. Rick Llewellyn of The Commonwealth Scientific and Industrial Research Organisation (CSIRO) for writing this report. As we continue to face challenges in food security and sustainability, this report providing predictions using ADOPT to analyze the performance of the agriculture sector in terms of productivity and resiliency will serve as a useful reference for those involved in agricultural policy and program design across the region. The practices and recommendations shared here can contribute to more effective decision-making and improvement in the agricultural sector in the Asia-Pacific region and elsewhere.

Dr. Indra Pradana Singawinata
Secretary-General
Asian Productivity Organization

PREFACE

Agricultural policy makers' approaches on agricultural investment decisions, particularly on where to direct financial and human resources, can be fraught with untested assumptions and unknown biases. The Adoption and Diffusion Outcome Prediction Tool (ADOPT) is designed to provide a structured approach to predict, inform and engage a range of stakeholders in a better understanding of adoption dynamics. This publication was conceived as a mechanism to both raise awareness and validate the accuracy of ADOPT, serving as a pathway to assist more Asian policy and programming bodies with their agricultural investment decisions. As such, the purpose of this report is to help policy and programming stakeholders become more aware of this structured approach to help inform their decision making.

We acknowledge the many organizations and individuals who have helped in this process, including (but not limited to) those within CSIRO (Mackenzie Coopman and Sam Coggins), as well as partners from the International Maize and Wheat Improvement Centre (Pragya Timsina, Akriti Sharma, Sreejith Aravindakshan, Bharathi Parupalli and Timothy Krupnik). Institutionally, this work would not have been possible without the SRFSI (funded by ACIAR) and CSISA MEA (funded by USAID) programs, and the TAFSSA initiative of the CGIAR. The authors appreciate the review and comments from APO colleagues, Santi Setiawati and Keiichi Sugita. We also appreciate the Asian Development Bank Institute for the opportunity to present parts of this work at the 2024 'Mechanization of Small-Scale Farms in Asia: Current Status, Impacts, and Future Prospects' Conference. We are grateful to all of these people and organizations for their contributions to this body of work.

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EXECUTIVE SUMMARY

Informed research decisions in agricultural contexts (policy, research and extension) require an understanding of how various competing practices and technologies might be adopted within populations. The Adoption and Diffusion Outcome Prediction Tool (ADOPT) is a workshop-based decision support tool that is potentially useful to policy and programming stakeholders in their pursuit of data-driven decision making. The objective of ADOPT is to support stakeholders in removing some of the guesswork, assumptions, and biases from adoption-oriented decision making, as well as to provide opportunities for a range of stakeholders to learn about adoption processes and collaborate with others.

This report documents the ADOPT process and framework, as well as providing a series of validation of ADOPT predictions from India, Lao PDR and Bangladesh. It concludes with a guide for discussing adoption processes in policy and programming decision making. Original validations in India and Laos PDR highlight mixed results with a general overestimation of time to peak adoption, but true validation to date has been limited by a lack of time series data to compare validations with actual adoption outcomes. To overcome this, an in depth validation based on machinery adoption data in Bangladesh was undertaken, which provides a clear basis to suggest that the prediction of peak adoption is accurate, while the prediction of the time to peak adoption is overestimated. Slowing the rate by approximately half provides a more accurate prediction of time to peak adoption, likely due to the slow nature of diffusion in smallholder contexts. Such issues will be addressed in future updates to ADOPT.

In conclusion, ADOPT is found to be a valid tool for stakeholders and policy makers across Asia to help inform their program and policy-based decision making, both through ex-ante prediction of adoption rates, as well as to assist in a deeper understanding of adoption processes and a mechanism to aid collaboration. Finally, to complement the data-driven inputs ADOPT can provide, a discussion of important further considerations to structure policy and programming discussions around adoption are suggested.

1. INTRODUCTION

Introduction

Governments and organizations face challenges in allocating scarce resources in the pursuit of more productive and sustainable agricultural production systems. Predicting and discussing adoption processes can be difficult, given the many factors that interact. Most work in this area is based on undiscussed assumptions and lacks a transparent and collaborative approach. The outcome of this is a loss of efficiency, a lack of data-driven decision making, and unrealistic assumptions on how change in agricultural production systems occurs.

The Adoption and Diffusion Outcome Prediction Tool (ADOPT) has been developed to address these issues by incorporating a set of 22 factors that studies have shown to commonly influence the peak level of adoption within a population (Kuehne et al., 2017). ADOPT predicts how quickly an innovation will spread and what percentage of adoption can be expected, along with suggestions to help improve adoption outcomes. ADOPT does so as an interactive knowledge tool, helping decision makers assess potential agricultural practice changes at a population level in a structured way. In doing so, it also provides a collaborative learning experience, bringing stakeholders together to collectively understand how adoption is driven generally, as well as specifically to case study examples.

Specifically, ADOPT has three objectives:

- **Predict** the percentage of a given farming population that will 'adopt' a nominated agricultural practice, as well as predict the time taken to reach this 'peak adoption' level; and

- **Inform** decision makers about the key factors that affect adoption of the nominated practice. Importantly, ADOPT personalizes this guidance for the farming practice and nominated population; and

- **Engage** decision makers in discussions on what will make a given farming practice more useful and usable to a given population of farmers.

This report focuses on ADOPT, an agricultural adoption tool that could potentially be applied in APO member countries to assist in agricultural policy and programming. It was proposed to provide a rationale for the wider use of agricultural policy decision support tools such as ADOPT to help program and policy makers assess the potential of different agricultural investment strategies and understand leverage points therein. In this light, the objectives of this report are to:

- Introduce ADOPT as a digital ex-ante adoption prediction tool available to APO member countries to undertake ex-ante assessments in the agriculture sector; and

- Showcase the value of ADOPT in terms of its ability to predict adoption, engage stakeholders' data driven discussions, and inform stakeholders about different drivers of adoption; and
- Explore existing limited validations of ADOPT in India and Lao PDR to identify a need for more in depth validation against temporal adoption datasets;
- Undertake additional in depth validation of ADOPT's accuracy or prediction using temporal data related to machinery adoption in Bangladesh; and
- Highlight other key considerations when undertaking adoption-oriented discussions.

2. UNDERSTANDING INNOVATION DIFFUSION AND ADOPTION PATTERNS

2.1 Diffusion Curves and Key Elements of Agricultural Innovation Adoption

Widespread adoption of something new (i.e., an innovation) can be a difficult process and often does not happen at all. Even when the potential advantages seem obvious, many innovations require extended periods of time to become widely known, then available, and then widely adopted. This process is often referred to as diffusion, involving information and adoption decisions spreading over time among members of a social system (Rogers, 2003).

The outcome of diffusion in a population can be primarily defined by three elements:

[1] the peak adoption level (i.e., the maximum proportion of the population who have used a practice); and

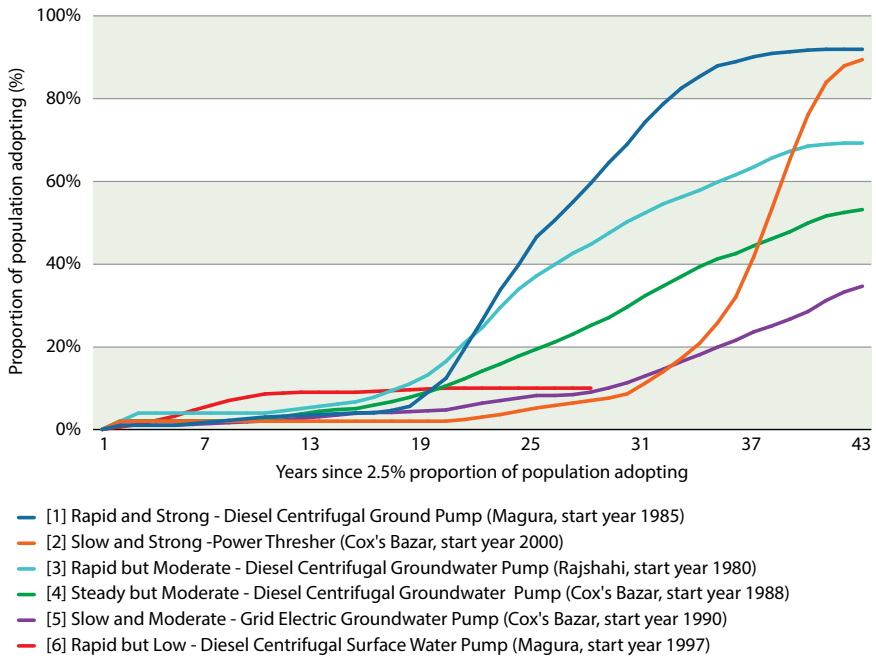
[2] the time to peak adoption level (i.e., the years that it will take to reach peak adoption level); and

[3] the shape of the curve between the start of the diffusion process and peak adoption.

In practice, adoption can occur in a myriad of ways. In Figure 1, six adoption curves from agricultural machinery adoption in Bangladesh are visualized to highlight types of diffusion curves possible (i.e., curves showing cumulative adoption). For example, both curves [1] and [2] have a peak adoption rate of approximately 90%, yet curve [1] reaches adoption more quickly (by approximately 8 years) and more rapidly (with an inflection point approximately 12 years earlier) than curve [2]. Conversely, curve [3] had comparatively rapid adoption in earlier years but a much lower peak adoption rate of around 70%, and curve [6] had the most rapid early growth in adoption but a peak adoption rate of only 10%. Curves [4] and [5] have much steadier growth, but after more than 40 years, still may not have reached peak adoption.

FIGURE 1

DIFFERENT TYPES OF DIFFUSION CURVES THAT VARY IN PEAK ADOPTION RATE, TIME TO PEAK ADOPTION RATE AND SLOPE OF ADOPTION CURVE.



Source: Brown et al., (2024a; 2024b).

What is most observable in these curves is that adoption takes time, first with the initial diffusion delay, in many cases spanning up to a decade before appreciable adoption occurs. Second, once this initial diffusion occurs, the trajectory of adoption can vary greatly. A better understanding of this can help policy and programming stakeholders better plan for expected adoption of supported innovations.

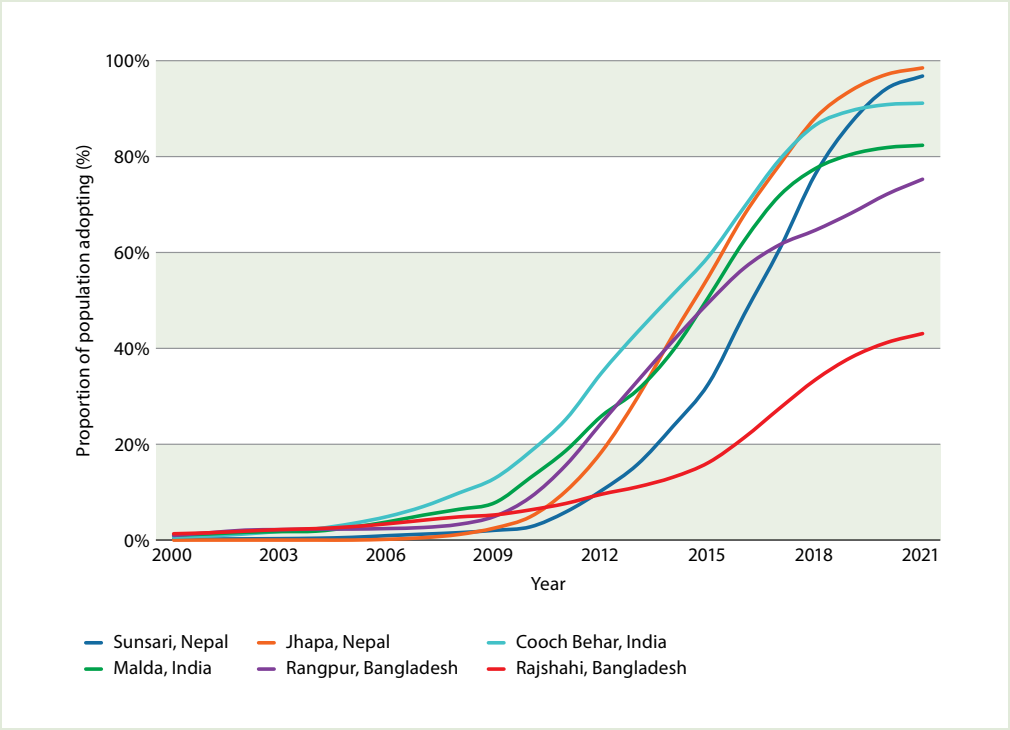
2.2 Challenges in Predicting Agricultural Technology Adoption Rates

There are many drivers of adoption that will determine the shape and characteristics of an adoption curve. For agricultural systems, there is a comprehensive body of research explaining the broad range of factors influencing the adoption and diffusion of practices (for example, Feder and Umali (1993), Pannell et al. (2006), Knowler and Bradshaw (2007), Alcon et al. (2014) and Kassie et al. (2013)). Despite this, predicting adoption rates is complex, given that any prediction of the future is fraught with uncertainties. Predictions need to account for a wide range of drivers in the diffusion and adoption process specific to each location, population, and innovation.

As an example, Figure 2 visualizes the adoption rate of the rotovator in six locations in Nepal, India, and Bangladesh on the Eastern Gangetic Plains (EGP) of South Asia. While the machinery is similar (the major exception being that the machinery is a two-wheel tractor operated in Bangladesh and a four-wheel tractor operated in Nepal and India) and was introduced to the districts at similar periods, each of the six locations experiences different adoption curves. This highlights the need to not just consider the characteristics of the technology, but also the nuanced characteristics of the population (as well as ensuring not to aggregate populations that may have vastly different characteristics).

FIGURE 2

ADOPTION RATES FOR THE ROTOVATOR IN SIX LOCATIONS ON THE EGP OF SOUTH ASIA (SRFSI PROJECT)



Source: Brown et al., (2021d).

As exemplified in both Figure 1 and Figure 2, the shape of adoption curves can vary greatly. It can be observed that various machines are adopted differently in the same location and that various populations adopt machinery in different ways. Any attempt at predicting agricultural adoption must be robust enough to account for such diversity of outcome, population, and innovation. Because of this, prediction of adoption has been challenging, and generally conversations default to guesswork and untested assumptions.

3. THE ADOPT DECISION SUPPORT TOOL

ADOPT is a digital decision support tool that, when provided key information related to common adoption processes, is able to predict key adoption metrics, such as the peak rate of adoption and time to peak rate of adoption for a specified population and innovation. It does this by transferring an extensive technical ex-post adoption literature body established over several decades into an ex-ante prediction tool, with the aim of ensuring the deep knowledge developed on adoption can be optimized to support localized policy and program decision making. During original development, the underlying principles of ADOPT were to ensure that it considered a comprehensive range of population-specific and practice-specific factors that influence adoption by farmers, as established via the extensive adoption literature body, while being simple enough to be applied by non-technical project practitioners who usually operate in low resource, low data environments (Kuehne et al., 2017). To do this, an intuitive tool was developed to guide individuals and groups through a structured evaluation process of key adoption processes relevant to a particular innovation and population, while also stimulating structured and systematic discussions about factors relevant to adoption. The target audience for ADOPT are those who may not otherwise be undertaking a structured evaluation of adoption potential.

To achieve this, ADOPT is structured around 22 key questions that reflect key and common adoption drivers. ADOPT then provides users with three **prediction** outputs: [1] A prediction of **how many** farmers will try using a technology, predicted as a proportion of the population of interest; [2] prediction of **how soon** this level of 'peak adoption' will be reached; and [3] A summary of the most important factors influencing these outcomes, for the given technology and population. Further to this, ADOPT also aims to stimulate greater understand and collaborative engagement as part of the workshop process.

While ADOPT provides a prediction of peak adoption and time to peak adoption, it is not the only, nor even most important, aim of ADOPT. The second aim of ADOPT is to **engage** decision makers in discussions on what will make a given farming practice more useful and usable to a given population of farmers. There is known value in participatory approaches to policy and decision making, to which ADOPT aims to contribute. Engaging a group of stakeholders in discussing the characteristics of populations and technologies will not only enable the development of numbers and outputs but build connections between stakeholders that will aid broader collaboration and understanding. These qualitative benefits are additional upsides of ADOPT's approach.

The third aim of ADOPT is to **inform** participants about the key factors that affect adoption of the nominated practice. Importantly, ADOPT personalizes this guidance for the farming practice and nominated population. The objective is to help stakeholders with improved thinking and decision making, and especially close blind spots and areas that might have been forgotten or overemphasized in individual evaluations. The key goal of the sensitivity analysis is to highlight where policy and programming resources would be best placed to increase the speed and peak rate of adoption of the

nominated innovation. In this way, ADOPT informs stakeholders and aids in analytically informed decision making. Kuehne et al. (2012) highlight that ADOPT played an effective and valuable role in encouraging thinking about the influences on adoption.

A short introductory video is accessible at: adopt.csiro.au/howItWorks.aspx. For an in depth understanding of the development of ADOPT see Kuehne et al., 2017, Brown et al., 2016 and Llewellyn and Brown (2020).

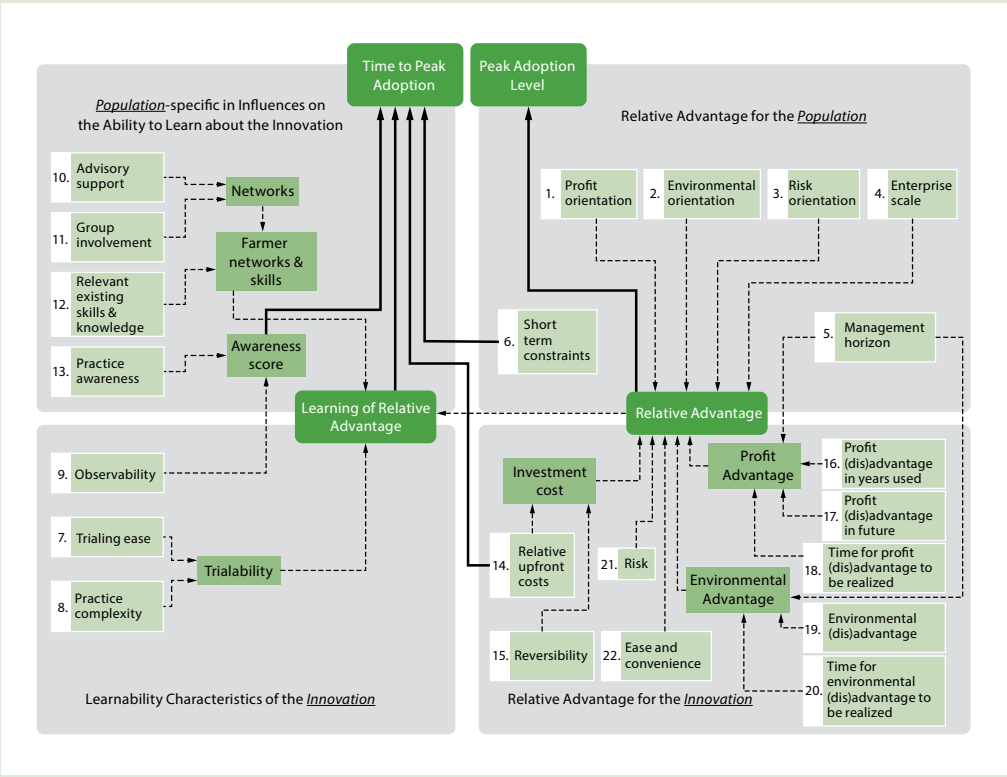
3.1 ADOPT's Framework for Adoption Prediction

The underlying theory of ADOPT is based on the 'Diffusion of Innovation' theory framed by Rogers (2003), specifically the theme of relative advantage. ADOPT frames adoption as an outcome of four interacting elements that consider [a] relative advantage and [b] learnability in relation to [i] a population and [ii] an innovation. The combination of these elements leads to the prediction of peak adoption and time to peak adoption (Figure 3). Underwritten in this is the assumption that substantial relative advantage is required to stimulate high levels or adoption; a process that takes time will usually only be adopted by a subset of an overall population.

In this way, the peak adoption level for an explored innovation is derived primarily by its relative advantage, in turn determined by factors such as its riskiness, ease of use and profitability (Pannell et al., 2006). Likewise, the time taken to reach peak adoption is derived primarily from the speed that farmers are able to learn about the innovation, in turn determined by factors such as existing engagement with social and/or extension networks, practice changes required and how easily innovations can be observed. These factors and their relationships are widely discussed in the existing literature body (e.g., Vanclay (2004); Lindner (1987); Griliches (1957); Feder and Umali (1993); Pannell et al. (2006); and Rogers (2003)).

FIGURE 3

THE ADOPT THEORETICAL FRAMEWORK



Source: Llewellyn and Brown (2020).

3.2 Using ADOPT for Agricultural Innovation Assessment

ADOPT is often used in a workshop setting, where the exploration of various stakeholder perspectives is encouraged. The process is designed to be discussive within a workshop setting, to engage participant in discussion, collaboration and learning. ADOPT is accessed via https://adopt.csiro.au/. A free trial version is openly available, with a small fee for full access enabling the full results of an analysis.

3.2.1 Establishment of Project Details

ADOPT works by specifically exploring the characteristics of a nominated innovation and population. The first step of ADOPT is therefore to define these as specifically as possible. For example, in defining the population you do not need to define every individual in a geographic area but may instead select a subpopulation such as maize farmers, female-headed households, or those with farms over a certain size or with certain irrigation facilities. Likewise, when detailing the innovation, it can be useful to define certain key features, such as if machinery ownership, rental, or services are likely to be the common method of access to the machinery.

3.2.2 Detailing Responses to ADOPT Questions

To use ADOPT, 22 questions must be addressed (Table 1). These cover the four quadrants of the theoretical framework applied (*see section 3.1*). Responses are used in functions that describe quantitatively how the variables relate to each other, and how they influence time to peak adoption and peak adoption level.

TABLE 1

ADOPT QUESTIONS FROM THE SMALLHOLDER MODEL.

Title	Question
Productivity (or profit) orientation	What proportion of the target population has maximizing farm productivity (or profit) as a strong motivation?
Local community benefit orientation	What proportion of the target population has benefits to their local community or village as a strong motivation?
Risk orientation	What proportion of the target population has minimizing the risk of production (or profit) losses as a strong motivation?
Enterprise scale	What proportion of the target population depend highly on the activity(s) that the innovation will affect for their livelihood?
Management horizon	What proportion of the target population consider what happens beyond 10 years' time to be very important in their farm decision making?
Short term constraints	What proportion of the target population are currently affected by a severe but temporary short-term constraint?
Trialable	How easily can a potential adopter of the innovation trial it on their own farm before deciding whether to adopt?
Innovation complexity	How easily can the full range of implications and effects of the innovation be evaluated once it is used?
Observability	How easy is it for others in the target population to observe that the innovation is being used by a farmer in their local area?
Advisory support	What proportion of the target population have regular contact with people who provide farm-specific advice and have the potential to provide advice relevant to the innovation?
Group involvement	What proportion of the target population regularly participate in farmer communication networks that have the potential to discuss the innovation?
Relevant existing skills & knowledge	What proportion of the target population will need to develop substantial new skills and knowledge to successfully use the innovation?
Innovation awareness	What proportion of the target population are already aware of the use or trialling of the innovation in their local area?
Relative upfront cost of innovation	To what extent does adopting the innovation require initial up-front investment?
Reversibility of innovation	How easy is it to dis-adopt the innovation?
Productivity (or profit) benefit in years that it is used	To what extent does the innovation affect productivity (or profit) in the years that it is used?
Future productivity (or profit) benefit	To what extent does the innovation change productivity (or profit) in a future period after it is used?
Time until any future productivity (or profit) benefits are likely to be realized	How long after the innovation is used does it take for the future effects on productivity (and profit) considered in the previous question to be realized?
Local village/community costs & benefits	To what extent does the innovation affect the local community or village?
Time to local village/community benefit	How long does the innovation take to affect the local community or village?
Risk exposure	To what extent does the innovation affect the risk of production (or profit) losses?
Ease and convenience	To what extent does the innovation affect the ease and convenience of farming?

Source: Author (2024)

3.2.3 Exploring Predicted Results

ADOPT provides two key numbers to predict adoption:

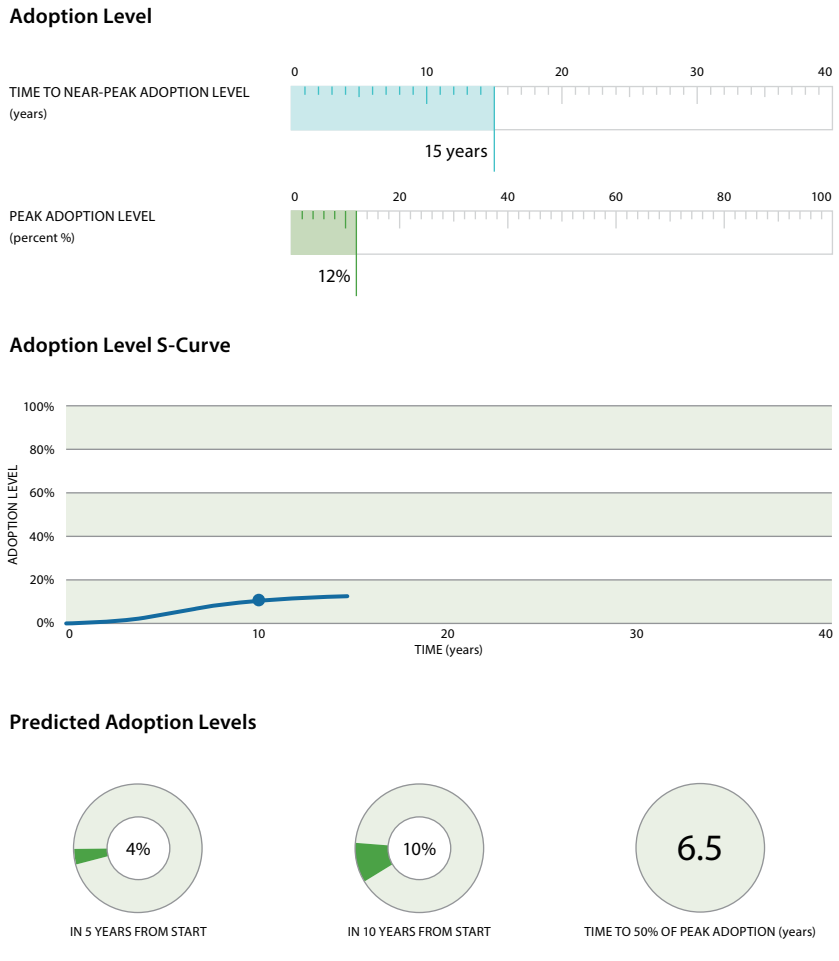
[1] the time to near peak adoption in years; and

[2] the peak adoption level.

These can then be plotted as a figure to produce an adoption curve. In Figure 4, example output from ADOPT is visualized, offering with information on time to peak adoption and peak adoption level, expected adoption at five and ten years from inception, and the time to 50% predicted adoption in years.

FIGURE 4

THE ADOPT INTERFACE SHOWING ADOPTION PREDICTION RESULTS. THE EXAMPLE SHOWN COURTESY OF THE SRFSI PROJECT, WHERE MUSHROOM FARMING IN COOCH BEHAR BLOCK, INDIA WAS EXPLORED.



NOTES: The prediction of Peak Adoption Level and Time to Peak Adoption Level are numeric outputs that are provided to assist with insight and understanding and like any forecasts should be used with caution. Time to Neat peak Adoption represents the time to 99% of the maximum predicted adoption level.

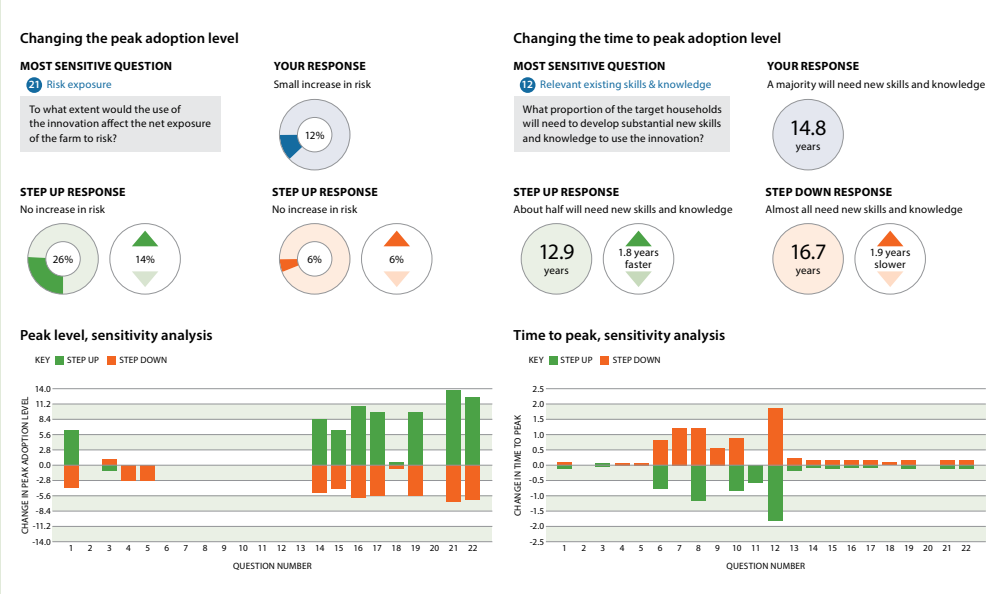
Source: Author (2024)

3.2.4 Exploring Sensitivity Results

ADOPT also provides a sensitivity analysis to guide discussions on mechanisms to increase both the speed and peak rate of adoption. Figure 5 visualizes ADOPT example output of the sensitivity of each question to the output of the ADOPT model for both the peak rate of adoption and time to peak adoption. This can be used to identify certain factors that are influential, which could be incorporated into data driven extension or policy strategy to encourage adoption. In the example below, risk exposure is identified as the most sensitive input for peak adoption and may be interpreted as a need for a mechanism to reduce risk through insurance schemes or government interventions to aid in adoption. Likewise, existing skills and knowledge had the most influence on the time to reach peak adoption, so an improved extension and training package would be optimal to ensure a more rapid adoption.

FIGURE 5

ADOPT INTERFACE OUTPUT THAT SHOWS THE IMPACT OF INPUT CHANGES INTO ADOPT ON PEAK ADOPTION RATES. THE EXAMPLE SHOWN COURTESY OF THE SRFSI PROJECT, WHERE MUSHROOM FARMING IN COOCH BEHAR BLOCK, INDIA WAS EXPLORED WITH PROJECT PARTNERS.



Source: Author (2024)

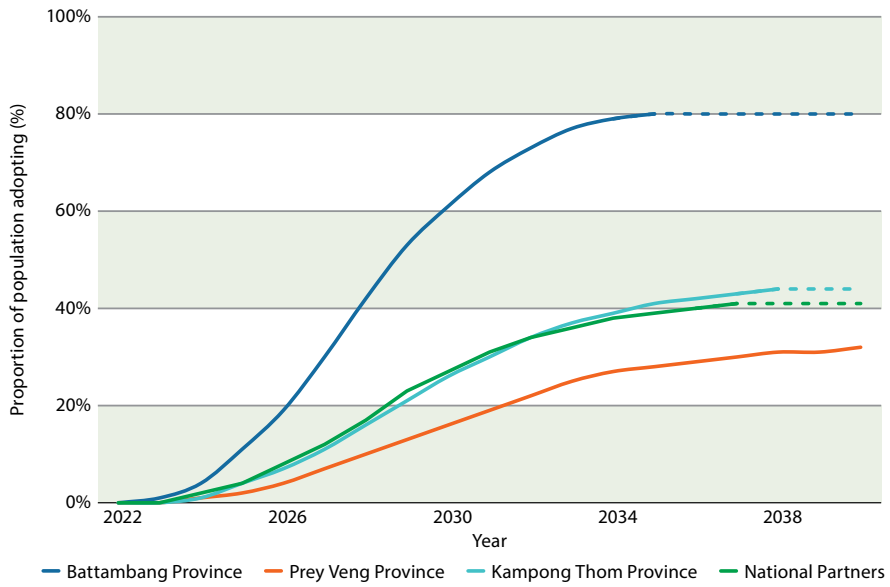
3.3 Case studies of ADOPT Use in Asia

3.3.1 Scaling of Mechanized Direct Seeded Rice (mDSR) in Cambodia

mDSR is an emergent planting technique to address multiple production constraints in Cambodia, though it is still in an emergent phase of development. Brown et al. (2021b) document four ADOPT workshops (three provincial and one national) run in Cambodia as part of the Consultative Group on International Agricultural Research (CGIAR) Excellence in Agronomy-2030 use-case on mDSR. Results indicate a strong potential to scale mDSR in Battambang province and moderate potential in Prey Veng and Kampong Thom provinces and countrywide (Figure 6).

FIGURE 6

ADOPT RESULTS FOR MDSR IN CAMBODIA



Source: Brown et al. (2021b).

When considering interventions that future projects could leverage, the most important factor in all provinces was the productivity of machinery. The most sensitive element influencing peak adoption is that of productivity benefits. As such, ensuring productivity benefits through improved machinery performance, ensuring correct protocols of use are followed, and resolving concerns over seed drop would substantially increase peak adoption levels (between 16% and 24% on current predictions). Yet per sensitivity analysis, the adoption curve is relatively sensitive, and multiple factors in each location can enable a >15% increase in peak adoption rate. Likewise, the time to peak adoption in each province was most sensitive to the trialability of the mDSR machinery, and as such, the time to peak adoption could be reduced 1.2 years by ensuring adequate access to machinery via service provision support, thereby making farmers' ability to trial easier. In summary, efforts to scale mDSR in Cambodia should be focused on: [1] a broad sensitization program targeted at wide-reaching exposure of farmers to increase awareness; [2] further modification to mDSR machinery to ensure productivity benefits; and [3] empowering (potential)

service providers with training and business development skills so as to service created demand from the sensitization campaign.

3.3.2 Potential adoption of oil palm agroforestry in Indonesia

Indonesia aims to enrich monoculture oil palm plantations using forest tree species, as associated with the social forestry program. Research on oil palm agroforestry adoption has focused on the factors and barriers to the adoption process but little about the ex-ante potential for adoption itself. Madjid et al. (2023) applied ADOPT to explore the potential for moving away from monoculture oil palm with forest farmer groups in Jambi Province, Indonesia. ADOPT predicted 19 years to reach a peak adoption rate of 79%. The conclusions of this work highlight the need for external and government assistance to ensure speedy and substantial adoption of social forestry programs to replace oil palm monocultures.

3.3.3 Biofortified Wheat Seed Production in India

In India, high-yielding wheat varieties are becoming widespread in use. Meanwhile, biofortification increasingly offers promise in tackling micronutrient deficiency while helping to address poverty and hunger. Singh et al. (2022) collect ADOPT data from farmers in Haryana and Punjab to assess the potential of biofortified wheat variety seed production. In Haryana, peak adoption was estimated at 98%, taking seven years, while in Punjab, peak adoption was estimated at 2%, taking 18 years. Various reasons for the divergence in results were discussed, ranging from current awareness levels and promotional activities, a lack of premium pricing, spatial considerations, socio-economic conditions, and psychology.

4. EVALUATING ADOPT'S ACCURACY IN ASIAN AGRICULTURAL SETTINGS

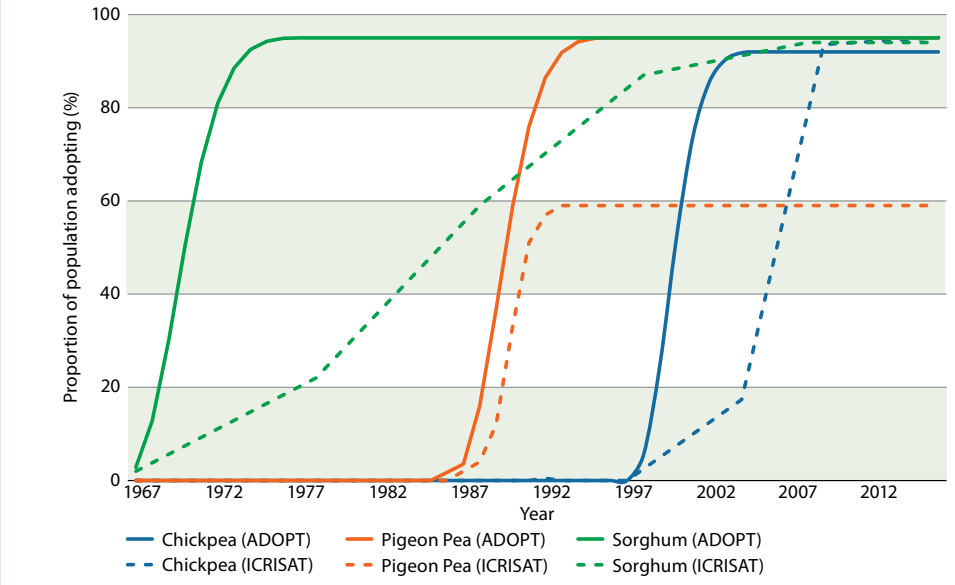
For APO member countries to be confident in the use of ADOPT, an understanding of its accuracy is necessary. While ADOPT has been found to make accurate predictions for agricultural technologies in Australia (Kuehne et al., 2017), less validation work has been done in developing countries where contexts are quite different. Identifying where ADOPT makes *accurate* predictions would justify the use of ADOPT in APO member countries. In addition, identifying where ADOPT makes *inaccurate* predictions would help researchers identify where further work is needed to make ADOPT even more useful to technology funders and developers in APO member countries. To date, several validations of ADOPT have been undertaken for Asian situations, with varying extents of data to validate outputs.

4.1 Validating ADOPT Against ICRISAT Data: Crop Variety Adoption in India

In India, ADOPT was tested by comparing its predictions with the independent International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) surveyed adoption rates of three crop varieties: chickpea JG-11, pigeon pea ICP 8863 (Maruthi), and a sorghum variety. This evaluation was conducted at a workshop with 15 ICRISAT researchers in Hyderabad, Telangana State. Smallholder ADOPT predictions were compared against the ICRISAT data to assess their accuracy (Figure 7). The validation showed varied results for different crops. For chickpeas, ADOPT predicted peak adoption of 53% in 10 years, which closely matched the ICRISAT data initially but plateaued later, indicating a higher (97%) but slower adoption (12 years). For sorghum, adoption was high (94%) but slow (40 years) in ICRISAT data, with ADOPT predicting 84% over 13.5 years. Overall, compared to the validation data, the Smallholder ADOPT model overestimated the speed of adoption for all varieties and demonstrated varied accuracy for peak rates of adoption.

FIGURE 7

VALIDATION OF ADOPT FOR VARIOUS CROP VARIETIES IN INDIA



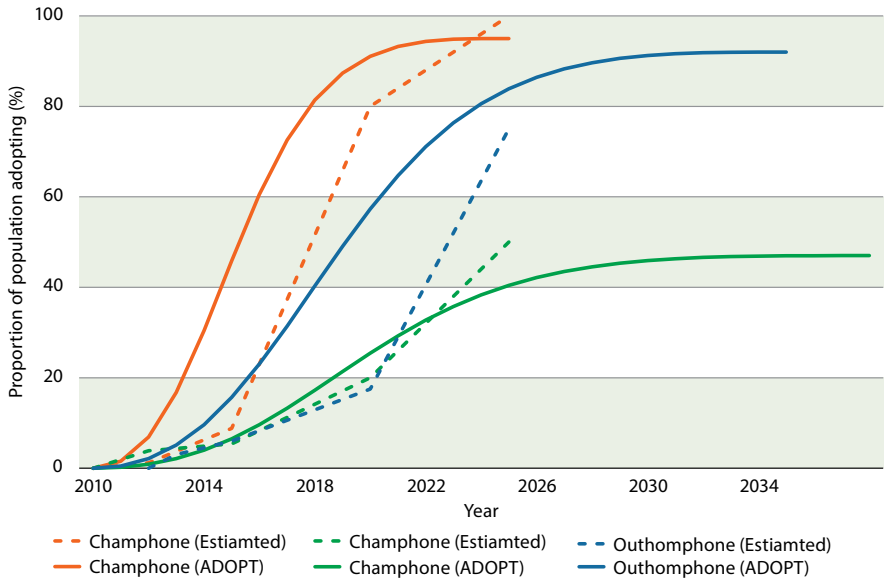
Source: Brown et al. (2016).

4.2 Testing ADOPT's Predictions: Direct Seeder Adoption in Savannakhet, Lao PDR

In Lao PDR, validation of ADOPT focused on the adoption of direct seeder machines by farmers in the Savannakhet Province. Over a two-day field visit, information was gathered from researchers and extension workers. This information was used to make ADOPT predictions, as well as measure how much and how quickly the machinery was taken up in reality (Figure 8). Results were then unpacked with sixteen farmers from three villages. The validation indicated that initial ADOPT predictions were overly optimistic, and careful re-examination of inputs with researchers and extension workers led to more realistic adoption curves, with lower and slower adoption rates. Further discussions with the sixteen farmers revealed unexpected factors that influenced the use of the seeding machines, namely labor-saving advantages, limited training to use the machinery, and limited capital availability for farmers to invest in the machinery.

FIGURE 8

ADOPT VALIDATION FOR RICE SEEDING EQUIPMENT IN LAO PDR.



Source: Brown et al. (2016).

4.3 Comprehensive Validation Study: Multi-Machine Adoption Analysis in Bangladesh

The above validation highlights a limited extent of the validation of ADOPT, due mainly to limited datasets to independently validate ADOPT predictions. To address this, representative machinery adoption data was collected using a multi-stage, stratified random sampling strategy to achieve a representative sample of households across ten districts in Bangladesh. To remove selection bias, locations were completely randomized by lottery with the following parameters: five villages within each union, two unions within each upazila, and two upazilas within each district. Since household-level sampling frames were unavailable, an estimated number of households were obtained in each village through consultation with local points of contact. A systematic random sampling approach with a fixed interval was then implemented within each village to ensure households across different village sections were included and to avoid clustering, with the interval ensuring no two sampled households shared a boundary. The main decision-making head of household was invited for a voluntary interview, targeting the individual most knowledgeable about household decisions and activities. The questionnaire covered adoption behaviors for 22 machines across five machinery categories: (1) land preparation, (2) planting, (3) irrigation, (4) harvest, and (5) postharvest. In total, 1,000 households were surveyed.

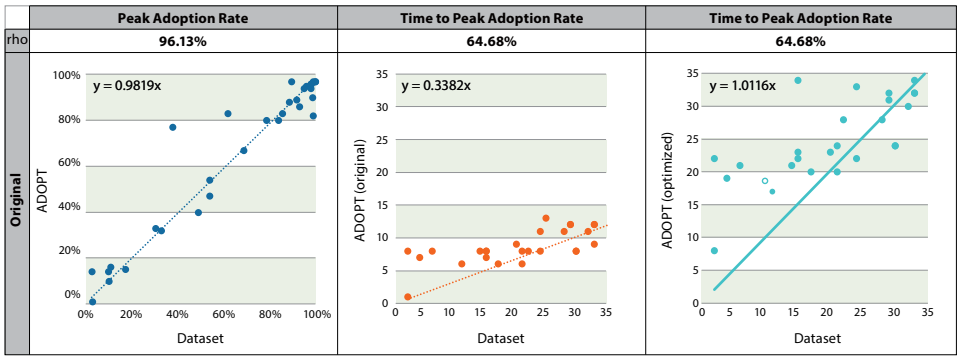
From the 220 adoption curves generated, 31 curves were selected that were deemed 'mature' curves where peak adoption was likely reached (as observed by four consecutive years with a stable proportion of adopters). For each of these curves, local expert opinion from field staff at local

International Maize and Wheat Improvement Center (CIMMYT) offices were sought to help populate ADOPT. In doing so, paired adoption curves that are predicted and empirically measured by ADOPT could be compared.

Comparison of each of the 31 paired curves is provided in supplementary materials. Across the 31 evaluated curves, a similar pattern of accurate prediction of peak rates of adoption, but overestimation of speed to peak adoption, was observed. Sixty-seven percent of peak adoption rate predictions were within 5% of the actual adoption rate seen through the empirical datasets, with an observed correlation rho of 96%. In terms of time to peak adoption, the overestimation observed in previous validations was also observed, with the observed correlation rho of 65%. However, if the rate to peak adoption predicted by ADOPT was doubled and the start year of prediction delayed until 10% adoption, a much closer line of fit at 1:1 is generated (Figure 9).

FIGURE 9

PREDICTED ADOPT RATES COMPARED TO EMPIRICALLY MEASURED ADOPTION. FROM RIGHT TO LEFT: PEAK ADOPTION RATE, TIME TO PEAK ADOPTION RATE, AND TIME TO PEAK ADOPTION RATE (OPTIMIZED).

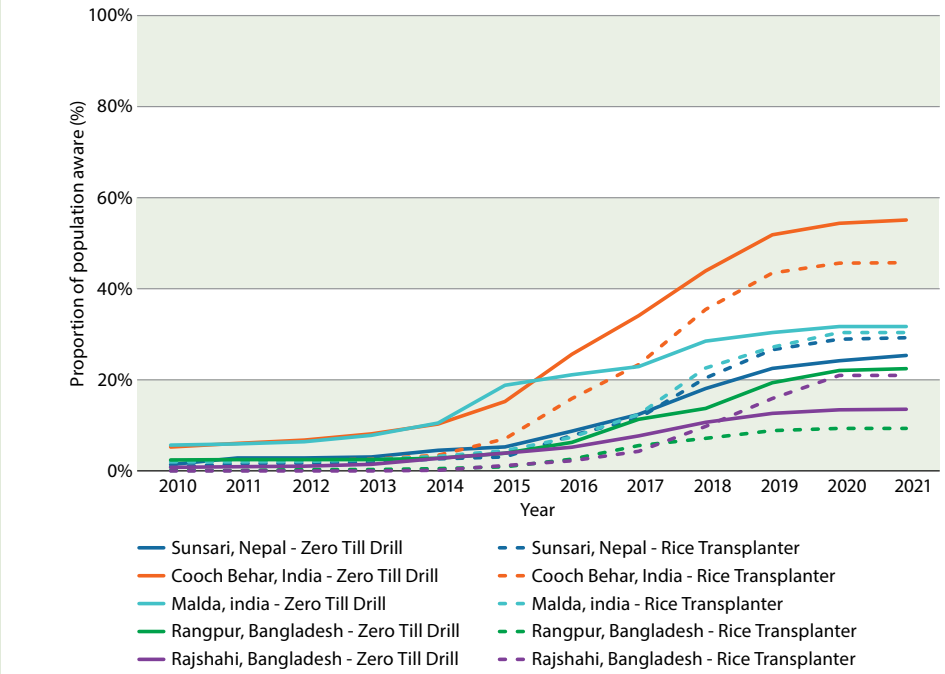


Source: Author

These results likely reflect the complexities of predicting adoption over a longer period than the original Australian ADOPT model was designed to accommodate. One key consideration for developing country contexts may be the slower diffusion process (Brown et al., 2018) than otherwise expected in the original ADOPT model. Figure 10 highlights the slow nature of information diffusion of the Mechanical Transplanter of Rice (MTR) and zero tillage drill (ZTD) in five locations on the EGP of South Asia. In most cases, many years are needed to develop even moderate awareness of new agricultural machinery, which is correspondingly likely to slow down adoption (Brown et al., 2021d).

FIGURE 10

RATES OF AWARENESS IN FIVE LOCATIONS ON THE EGP OF SOUTH ASIA FOR TWO AGRICULTURAL MACHINES

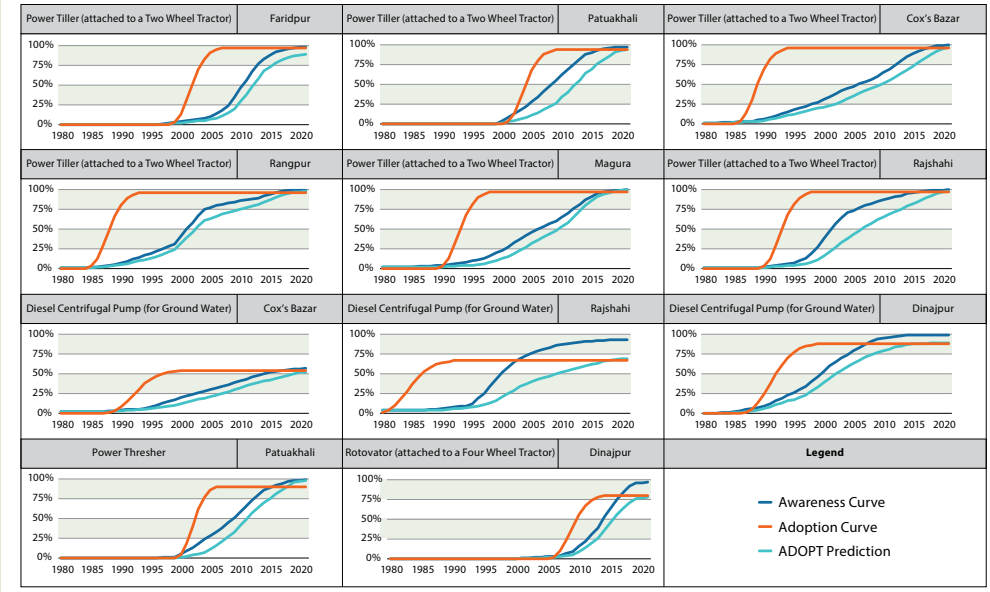


Source: Brown et al. (2021d).

This pattern can be clearly seen when ADOPT results are compared to the empirical adoption and awareness curves (Figure 11). These 11 exhibited examples highlight that while the peak adoption estimate is accurate, the time to peak is outpacing even awareness growth. Likewise, the inflection point of the curve tends to be geared toward a slower initial period and more rapid later adoption, as opposed to the more symmetrical ADOPT curve. This highlights that the time to peak adoption estimated by ADOPT could be improved by [a] increasing the lag time driven by slower diffusion of awareness within a population; and [b] moving the inflection point of the curve shape such that it occurs in an asymmetrical later point in the adoption curve.

FIGURE 11

CONSISTENT OVERESTIMATES OF THE LAG TIME FOR AWARENESS TO BUILD IN SELECTED COMPARATIVE EXAMPLES FROM BANGLADESH.



Source: Author

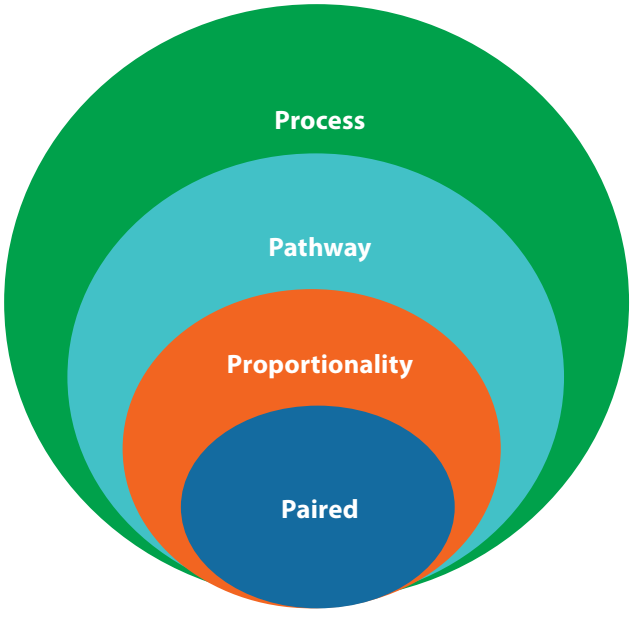
Because the time frames often span decades in developing countries due to more complex information diffusion systems, more complexities in prediction are also observed. For instance, the likelihood is increased for uncertainties, such as changes in policy, changing cost of machinery, changes in machinery service provision models and availability of rental machinery, import bans, technological obsolescence and leaps in technology performance. These all become more problematic; although they are likely to occur, they are impossible to predict temporally with accuracy.

5. BEYOND BINARY ADOPTION: THE FOUR P'S FRAMEWORK FOR DEEPER ADOPTION ANALYSIS

The ADOPT tool offers a valuable first step for facilitating the evaluation of potential farming practices in a simple, low data and non-technical process. To achieve this, it necessarily sacrifices a more nuanced understanding of adoption. Where time and resources are available, there is valuable insight to be gained by deeper considerations of adoption dynamics. Overall, the approach taken to adoption discussion will depend on the time, budgets, and stage of adoption that is in discussion. Initial ex-ante prediction, as ADOPT undertakes, is best in low data, time scarce environments, but is best supported by deeper considerations. The 'Four Ps' of adoption discussion (Figure 12) provide a basis for more in-depth adoption discussions.

FIGURE 12

THE 'FOUR PS' OF ADOPTION DISCUSSION, VISUALIZING THE DIFFERENT POSSIBLE LEVELS OF ADOPTION DISCUSSION.

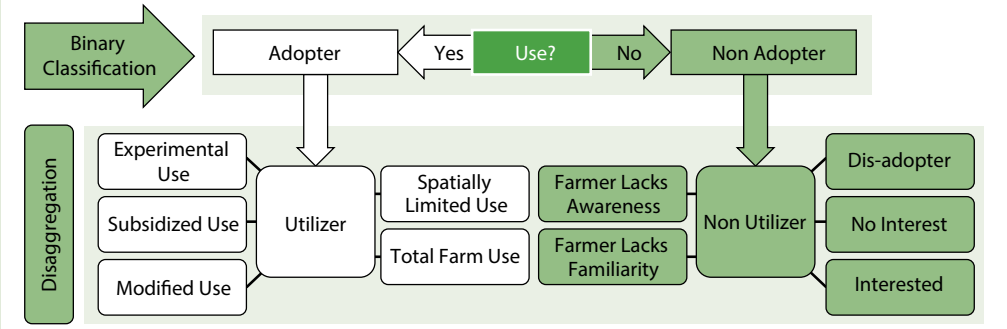


Source: Author

The first P relates to 'paired' adoption discussions. In practice, this pairing refers to the binary framing of 'adoption' vs 'non adoption'. For example, ADOPT defines adoption as a farmer's first use of a farming practice, a simple definition that enables timely and practical predictions of practice change and makes ADOPT accessible to non-specialist users of the tool. The limitation of this framing is that practice change is better framed as a continuous process that does not start and end with first use by farmers (Brown et al., 2017a; Figure 13). A category-based understanding, in combination with ADOPT, can offer a more complete picture of how farmers and other actors engage with new practices. This understanding can help ADOPT users collaboratively make appropriate use of ADOPT and its predictions.

FIGURE 13

BINARY VS CATEGORICAL FRAMING OF ADOPTION.



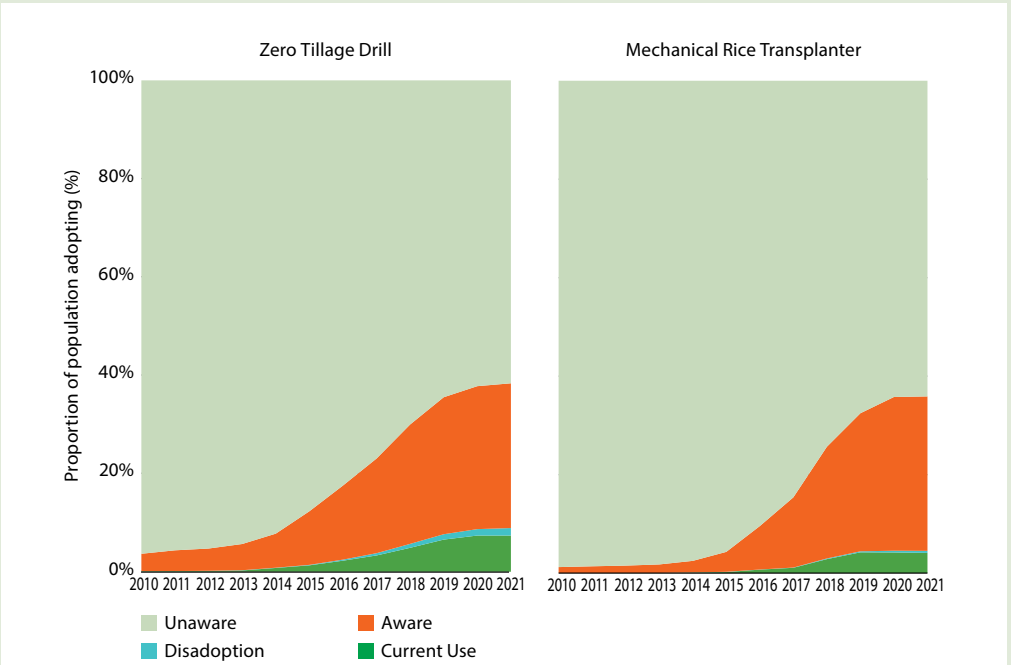
Source: Brown et al. (2017a).

5.1 Proportional Adoption Framing

Previous literature has advocated for a deeper understanding of adoption as a dynamic process rather than a binary outcome (e.g., Brown et al., 2017a; Chaudhary et al., 2022; de Oca Munguia et al., 2021; Chaudhary et al., 2023). One way to achieve this is to convert from a binary categorization to a four-category disaggregation, where adoption is split between unawareness and awareness and adoption is split into current use and disadoption. In doing this, the population is always visualized as 100% (e.g., a fixed y-axis). By framing it this way, the trends that occur with awareness (or lack of) can be visualized, as can populations that have awareness without progressing to use. For instance, a lack of awareness, as opposed to growing awareness without adoption, may be diagnosed as a very different barrier to adoption and requires very different actions to resolve. This is visualized for two machines across the EGP of South Asia (Figure 14). As indicated, there has been substantial growth in the awareness of the mechanical rice transplanter and zero tillage drill, but that has not corresponded to any adoption pattern. Likewise, a substantial proportion of the population remains unaware. Such trends might not be observed by using traditional paired adoption analysis but can provide valuable insights into the most impactful policy and programming approaches (Brown et al., 2021d).

FIGURE 14

A PROPORTIONAL BREAKDOWN OF MACHINERY STATUS ACROSS THE EGP OF SOUTH ASA

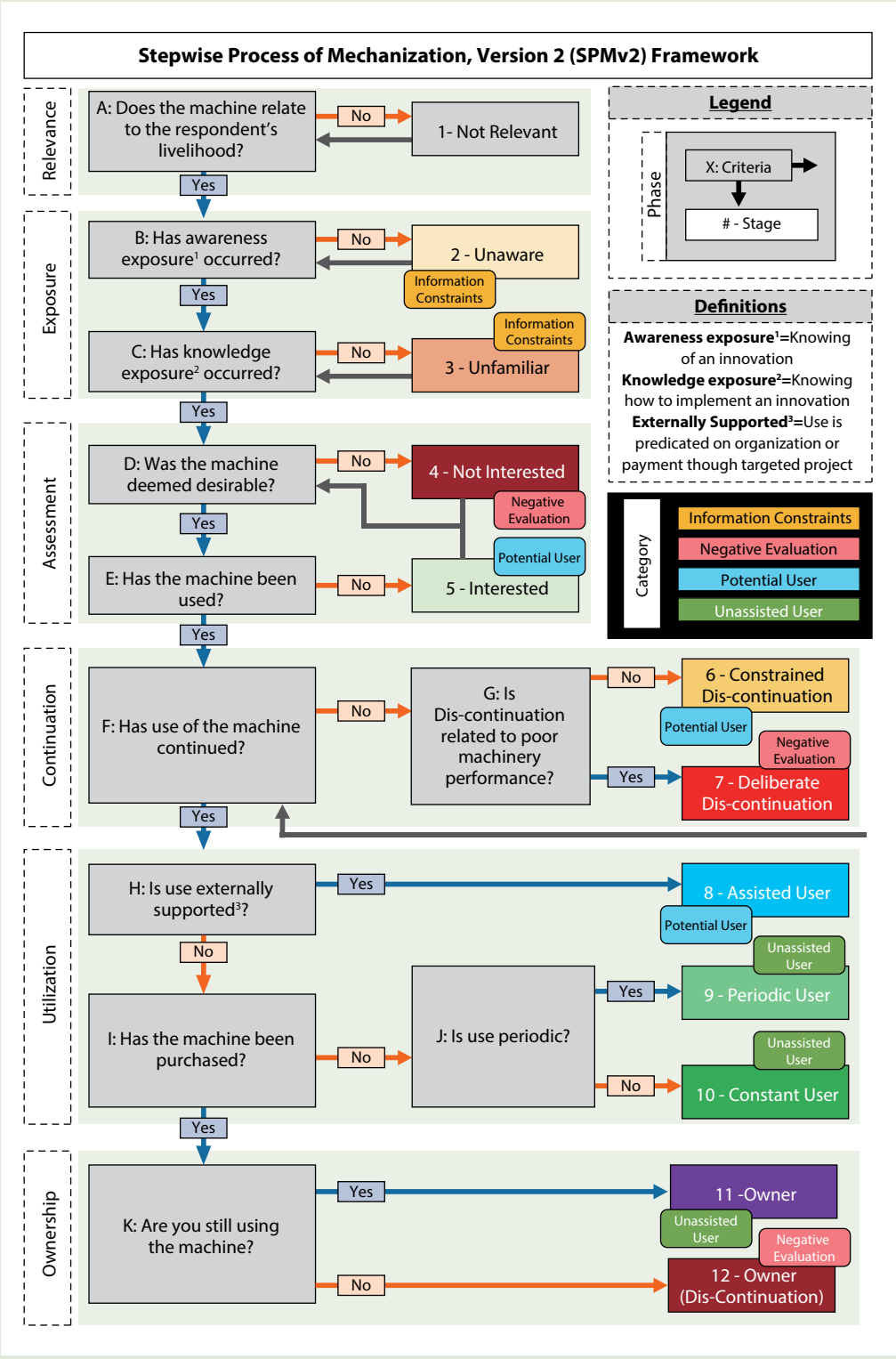


Source: Brown et al. (2021d).

The Stepwise Process of Mechanization (SPM) framework provides an additional disaggregation of adoption and non-adoption to 12 categories (Brown et al., 2021a). Central to such approaches is the conceptualization of adoption as a stepwise transition, transcending the adopter versus non-adopter dichotomy. This approach draws from the Process of Agricultural Utilization Framework (PAUF; Brown et al., 2017a), initially applied to investigate the status of Zero Tillage and Conservation Agriculture in Eastern and Southern Africa. Adapted to examine the mechanization status in the Nepal Terai, this framework evolved into the Stepwise Process of Mechanization Framework (SPM, Figure 15; Brown et al., 2021a). The SPM classifies individuals into 12 stages that fit within five phases: Exposure, Assessment, Continuation, Utilization, and Ownership.

FIGURE 15

ADAPTED STEPWISE PROCESS OF MECHANIZATION FRAMEWORK

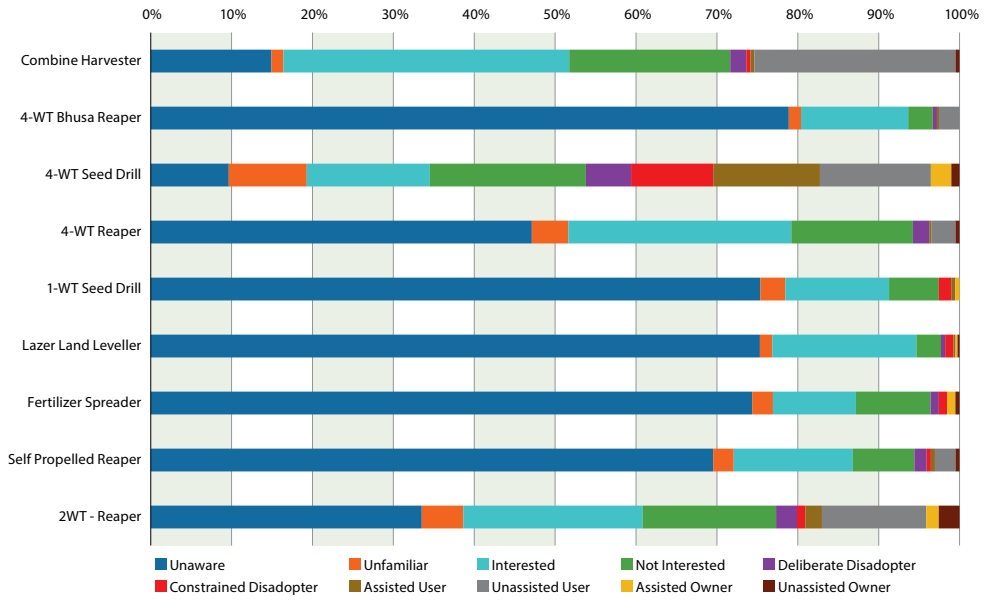


Source: Brown et al. (2024a). .

The outputs of the SPM enable a proportional breakdown across these categories and, thereby, a much more nuanced understanding of the adoption status. Figure 16 provides the output of an SPM analysis for nine machineries on the Nepal Terai. As indicated below, there is much more value in discussing this in categorical terms, which can help diagnose key issues and trends, rather than in binary terms. For example, concerning Nepal Terai, it is evident through an SPM analysis that information constraints are the primary constraint to adoption for most machines, while negative evaluation is much more likely on older machinery. The downside to this approach is that it requires much more intensive data to achieve interpretable outcomes, and that data needs to be widely representative and unbiased to represent a target population.

FIGURE 16

EXAMPLE SPM OUTPUT FROM THE NEPAL TERAI



Source: Brown et al. (2021a).

5.2 Pathway to Adoption Framing

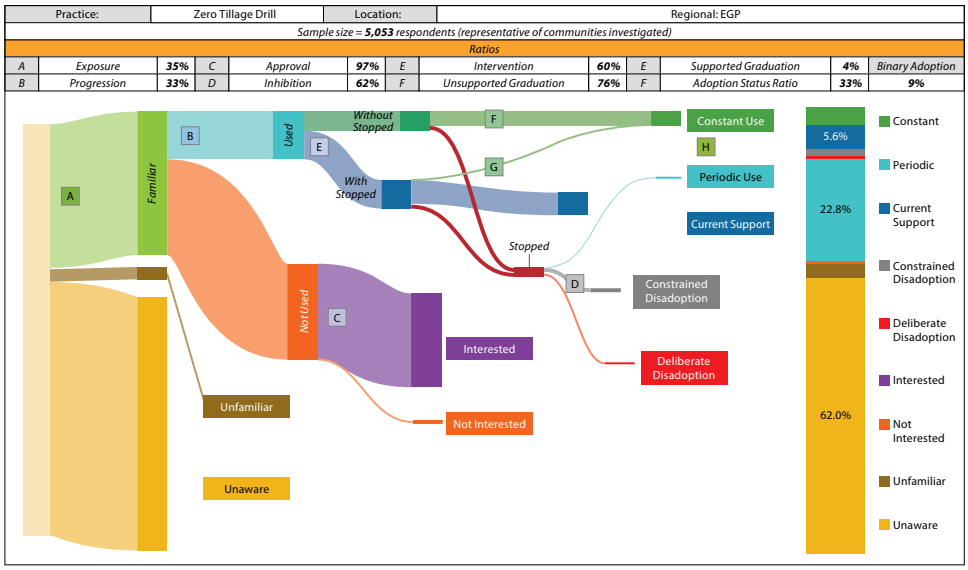
For a complete understanding of adoption, it is important to be cognizant of the flow between different categories of the SPM framework. For instance, how successful have subsidies or extension supports been in encouraging sustained adoption? Often subsidization is considered in the same way as full adoption, despite evidence that it often leads to disadoption (Brown et al., 2017b). Alternatively, is maladaptation or suboptimal adaptation occurring? For instance, farmers often use part but not all of a recommended farming practice, as illustrated by those who practice minimum tillage while neglecting conservation agriculture practices such as legume diversification and crop stover retention (Brown et al., 2017a). This can have suboptimal consequences for productivity and sustainability (Guto et al., 2011). Similarly, farmers often use a new farming practice on some but not all of their fields or livestock. This is significant, as the impacts of partial adoption can be smaller, or even categorically different, when compared to full adoption.

There is also value in understanding what drives noninterest or disadoption, rather than simply identifying that it is occurring. Understanding disadoption is also crucial to understanding adoption dynamics and problems that need to be overcome. For example, some farmers in Nepal used and then stopped using four-wheel tractors, either voluntarily or because machinery service providers were no longer accessible (Brown et al., 2021a). Similarly, some farmers in northern India, western Bangladesh, and the Terai of Nepal used conservation agriculture when there was government support to do so, but abandoned the practice when government support ceased (Chaudhary et al., 2023). Understanding these as separate issues allows for an accurate diagnosis of adoption bottlenecks and helps direct policy and programming interventions to where they are most needed.

These questions become increasingly important in the process of monitoring, evaluating, and learning about interventions. Using a Sankey visualization, the SPM framework visualizes these types of adoption pathways, particularly in terms of drivers of non-use and disadoption, altered adoption, and subsidized or trial adoption (Brown et al., 2017a). Understanding these different adoption outcomes can fundamentally inform how adoption is occurring and what interventions will be most impactful. Figure 17 presents a Sankey SPM visualization of zero tillage drill adoption across the EGP of South Asia. It is clear, for example, that the majority of adoption is actually via subsidies, which may produce more varied long-term adoption outcomes. Likewise, the progression from subsidies is primarily to disadoption and not sustained autonomous adoption, raising questions about these subsidies' effectiveness. Likewise, the vast majority of interested nonusers are positive, yet have not progressed to use. This raises questions about support structures in place to enable adoption. All these trends would not be observable by a simple, binary 9% adoption assessment.

FIGURE 17

AN SPM SANKEY VISUALIZATION OF THE PATHWAY OF ZERO TILLAGE ON THE EGP OF SOUTH ASIA



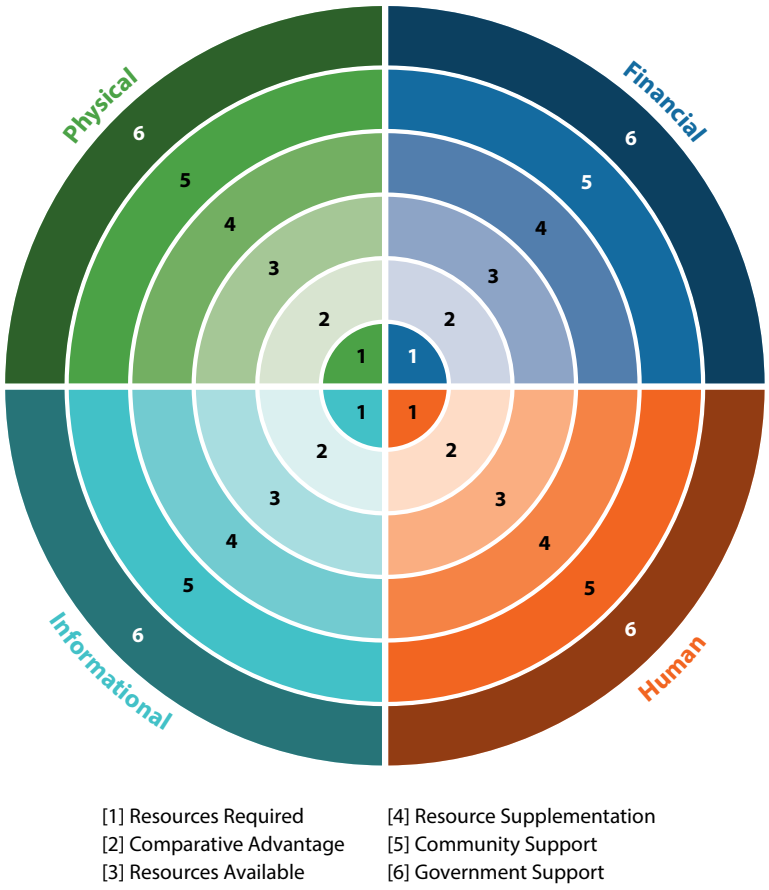
Source: Author

5.3 Process of Adoption Framing

The gold standard of discussion around adoption involves pairing the aforementioned quantitative methods with in-depth qualitative approaches. This allows for an understanding of not only outcomes, but also the decision processes of existing and potential users. Where possible, programming and policy makers should allocate resources to the ground truth of any assumptions input into ADOPT or used in general decision making. An emerging body of work applies frameworks such as the Decision-making Dartboard approach (DmD; Brown et al., 2021c; Figure 18) to diagnose perceptions and bottlenecks in adoption processes, often paired with the SPM approach where subsets of typologies are specifically explored to understand their adoption outcomes. Such frameworks explore the uptake of agricultural technologies at individual, household, community, and institutional 'platform' levels. The aim is to deepen understanding of perceptions, abilities, and enabling environments in which farmers make technological evaluations and decisions (Anibaldi et al., 2021).

FIGURE 18

THE DECISION-MAKING DARTBOARD (DMD) AIMS TO UNPACK DECISION PROCESSES AND DRIVERS AT VARIOUS SCALES TO AID IN UNDERSTANDING WHY ADOPTION TRENDS ARE OCCURRING.



Source: Brown et al. (2021c).

Recent examples of in-depth qualitative studies in South Asia highlight the prevalence of poverty traps in mechanization initiatives (e.g., Chaudhary et al., 2023), gender as a key driver of agricultural change (e.g., Timsina et al., 2023, Karki et al., 2023), breakdowns in the adoption process causing stagnation before use (e.g., Karki et al., 2024), and a lack of incentive for mechanization service provision (e.g., Sharma et al., 2024; Brown et al., 2021c). Such work was catalyzed by initial process-oriented works that identify key trends to be explored (Brown et al., 2021a).

6. CONCLUSIONS AND POLICY RECOMMENDATIONS

In order to ensure that assumptions about likely benefits and impacts actually reflect real-life situations, it is imperative to obtain a clearer picture of the likely adoption extent and speed of emerging agricultural practices and innovations. In turn, this will benefit extension, research, and policy interventions. Further, an understanding of areas that can be leveraged to increase impact can provide a pathway to responsible policy and programming resource allocation.

ADOPT is a decision support tool with potential uses for policy and programming stakeholders in their pursuit of data-informed decision making. ADOPT provides a structured process to not only make predictions, but also engage and inform stakeholders about considerations for adoption. This report documents the ADOPT process and framework, and provides an in-depth validation of ADOPT against real adoption data.

Limited previous validations of ADOPT in Lao PDR and India highlighted a mixed accuracy of ADOPT predictions with a general overprediction of the speed to peak rates of adoption, but these validations were limited by access to reliable and representative adoption datasets. To overcome this, an in-depth validation of ADOPT was undertaken with district representative machinery adoption data from Bangladesh. This validation of ADOPT in provides a clear basis to suggest that the prediction of peak adoption is relatively accurate, while the prediction of the time to peak adoption is overestimated. Notably, this overestimation is consistently fast by a factor of two. This is likely driven by slower than expected information diffusion and awareness growth processes in contexts with more limited extension networks, and slowing the predicted rate of adoption by half provides a more accurate prediction of time to peak adoption. This trend reinforces that awareness growth is often slower than expected and overall, points to the need for tempered expectations about just how quickly beneficial technologies can be adopted in larger populations. Such issues should specifically be considered in future updates to ADOPT.

Despite this, ADOPT is shown to be a valid tool for stakeholders and policy makers across Asia to help inform their program and policy-based decision making. Observations from workshops held in Asia highlight that respondents find value in the ADOPT process, with many wondering whether alternatives to ADOPT can consider a wide range of factors that impact adoption; perhaps they might simply defer to unclear and potentially biased decision making by a singular, usually senior, individual. Such processes are neither collaborative nor transparent, and they have high potential to lead to suboptimal decision making. These sentiments are reflected in ADOPT's pitch: it is not simply a tool for predicting adoption, but also one that aims to engage participants through collaboration and inform general discussions about adoption processes.

In closing, suggestions on important further considerations to structure policy and programming discussions around adoption complement the data-driven inputs ADOPT can provide. Complementing binary estimates of adoption, whether ex-ate or ex-post, with proportional, pathway, and process-oriented investigations, is likely to greatly increase the robustness of thought

around agricultural programming and policy. There is hope that ADOPT, paired with these additional considerations, will provide an avenue for more data-driven, informed policy and programming discourse for agriculture in Asian contexts.

7. REFERENCES

Alcon, F, Tapsuwan, S, Brouwer, R., and de Miguel, M (2014) Adoption of irrigation water policies to guarantee water supply: A choice experiment, Environmental Science & Policy, Volume 44, Pages 226–236, https://doi.org/10.1016/j.envsci.2014.08.012.

Anibaldi, R., Rundle-Thiele, S., David, P., & Roemer, C. (2021). Theoretical underpinnings in research investigating barriers for implementing environmentally sustainable farming practices: Insights from a systematic literature review. *Land, 10*(4), 386. https://doi.org/10.3390/land10040386

Brown, B; Sharma, A; Timsina, P, Krupnik, T (2024a) Pump Power: The 'what, how, when, and why' of irrigation machinery adoption in Bangladesh. Asian Development Bank Special Issue on Mechanisation in Asia. 10.13140/RG.2.2.19356.30081

Brown, B; Sharma, A; Timsina, P, Aravindakshan, S; Krupnik, T (2024b) Stepwise methods for more nuanced adoption analysis: A case study harvest and post-harvest mechanization in Bangladesh. Discover Agriculture 10.13140/RG.2.2.26067.18727

Brown, B., Paudel, G.P. and Krupnik, T.J., (2021a) Visualising adoption processes through a stepwise framework: A case study of mechanisation on the Nepal Terai. *Agricultural Systems, 192*, p.103200. https://doi.org/10.1016/j.agsy.2021.103200

Brown, B., Ouk, A., Flor, R.J., Keo, S. and Rathmuny, T. (2021b) Mechanised Direct Seeding of Rice in Cambodia: EiA ADOPT Workshops Initiative 10.13140/RG.2.2.22711.74408

Brown., B, Samaddar, A., Singh, K., Leipzig, A., Kumar, A., Kumar, P., Singh., D, Malik, R., Craufurd, P., Kumar, V., McDonald, A. (2021c) Understanding decision processes in becoming a fee-for-hire service provider: a case study on direct seeded rice in Bihar, https://doi.org/10.1016/j.jrurstud.2021.09.025

Brown. B. et al (2021d) Final Report – The Sustainable and Resilient Farming System Intensification (SRFSI) in the Eastern Gangetic Plains Project https://www.aciar.gov.au/publication/technical-publications/sustainable-and-resilient-farming-systems-intensification-eastern-gangetic-plains-srfsi

Brown, B., Nuberg, I., Llewellyn, R. (2019) Pathways to intensify the utilization of conservation agriculture by African smallholder farmers. *Renewable Agriculture and Food Systems. 34*(6), 558-570 https://doi.org/10.1017/S1742170518000108

Brown, B., Llewellyn, R., Nuberg, I. (2018) Why do information gaps persist in African smallholder agriculture? Perspectives from farmers lacking exposure to conservation agriculture. *Agricultural Education and Extension 24 (2) pp 191–208* http://dx.doi.org/10.1080/1389224X.2018.1429283

Brown, B., Nuberg, I., Llewellyn, R. (2017a) Stepwise frameworks for understanding the utilisation of conservation agriculture in Africa. *Agricultural Systems* 153 (11–22) https://doi.org/10.1016/j.agsy.2017.01.012

Brown, B., Nuberg, I., Llewellyn, R. (2017b) Negative evaluation of conservation agriculture: perspectives from African smallholder farmers. *International Journal of Agricultural Sustainability* vol. 15, no. 4, pp. 467-481 http://dx.doi.org/10.1080/14735903.2017.1336051

Brown P. R., Nidumolu U. B., Kuehne G., Llewellyn R., Mungai O., Brown B., and Ouzman J. (2016) Development of the public release version of Smallholder ADOPT for developing countries. ACIAR Impact Assessment Series Report No. 91. Australian Centre for International Agricultural Research. 56 pp https://www.aciar.gov.au/publication/technical-publications/development-public-release-version-smallholder-adopt-developing-countries

Chaudhary, A: Timsina, P; Suri, B; Karki, E; Sharma, A; Sharma, R; Brown, B (2023) Contextual realities and poverty traps: why South Asian smallholder farmers negatively evaluate conservation agriculture, Renewable Agriculture and Food Systems https://www.doi.org/10.1017/S1742170523000066.

Chaudhary, A: Timsina, P; Suri, B; Karki, E; Sharma, A; Sharma, R; Brown, B (2022) Experiences With Conservation Agriculture in the Eastern Gangetic Plains: Farmer Benefits, Challenges, and Strategies That Frame the Next Steps for Wider Adoption– *Frontiers in Agronomy https://doi.org/10.3389/fagro.2021.787896*

de Oca Munguia, O. M., Pannell, D. J., Llewellyn, R., & Stahlmann-Brown, P. (2021). Adoption pathway analysis: Representing the dynamics and diversity of adoption for agricultural practices. Agricultural Systems, 191, 103173. 10.1016/j.agsy.2021.103173

Feder, G., Umali, D., (1993). The adoption of agricultural innovations: a review. Technol. Forecast. Soc. Chang. 43, 215–239 https://www.sciencedirect.com/science/article/pii/004016259390053A

Feder, G., Just, RE., Zilberman, D. (1985) Adoption of Agricultural Innovations in Developing Countries: A Survey Economic Development and Cultural Change, Vol. 33, No. 2 (Jan., 1985), pp. 255–298 (44 pages) https://www.jstor.org/stable/1153228

Griliches, Z. (1957) An Exploration in the Economics of Technological Change Econometrica, Vol. 25, No. 4 (Oct., 1957), pp. 501-522 Published by: The Econometric Society Stable URL: http://www.jstor.org/stable/1905380

Guto, S. N., De Ridder, N., Giller, K. E., Pypers, P., & Vanlauwe, B. (2012). Minimum tillage and vegetative barrier effects on crop yields in relation to soil water content in the Central Kenya highlands. *Field Crops Research, 132*, 129–138. https://www.sciencedirect.com/science/article/pii/S0378429011003534

Kassie, M., Jaleta, M., Shiferaw, B., Mmbando, F., Mekuria, M., (2013). Adoption of interrelated sustainable agricultural practices in smallholder systems: evidence from rural Tanzania. Technol. Forecast. Soc. Chang. 80, 525–540. https://www.sciencedirect.com/science/article/pii/S0040162512001898

Karki E, Sharma A, Timsina P, Chaudhary A, Sharma R, Brown B. (2024) Strategies to overcome stagnation in agricultural adoption despite awareness and interest: a case study of conservation agriculture in South Asia. Renewable Agriculture and Food Systems. 2024;39:e14. https://doi.org/10.1017/S1742170524000073

Karki, E., A. Chaudhary, A. Sharma, P. Timsina, R. Sharma, A. Leipzig & B. Brown (2023) What agricultural transition means for women in male-headed households in South Asia: an in-depth exploration of intrahousehold evaluation processes, Gender, Technology and Development, Vol.27 (3) https://doi.org/10.1080/09718524.2023.2260655

Knowler, D., Bradshaw, B., (2007). Farmers' adoption of conservation agriculture: a review and synthesis of recent research. Food Policy 32, 25–48. https://www.sciencedirect.com/science/article/pii/S0306919206000224

Kuehne G, Llewellyn R, Pannell D, Wilkinson R, Dolling P, Ouzman J, Ewing M (2017) Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy, Agricultural Systems 156:115–125 https://doi.org/10.1016/j.agsy.2017.06.007

Lindner, R., (1987). Adoption and diffusion of technology: an overview in B. Champ, E. Highley, J. Remenyi (Eds.), Technological Change in Postharvest Handling and Transportation of Grains in the Humid Tropics, ACIAR, Bangkok, Thailand (1987), pp. 144–151 https://www.aciar.gov.au/publication/technical-publications/technological-change-postharvest-handling-and-transportation-grains-humid-tropics

Llewellyn, R., Brown, B. (2020) Predicting Adoption of Innovations by Farmers: What is Different in Smallholder Agriculture? Applied Economics Perspectives and Policy Vol 42 (1) pp 100 – 112 https://doi.org/10.1002/aepp.13012

Madjid, M. I. N., Marhaento, H., Permadi, D. B., Susanti, A., Riyanto, S., Imron, M. A., ... & Irawan, B. (2023, February). Potential adoption of oil palm agroforestry in Sungai Jernih Village, Jambi, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1145, No. 1, p. 012001). IOP Publishing. https://www.researchgate.net/publication/368710214_Potential_adoption_of_oil_palm_agroforestry_in_Sungai_Jernih_Village_Jambi_Indonesia

Pannell, D., Marshall, G., Barr, N., Curtis, A., Vanclay, F., Wilkinson, R., (2006). Understanding and promoting adoption of conservation technologies by rural landholders. Aust. J. Exp. Agric. 46, 1407–1424. https://api.research-repository.uwa.edu.au/ws/portalfiles/portal/88307669/Ch02_Pannell_et_al.pdf

Rogers, E., (2003). Diffusion of Innovations, 5th ed. Free Press, New York, NY https://teddykw2.wordpress.com/wp-content/uploads/2012/07/everett-m-rogers-diffusion-of-innovations.pdf

Sharma, A; Timsina, P; Chaudhary, A; Karki, E; Brown, B (2024) The Supply-Side Story of Zero Tillage Service Provision in the Eastern Gangetic Plains: Perspectives from Machinery Owners. Asia-Pacific Journal of Rural Development https://doi.org/10.1177/10185291241259809

Singh, S., Kumar, R., Kumar, S., Arora, K., Kumar, A., Khippal, A., ... & Singh, G. P. (2022). Predicting farmer uptake of innovation on 'Biofortified Wheat Variety' for seed production–An application of the adoption and diffusion outcome prediction tool (ADOPT). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4198456

Timsina, P; Sharma, A; Karki, E; Chaudhary, A; B, Suri; Sharma, R; Brown, B (2023) Necessity as a driver of bending agricultural gender norms in the Eastern Gangetic Plains of South Asia. International Journal of Agricultural Sustainability. Vol 21 (1) https://doi.org/10.1080/14735903.2023.2247766

Vanclay, F., (2004). Social principles for agricultural extension to assist in the promotion of natural resource management. Aust. J. Exp. Agric. 44, 213–222. https://www.publish.csiro.au/ea/pdf/ea02139

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10. ABBREVIATIONS

ADOPT	Adoption and Diffusion Outcome Prediction Tool
ACIAR	Australian Centre for International Agricultural Research
APO	Asian Productivity Organization
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Centre
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSISA MEA	Cereal Systems Initiative for South Asia-Mechanization Extension Activity
DmD	Decision Making Dartboard Framework
EGP	Eastern Gangetic Plains
ICRISAT	The International Crops Research Institute for the Semi-Arid Tropics
mDSR	mechanized Direct Seeding of Rice
MTR	Mechanized Transplanter of Rice
PAUF	Process of Agricultural Utilization Framework
SPM	Stepwise process of Mechanization Framework
SRFSI	Sustainable and Resilient Farming System Intensification
TAFSSA	Transforming Agrifood Systems in South Asia
USAID	United States Agency for International Development
ZTD	Zero Tillage Drill

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Dr. Brown has more than a decade of experience in participatory agricultural research (social science) in Australia, Asia, Africa and the Middle East, working with ACIAR, FAO, CIMMYT, and CSIRO. His academic research applies mixed methods and novel theoretical frameworks to offer deeper understanding while evaluating change processes within agricultural systems in both developed and developing country contexts, with a particular emphasis on moving scientific research 'from shelf to field'. Brendan has a Bachelor of Agricultural Science (with honors in soil science) from the University of Sydney and a PhD exploring the adoption dynamics of Conservation Agriculture across Eastern and Southern Africa from the University of Adelaide.

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12. APPENDICES
VALIDATION OF ADOPTION CURVES IN BANGLADESH

A note on the interpretation of ADOPT validation tables

The details of each of the 31 analyzed ADOPTs compared to empirical adoption curves are presented in the appendices. On the left-hand side, the response entered into ADOPT is shown, generally color-coded from green (positive) to red (negative). On the right-hand side, the resultant data is presented. 'Survey data' is that which is measured from the CSISA-MEA dataset and provides the measured awareness and adoption rate of the population. The orange curve reflects the ADOPT model prediction, while the green curve represents an 'optimized' ADOPT estimate that has two major changes:

[1] the start year of prediction is adjusted to the year in which adoption is 10%. This highlights that the technology will be possible to adopt on a farmer's field; and

[2] the speed to peak rate of adoption is halved, reflecting the need to better account for the lag and slow diffusion rates experienced in developing country contexts.

TABLE A1

POWER TILLER (ATTACHED TO A TWO WHEEL TRACTOR) [LOCATION: PATUAKHALI - BASE YEAR: 2000]

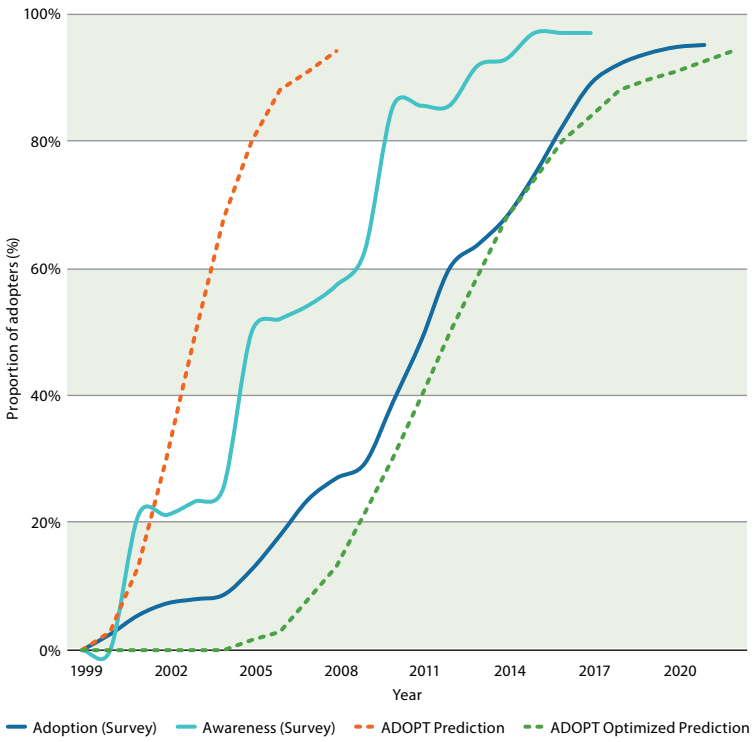
Machine	Power Tiller (attached to a two wheel tractor)	Location	Patuakhali	Base Year	2000

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	Almost all have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	About half have benefits to their community/village as a strong motivation
3. Risk orientation	Almost all have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	About half regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	95%	94%	1%	94%	1%
Time to Peak Rate	21 years	8 years	13 years	24 years	-3 years

Adoption Curves



Observations and Notes

The Power Tiller (attached to a two wheel tractor) is a land based tillage machine that transformed agriculture in Bangladesh though mechanizing traditional tillage practices. In Patuakhali the Power Tiller (attached to a two wheel tractor) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of nearly 3. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A2

POWER TILLER (ATTACHED TO A TWO WHEEL TRACTOR) [LOCATION: COX'S BAZAR - BASE YEAR: 1985]

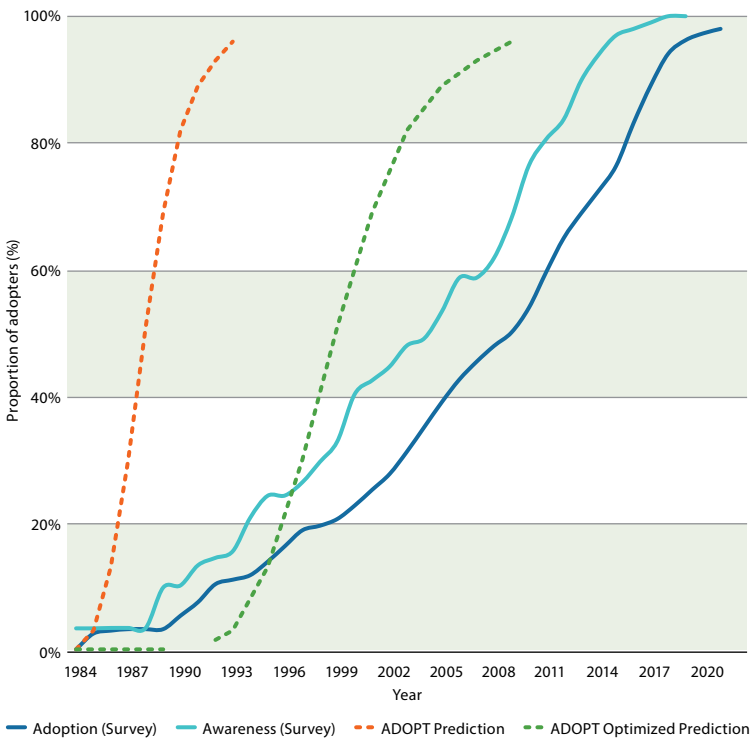
Machine	Power Tiller (attached to a two wheel tractor)	Location	Cox's Bazar	Base Year	1985

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	About half have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A minority have benefits to their community/village as a strong motivation
3. Risk orientation	A minority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Very large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Very large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	98%	96%	2%	96%	2%
Time to Peak Rate	36 years	8 years	28 years	24 years	12 years

Adoption Curves



Observations and Notes

The Power Tiller (attached to a two wheel tractor) is a land based tillage machine that transformed agriculture in Bangladesh though mechanizing traditional tillage practices. In Cox's Bazar the Power Tiller (attached to a two wheel tractor) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 4. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, there is still an overestimation of the speed of adoption. This highlights a reliance of the ADOPT model on the high profit benefit resulting in rapid adoption, which has not been the case here.

TABLE A3

POWER TILLER (ATTACHED TO A TWO WHEEL TRACTOR) [LOCATION: FARIDPUR - BASE YEAR: 1998]

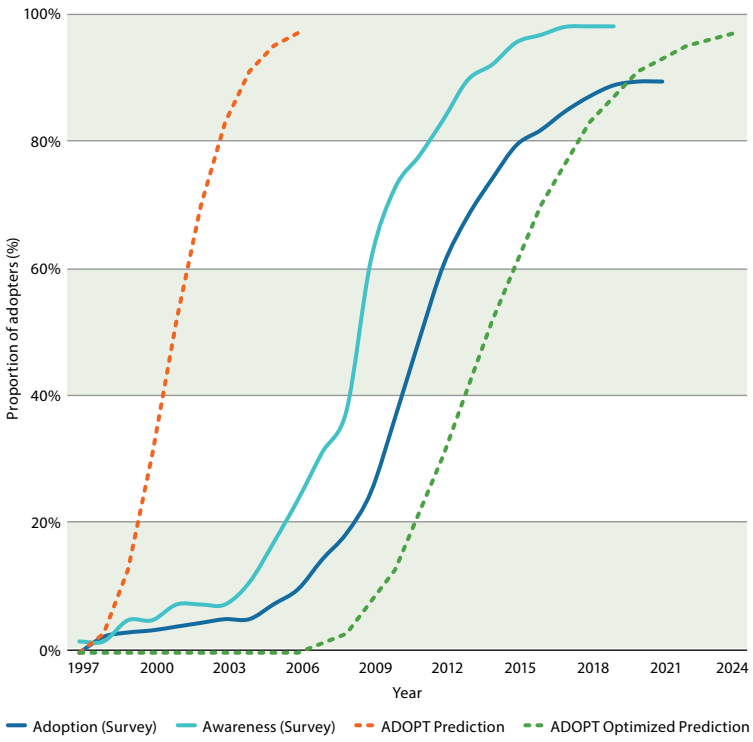
Machine	Power Tiller (attached to a two wheel tractor)	Location	Faridpur	Base Year	1998

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A majority have benefits to their community/village as a strong motivation
3. Risk orientation	Almost all have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	About half regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Very large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Very large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	89%	97%	-8%	97%	-8%
Time to Peak Rate	22 years	8 years	14 years	28 years	-6 years

Adoption Curves



Observations and Notes

The Power Tiller (attached to a two wheel tractor) is a land based tillage machine that transformed agriculture in Bangladesh though mechanizing traditional tillage practices. In Faridpur the Power Tiller (attached to a two wheel tractor) was widely and steadily adopted over the course of more than 3 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of nearly 3. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A4

POWER TILLER (ATTACHED TO A TWO WHEEL TRACTOR) [LOCATION: JASHORE - BASE YEAR: 2003]

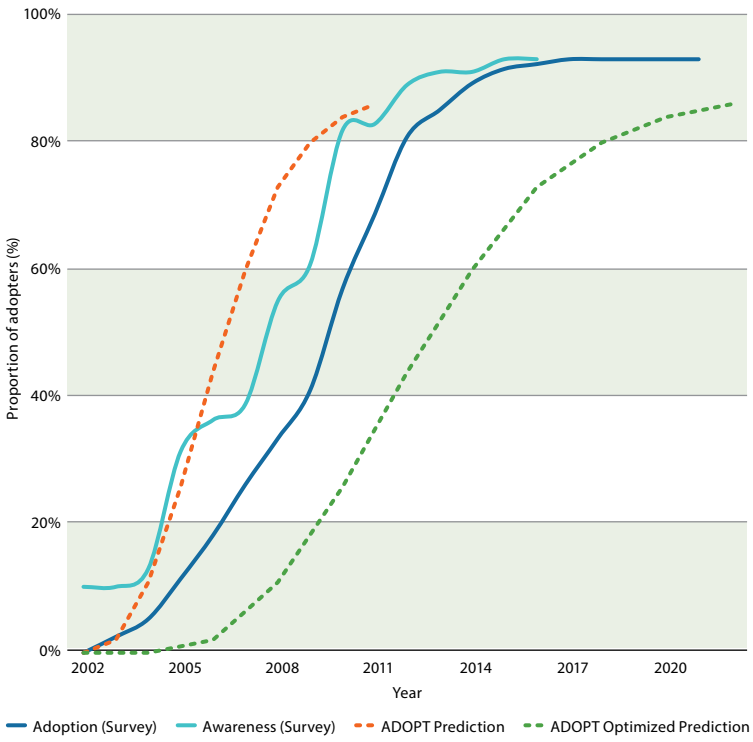
Machine	Power Tiller (attached to a two wheel tractor)	Location	Jashore	Base Year	2003

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	Almost all have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	About half have benefits to their community/village as a strong motivation
3. Risk orientation	A majority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Moderate productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Moderate increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	93%	86%	7%	86%	7%
Time to Peak Rate	14 years	8 years	6 years	21 years	-7 years

Adoption Curves



Observations and Notes

The Power Tiller (attached to a two wheel tractor) is a land based tillage machine that transformed agriculture in Bangladesh though mechanizing traditional tillage practices. In Jashore the Power Tiller (attached to a two wheel tractor) was widely and steadily adopted over the course of about 2 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of about 2. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction roughly matched the rate of awareness. By adjusting the start year of the prediction and slowing the rate by half, a closer match between survey and ADOPT prediction can be made. The lessening overprediction of speed in this case likely reflects a more recent socioeconomic context and improved extension systems, given the more recent introduction in Jashore.

TABLE A5

POWER TILLER (ATTACHED TO A TWO WHEEL TRACTOR) [LOCATION: JHENAIDAH - BASE YEAR: 2000]

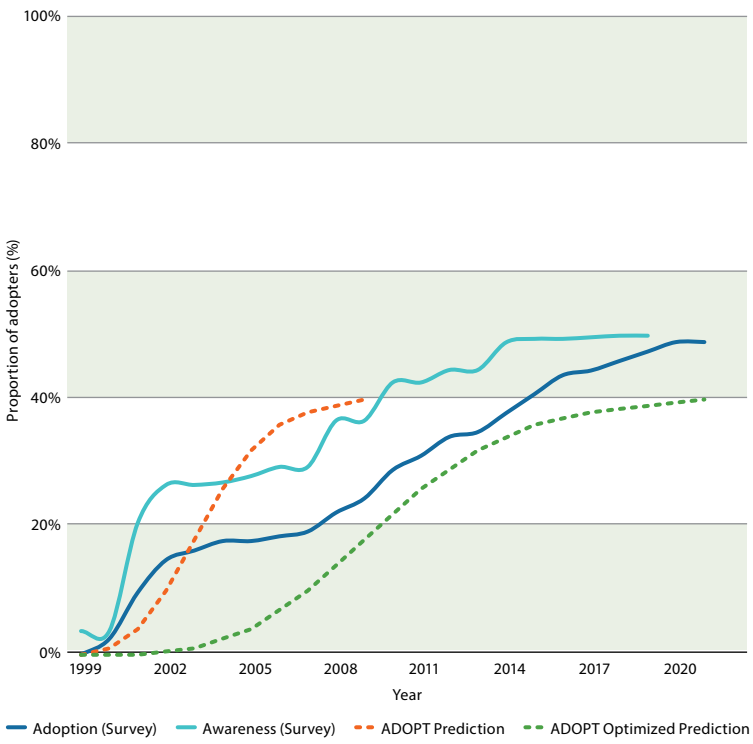
Machine	Power Tiller (attached to a two wheel tractor)	Location	Jhenaidah	Base Year	2000

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	About half have benefits to their community/village as a strong motivation
3. Risk orientation	A majority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	Almost none regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	49%	40%	9%	40%	9%
Time to Peak Rate	20 years	9 years	11 years	23 years	-3 years

Adoption Curves



Observations and Notes

The Power Tiller (attached to a two wheel tractor) is a land based tillage machine that transformed agriculture in Bangladesh though mechanizing traditional tillage practices. In Jhenaidah the Power Tiller (attached to a two wheel tractor) was widely and steadily adopted over the course of two decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 2. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, but similar to Jashore, to a lesser extent than the others examples due to more recent introduction and improved extension systems. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A6

POWER TILLER (ATTACHED TO A TWO WHEEL TRACTOR) [LOCATION: MAGURA - BASE YEAR: 1990]

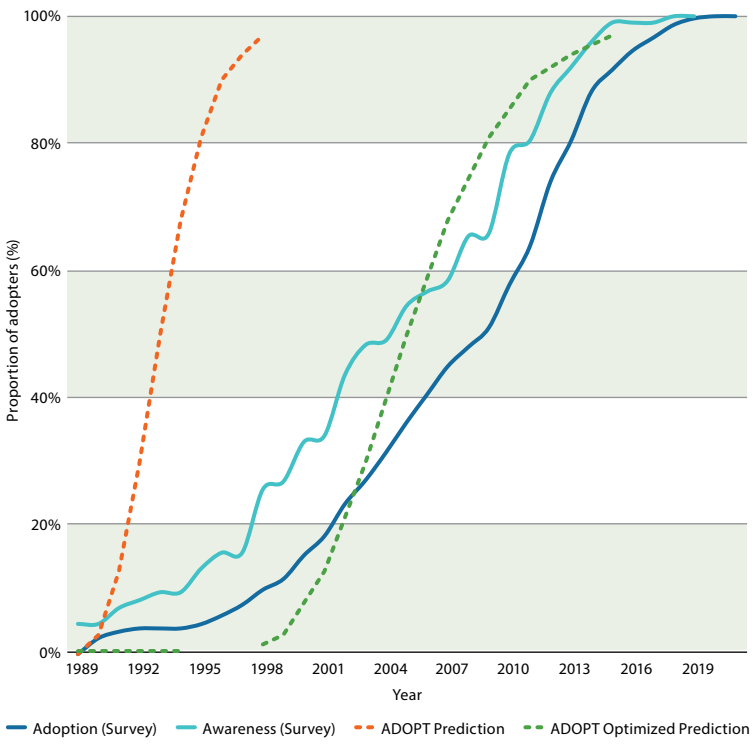
Machine	Power Tiller (attached to a two wheel tractor)	Location	Magura	Base Year	1990

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A minority have benefits to their community/village as a strong motivation
3. Risk orientation	About half have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Very large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Very large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	100%	97%	3%	97%	3%
Time to Peak Rate	30 years	8 years	22 years	24 years	6 years

Adoption Curves



Observations and Notes

The Power Tiller (attached to a two wheel tractor) is a land based tillage machine that transformed agriculture in Bangladesh though mechanizing traditional tillage practices. In Magura the Power Tiller (attached to a two wheel tractor) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 4. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A7

POWER TILLER (ATTACHED TO A TWO WHEEL TRACTOR) [LOCATION: NATORE - BASE YEAR: 1996]

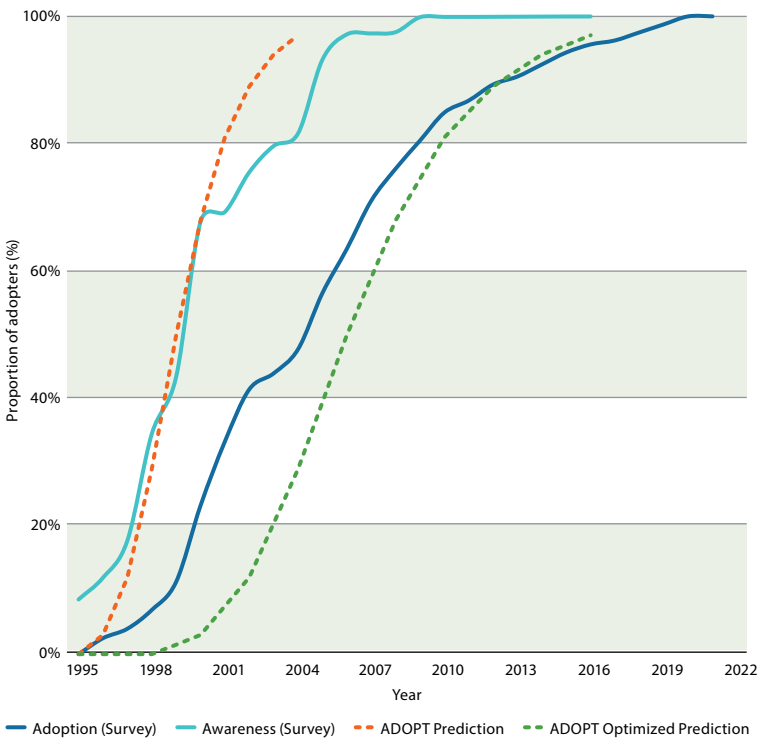
Machine	Power Tiller (attached to a two wheel tractor)	Location	Natore	Base Year	1996

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	Almost none have benefits to their community/village as a strong motivation
3. Risk orientation	A minority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Very large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Very large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	100%	97%	3%	97%	3%
Time to Peak Rate	24 years	8 years	16 years	22 years	2 years

Adoption Curves



Observations and Notes

The Power Tiller (attached to a two wheel tractor) is a land based tillage machine that transformed agriculture in Bangladesh though mechanizing traditional tillage practices. In Natore the Power Tiller (attached to a two wheel tractor) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of 3. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A8

POWER TILLER (ATTACHED TO A TWO WHEEL TRACTOR) [LOCATION: RAJSHAHI - BASE YEAR: 1990]

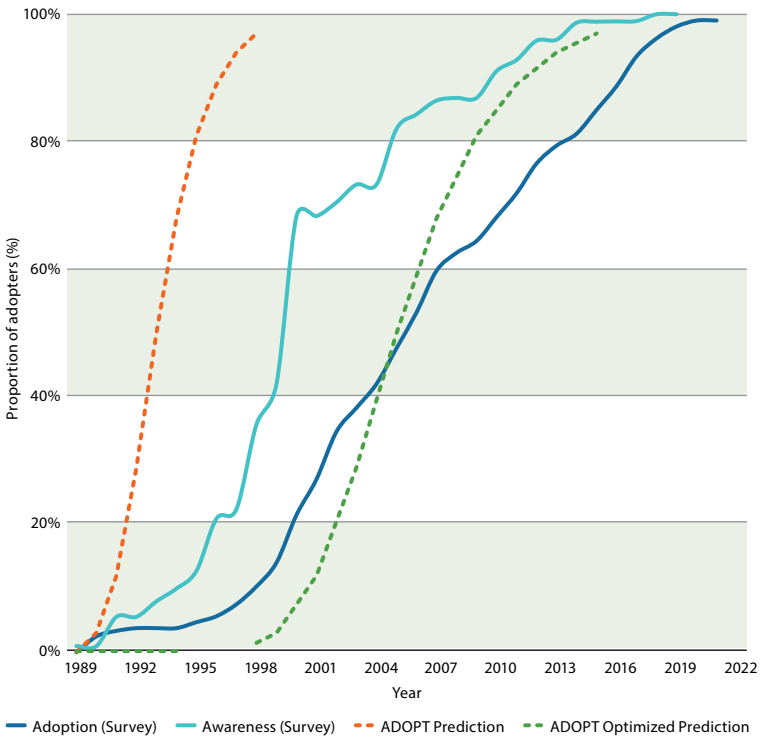
Machine	Power Tiller (attached to a two wheel tractor)	Location	Rajshahi	Base Year	1990

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	Almost none have benefits to their community/village as a strong motivation
3. Risk orientation	A minority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Very large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Very large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	99%	97%	2%	97%	2%
Time to Peak Rate	30 years	8 years	22 years	24 years	6 years

Adoption Curves



Observations and Notes

The Power Tiller (attached to a two wheel tractor) is a land based tillage machine that transformed agriculture in Bangladesh though mechanizing traditional tillage practices. In Rajshahi the Power Tiller (attached to a two wheel tractor) was widely and steadily adopted over the course of more than 3 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of nearly 4. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A9

POWER TILLER (ATTACHED TO A TWO WHEEL TRACTOR) [LOCATION: DINAJPUR - BASE YEAR: 1985]

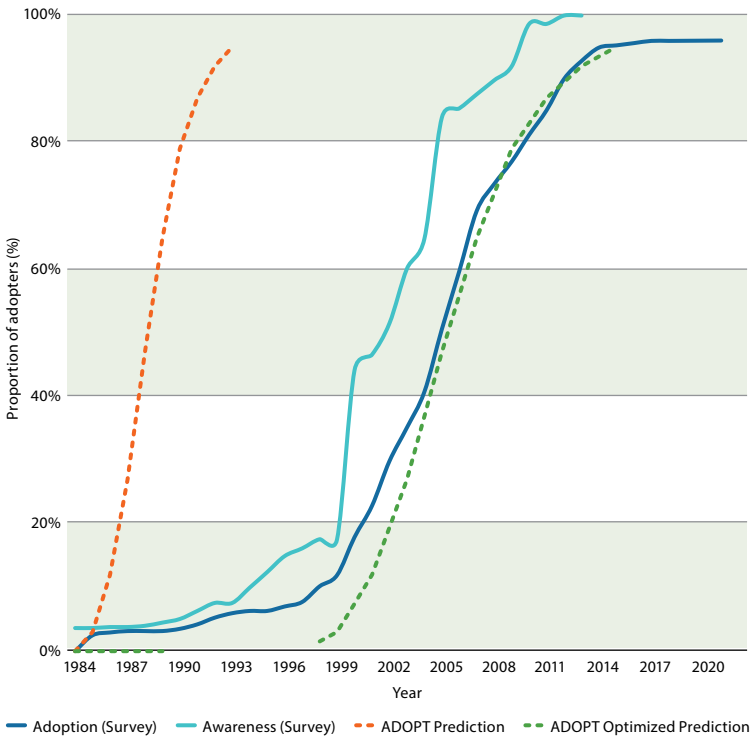
Machine	Power Tiller (attached to a two wheel tractor)	Location	Dinajpur	Base Year	1985

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	About half have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	Almost none have benefits to their community/village as a strong motivation
3. Risk orientation	A minority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	Almost none regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Very large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Very large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	96%	95%	1%	95%	1%
Time to Peak Rate	36 years	8 years	28 years	24 years	12 years

Adoption Curves



Observations and Notes

The Power Tiller (attached to a two wheel tractor) is a land based tillage machine that transformed agriculture in Bangladesh though mechanizing traditional tillage practices. In Dinajpur the Power Tiller (attached to a two wheel tractor) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 4. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A10

POWER TILLER (ATTACHED TO A TWO WHEEL TRACTOR) [LOCATION: RANGPUR - BASE YEAR: 1985]

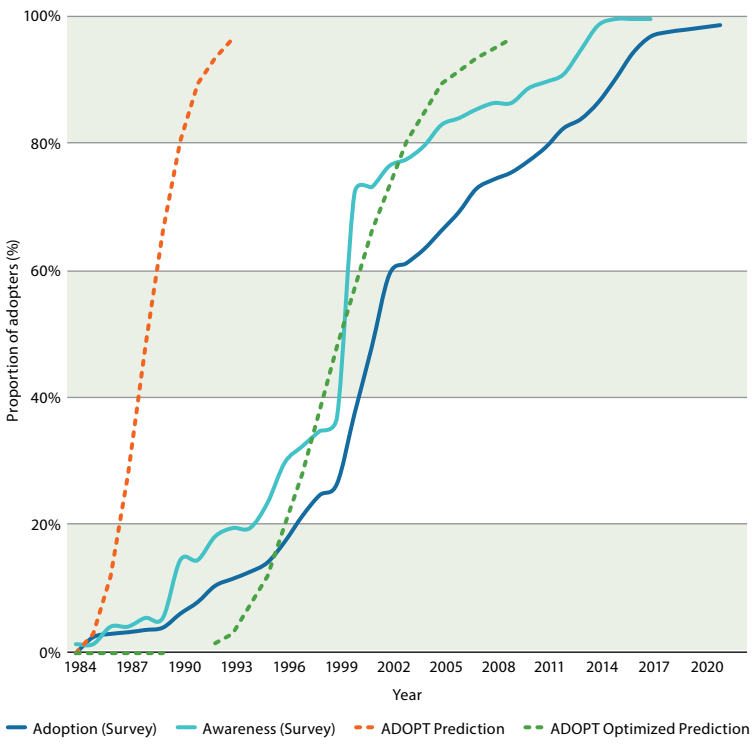
Machine	Power Tiller (attached to a two wheel tractor)	Location	Rangpur	Base Year	1985

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	Almost none have benefits to their community/village as a strong motivation
3. Risk orientation	A minority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	Almost none regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Very large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Very large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	98%	96%	2%	96%	2%
Time to Peak Rate	36 years	8 years	28 years	24 years	12 years

Adoption Curves



Observations and Notes

The Power Tiller (attached to a two wheel tractor) is a land based tillage machine that transformed agriculture in Bangladesh though mechanizing traditional tillage practices. In Rangpur the Power Tiller (attached to a two wheel tractor) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 4. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made, though this is still an over prediction.

TABLE A11

ROTOVATOR (ATTACHED TO A TWO WHEEL TRACTOR) [LOCATION: RAJSHAHI - BASE YEAR: 2005]

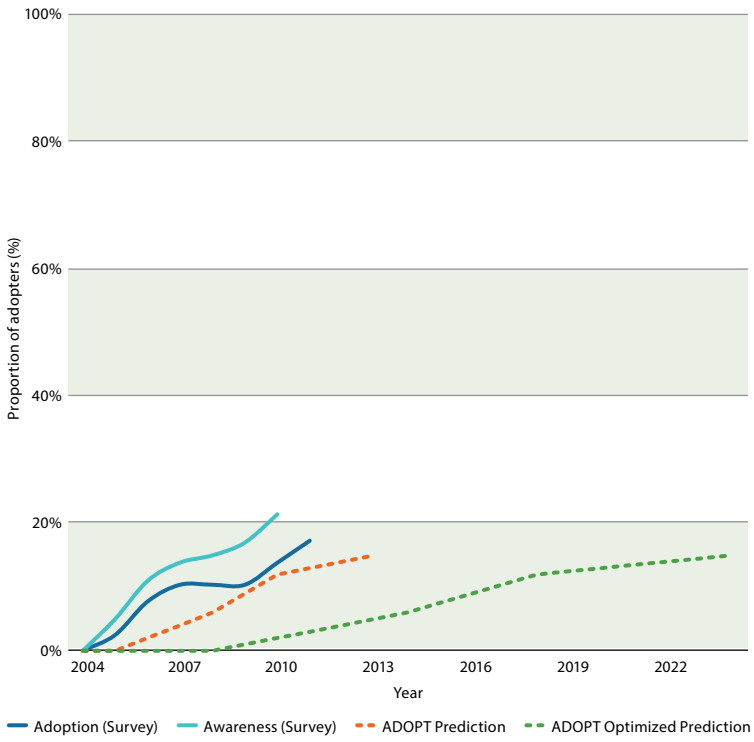
Machine	Rotavator (attached to a two wheel tractor)	Location	Rajshahi	Base Year	2005

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	Almost none have benefits to their community/village as a strong motivation
3. Risk orientation	A minority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Small productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	17%	15%	2%	15%	2%
Time to Peak Rate	6 years	8 years	-2 years	21 years	-15 years

Adoption Curves



Observations and Notes

The Rotavator (attached to a two wheel tractor) is a land based tillage machine that was more lately introduced to Bangladesh in an increasingly crowded mechanized tillage environment. In Rajshahi the Rotavator (attached to a two wheel tractor) was moderately and steadily adopted over the course of one decade. The original ADOPT model accurately predicted both the peak rate and time to peak rate of adoption.

TABLE A12

ROTOVATOR (ATTACHED TO A FOUR WHEEL TRACTOR) [LOCATION: DINAJPUR - BASE YEAR: 2006]

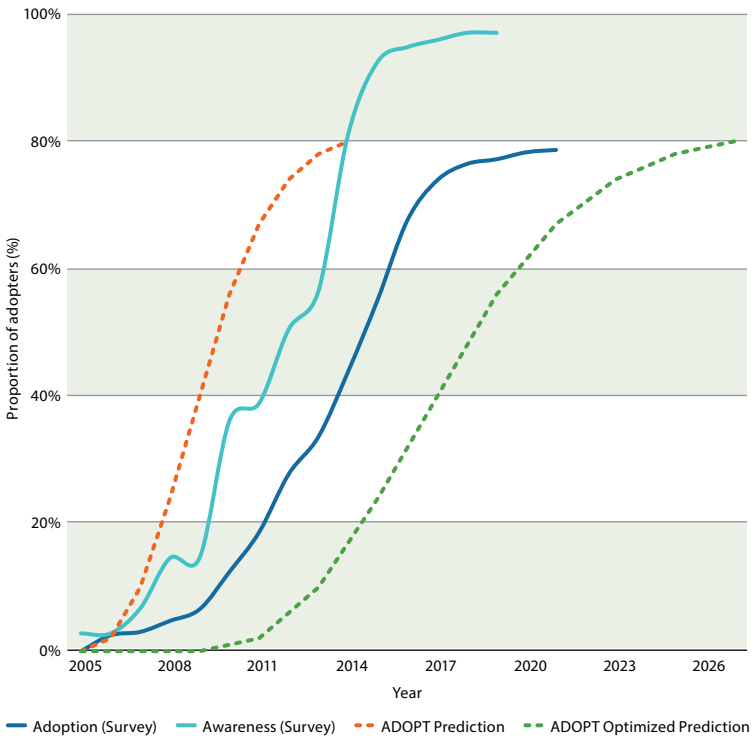
Machine	Rotovator (attached to a four wheel tractor)	Location	Dinajpur	Base Year	2006

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A minority have benefits to their community/village as a strong motivation
3. Risk orientation	About half have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Very easily trialable
8. Innovation complexity	Slightly difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	Small productivity (or profit) disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	3 - 5 years
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Moderate increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	79%	80%	-1%	80%	-1%
Time to Peak Rate	15 years	8 years	7 years	23 years	-8 years

Adoption Curves



Observations and Notes

The Rotovator (attached to a four wheel tractor) is a land based tillage machine that was more lately introduced to Bangladesh in an increasingly crowded mechanized tillage environment. Its primary difference is being attached to increasingly popular four wheeled tractors, more common in neighboring India and Nepal. In Dinajpur the Rotovator (attached to a four wheel tractor) was widely and rapidly adopted over the course of less than 2 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by double. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A13

DIESEL CENTRIFUGAL PUMP (FOR SURFACE WATER) [LOCATION: COX'S BAZAAR - BASE YEAR: 1988]

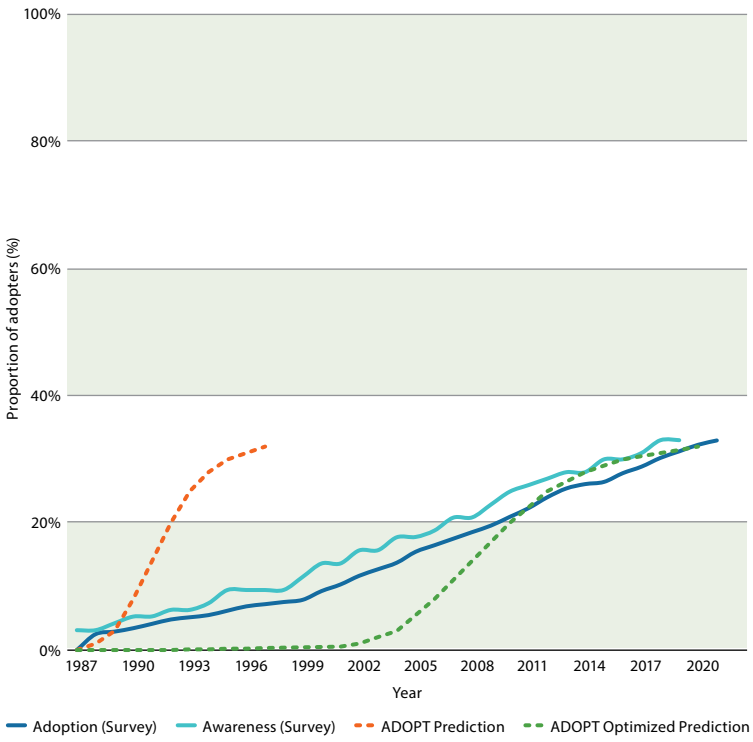
Machine	Diesel Centrifugal Pump (for surface water)	Location	Cox's Bazar	Base Year	1988

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	About half have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A minority have benefits to their community/village as a strong motivation
3. Risk orientation	About half have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost none depend highly on the activity that the innovation will affect
5. Management horizon	A minority consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Easily trialable
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	Almost none regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Moderate reduction in risk
22. Ease and convenience	Moderate increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	33%	32%	1%	32%	1%
Time to Peak Rate	33 years	9 years	24 years	34 years	-1 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Cox's Bazar the Diesel Centrifugal Pump (for surface water) was widely and steadily adopted over the course of 3 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 3. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made, though it underestimates initial adoption rates. The adoption rate experiences appears fairly unique in its linear nature, and also that awareness is nearly always matched to adoption, which is rather unusual to observe.

TABLE A14

DIESEL CENTRIFUGAL PUMP (FOR SURFACE WATER) [LOCATION: JASHORE - BASE YEAR: 2006]

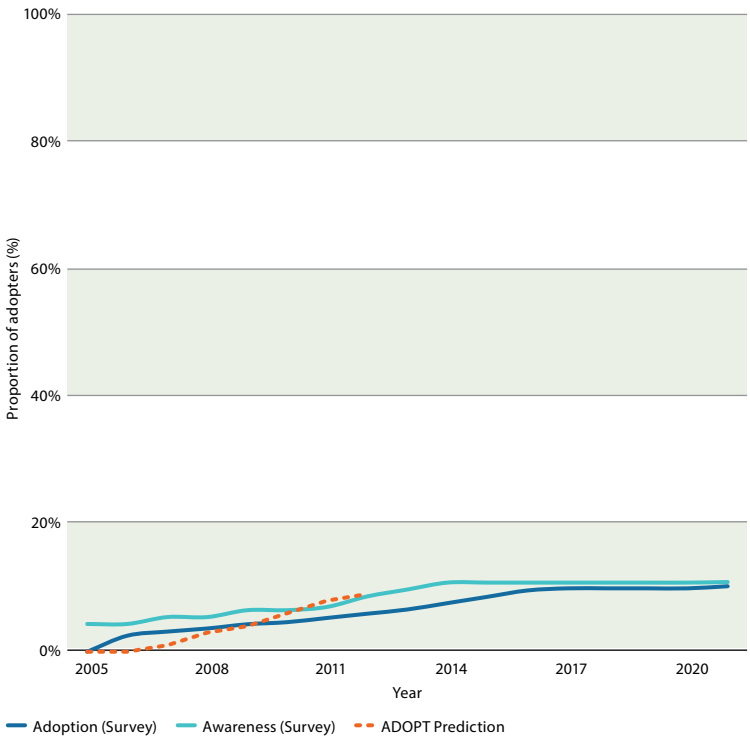
Machine	Diesel Centrifugal Pump (for surface water)	Location	Jashore	Base Year	2006

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	Almost all have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A majority have benefits to their community/village as a strong motivation
3. Risk orientation	A majority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost none depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Easily trialable
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Moderate productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	10%	10%	0%	10%	0%
Time to Peak Rate	15 years	7 years	8 years	34 years	-19 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Jashore the Diesel Centrifugal Pump (for surface water) was a relatively recent introduction, and was not widely adopted due to limited surface water availability. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of double. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. No optimized adoption curve is shown due to adoption only peaking at 10% adoption (the threshold for the curve is 10% adoption as base year).

TABLE A15

DIESEL CENTRIFUGAL PUMP (FOR SURFACE WATER) [LOCATION: JHENIDAH - BASE YEAR: 2006]

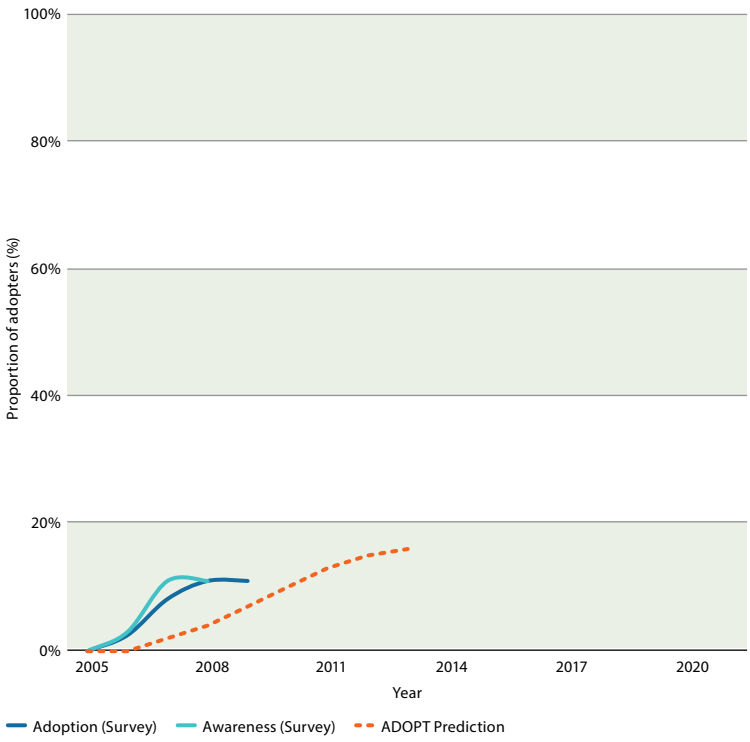
Machine	Diesel Centrifugal Pump (for surface water)	Location	Jhenaidah	Base Year	2006

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	Almost all have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	About half have benefits to their community/village as a strong motivation
3. Risk orientation	A majority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost none depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Easily trialable
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Moderate productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	11%	16%	-5%	16%	-5%
Time to Peak Rate	4 years	7 years	-3 years	19 years	-15 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Jhenaidah the Diesel Centrifugal Pump (for surface water) was a relatively recent introduction, and was not widely adopted due to limited surface water availability, but was rapidly adopted by those with access to it. The original ADOPT model accurately predicted the rate of peak adoption, but underestimated the time taken to reach peak adoption by half. The rapid adoption not being predicted by ADOPT may be related to question 4, where the actual number of surface water users is relevant. No optimized adoption curve is shown due to adoption only peaking at 10% (the threshold for the curve is 10% adoption as base year).

TABLE A16

DIESEL CENTRIFUGAL PUMP (FOR SURFACE WATER) [LOCATION: MAGURA - BASE YEAR: 1997]

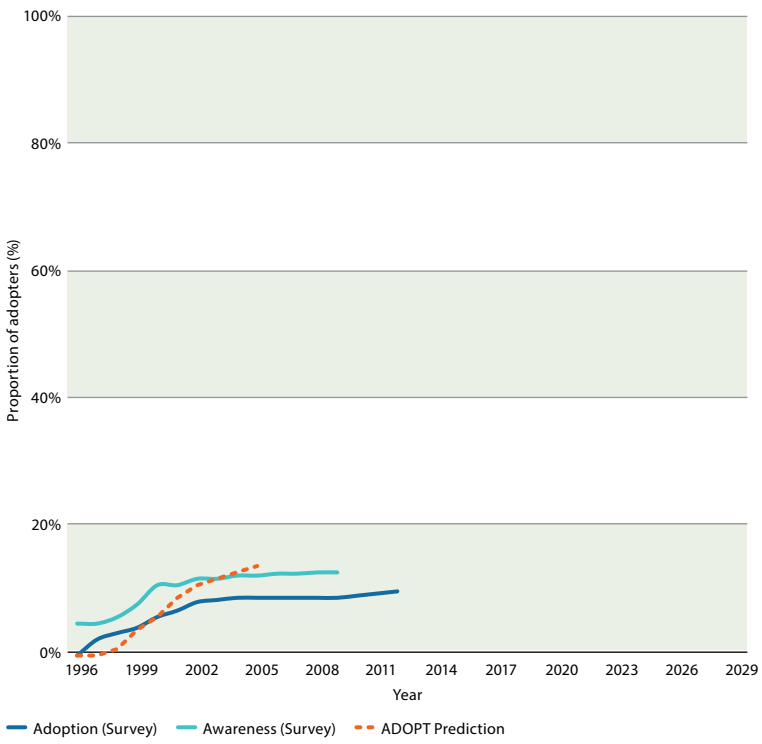
Machine	Diesel Centrifugal Pump (for surface water)	Location	Magura	Base Year	1997

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	About half have benefits to their community/village as a strong motivation
3. Risk orientation	A majority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost none depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Easily trialable
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Moderate productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	10%	14%	-4%	14%	-4%
Time to Peak Rate	15 years	8 years	7 years	22 years	-7 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Magura the Diesel Centrifugal Pump (for surface water) was steadily but minimally adopted, restricting access to surface water in the district. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of 2. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in. No optimized adoption curve is shown due to adoption only peaking at 10% (the threshold for the curve is 10% adoption as base year).

TABLE A17

DIESEL CENTRIFUGAL PUMP (FOR SURFACE WATER) [LOCATION: NATORE - BASE YEAR: 2000]

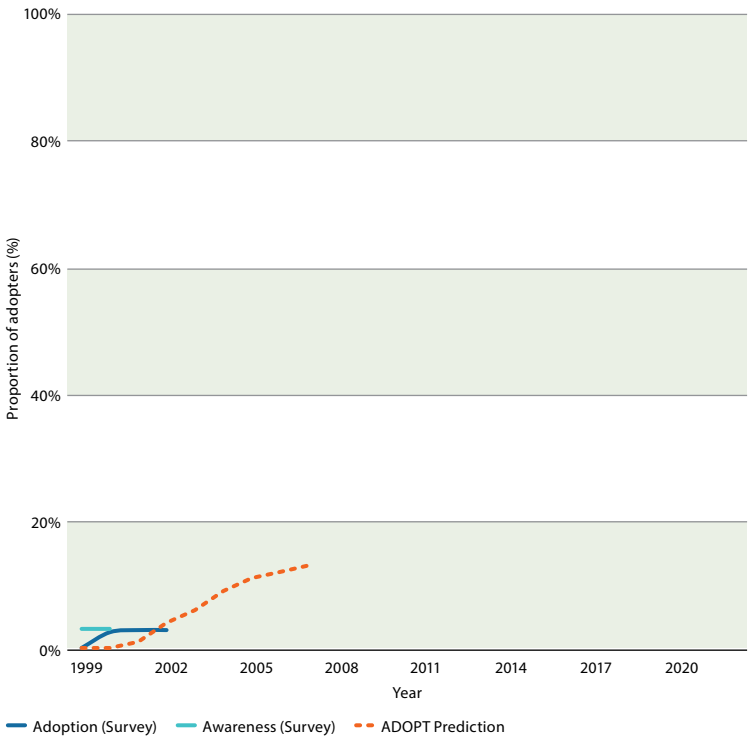
Machine	Diesel Centrifugal Pump (for surface water)	Location	Natore	Base Year	2000

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	Almost none have benefits to their community/village as a strong motivation
3. Risk orientation	About half have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost none depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Easily trialable
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Moderate productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	3%	14%	-11%	14%	-11%
Time to Peak Rate	2 years	8 years	-6 years	22 years	-20 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Natore the Diesel Centrifugal Pump (for surface water) was steadily but minimally adopted, restricting access to surface water in the district. The original ADOPT model overestimated both the peak rate and time to peak rate of adoption. This may be explained by the need to define in question 4 the very small number of farmers able to access surface water. No optimized adoption curve is shown due to adoption only peaking at 10% (the threshold for the curve is 10% adoption as base year).

TABLE A18

DIESEL CENTRIFUGAL PUMP (FOR GROUND WATER) [LOCATION: COX'S BAZAAR - BASE YEAR: 1988]

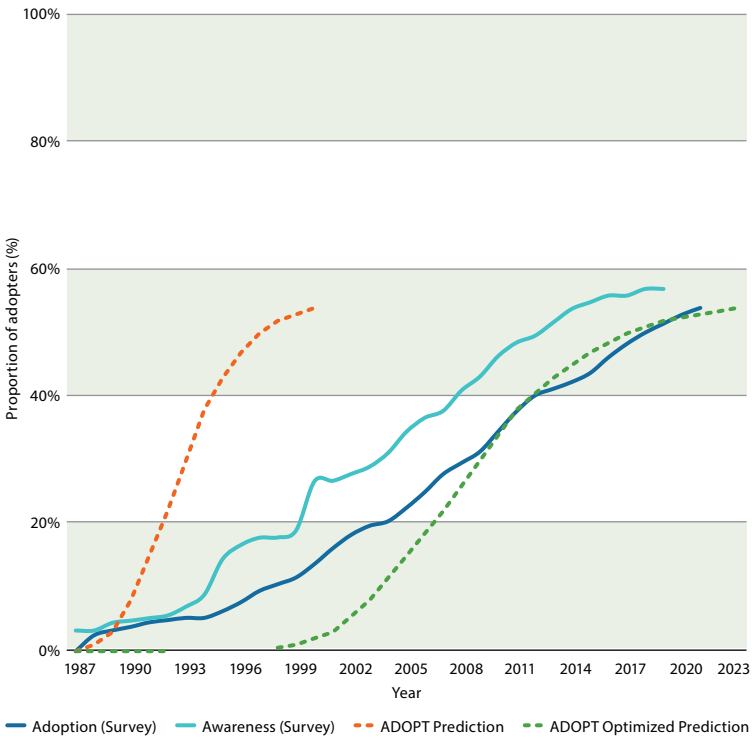
Machine	Diesel Centrifugal Pump (for ground water)	Location	Cox's Bazar	Base Year	1988

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	About half have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A minority have benefits to their community/village as a strong motivation
3. Risk orientation	About half have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	A minority consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Difficult to trial
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	Almost none regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Large initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Moderate reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	54%	54%	0%	54%	0%
Time to Peak Rate	33 years	12 years	21 years	32 years	1 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Cox's Bazar the Diesel Centrifugal Pump (for ground water) was widely and steadily adopted over the course of nearly 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of nearly 3. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A19

DIESEL CENTRIFUGAL PUMP (FOR GROUND WATER) [LOCATION: FARIDPUR - BASE YEAR: 1996]

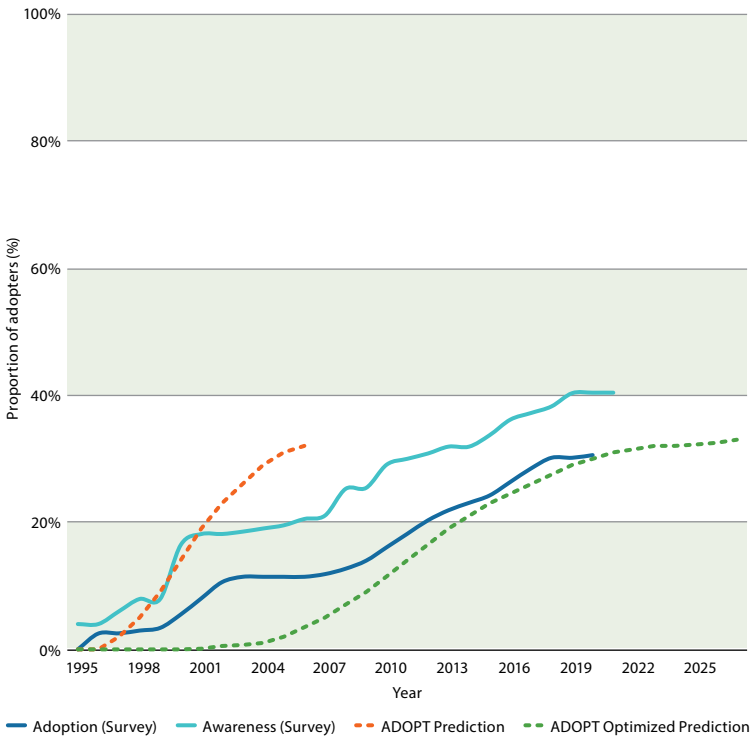
Machine	Diesel Centrifugal Pump (for ground water)	Location	Faridpur	Base Year	1996

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A majority have benefits to their community/village as a strong motivation
3. Risk orientation	Almost all have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	A majority depend highly on the activity that the innovation will affect
5. Management horizon	A minority consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Difficult to trial
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	About half regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Large initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Moderate productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Moderate reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	31%	33%	-2%	33%	-2%
Time to Peak Rate	24 years	11 years	13 years	33 years	-9 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Faridpur the Diesel Centrifugal Pump (for ground water) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 2. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A20

DIESEL CENTRIFUGAL PUMP (FOR GROUND WATER) [LOCATION: JAHORE - BASE YEAR: 1990]

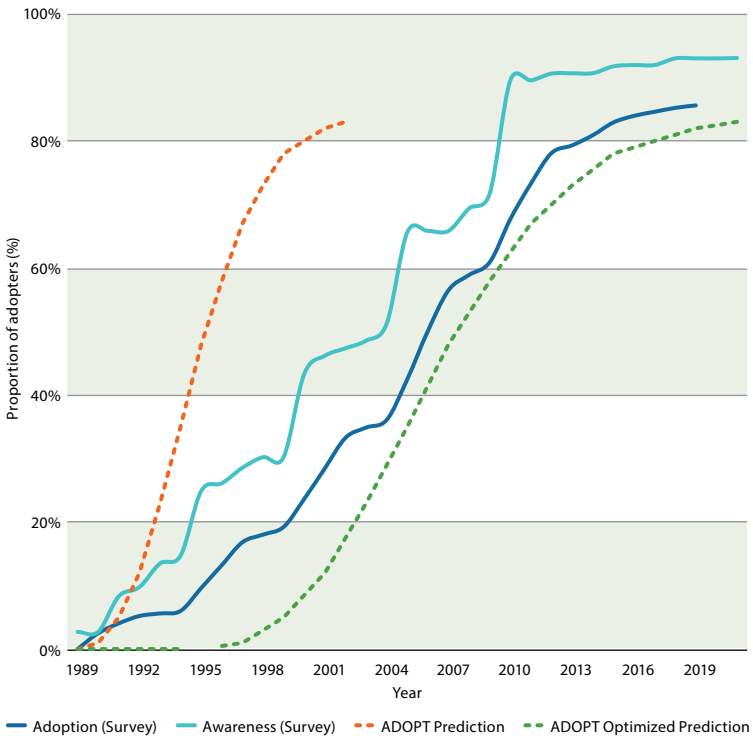
Machine	Diesel Centrifugal Pump (for ground water)	Location	Jashore	Base Year	1990

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A minority have benefits to their community/village as a strong motivation
3. Risk orientation	A majority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Difficult to trial
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Large initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Moderate reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	86%	83%	3%	83%	3%
Time to Peak Rate	29 years	12 years	17 years	32 years	-3 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Jashore the Diesel Centrifugal Pump (for ground water) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 2. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A21

DIESEL CENTRIFUGAL PUMP (FOR GROUND WATER) [LOCATION: JHENAIDAH - BASE YEAR: 1990]

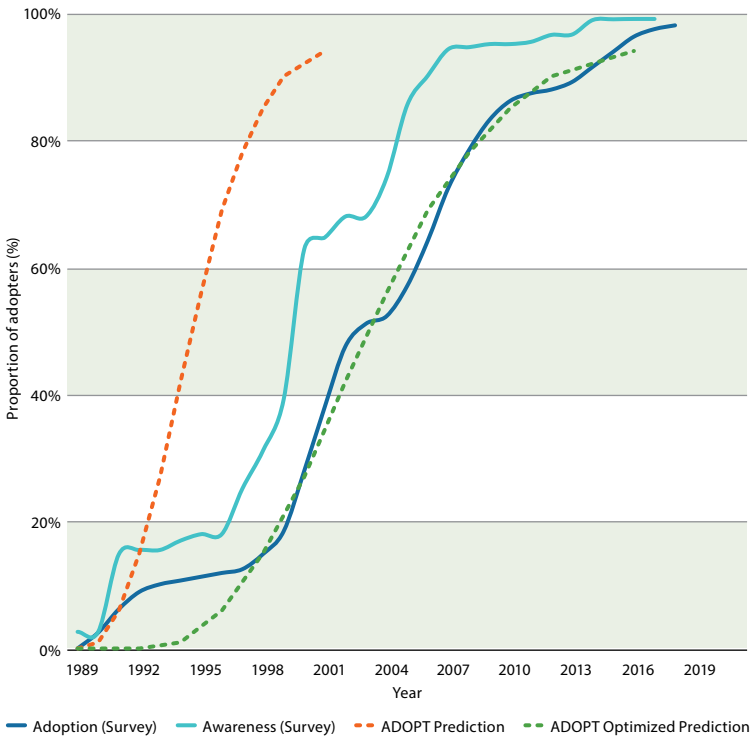
Machine	Diesel Centrifugal Pump (for ground water)	Location	Jhenaidah	Base Year	1990

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A minority have benefits to their community/village as a strong motivation
3. Risk orientation	A majority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Difficult to trial
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Large initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Moderate reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	98%	94%	4%	94%	4%
Time to Peak Rate	28 years	11 years	17 years	28 years	0 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Jhenaidah the Diesel Centrifugal Pump (for ground water) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by approximately 2.5 times. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A22

DIESEL CENTRIFUGAL PUMP (FOR GROUND WATER) [LOCATION: MAGURA - BASE YEAR: 1985]

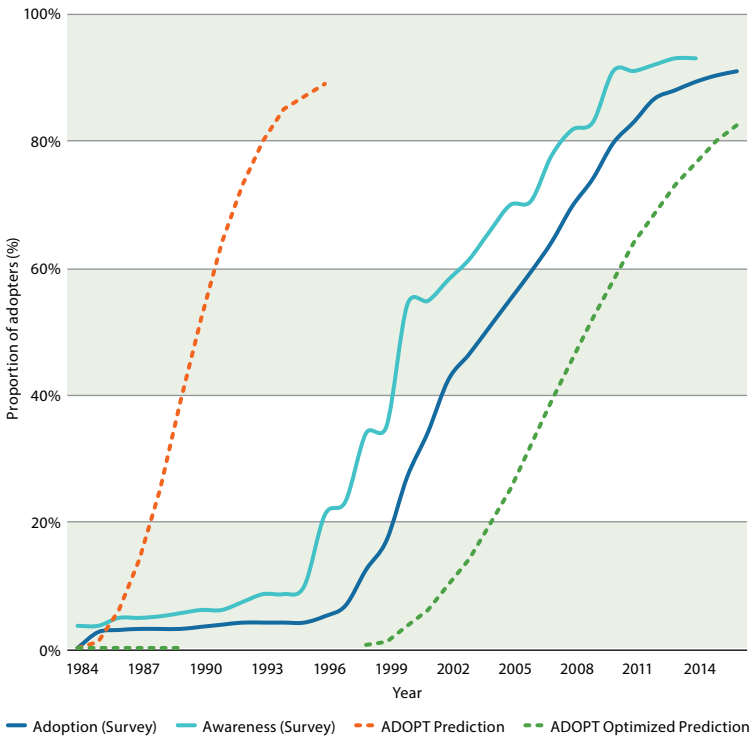
Machine	Diesel Centrifugal Pump (for ground water)	Location	Magura	Base Year	1985

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A minority have benefits to their community/village as a strong motivation
3. Risk orientation	About half have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Difficult to trial
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Large initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Moderate reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	92%	89%	3%	89%	3%
Time to Peak Rate	32 years	11 years	21 years	30 years	2 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Magura the Diesel Centrifugal Pump (for ground water) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 4. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A23

DIESEL CENTRIFUGAL PUMP (FOR GROUND WATER) [LOCATION: NATORE - BASE YEAR: 1987]

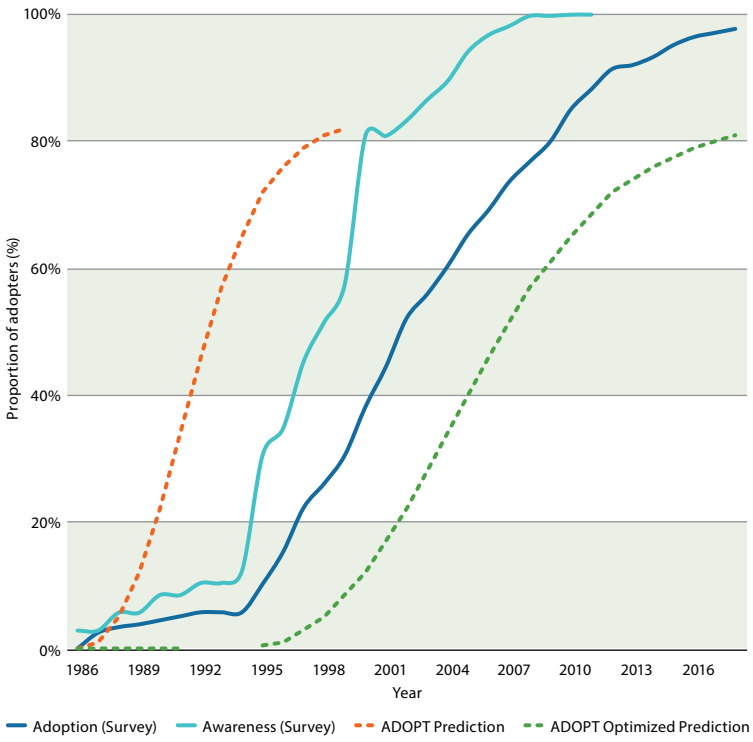
Machine	Diesel Centrifugal Pump (for ground water)	Location	Natore	Base Year	1987

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	About half have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	Almost none have benefits to their community/village as a strong motivation
3. Risk orientation	A minority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Difficult to trial
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	Almost none regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Large initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Moderate reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	99%	82%	17%	82%	17%
Time to Peak Rate	33 years	12 years	21 years	32 years	1 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Natore the Diesel Centrifugal Pump (for ground water) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of nearly 3. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A24

DIESEL CENTRIFUGAL PUMP (FOR GROUND WATER) [LOCATION: RAJSHAHI - BASE YEAR: 1980]

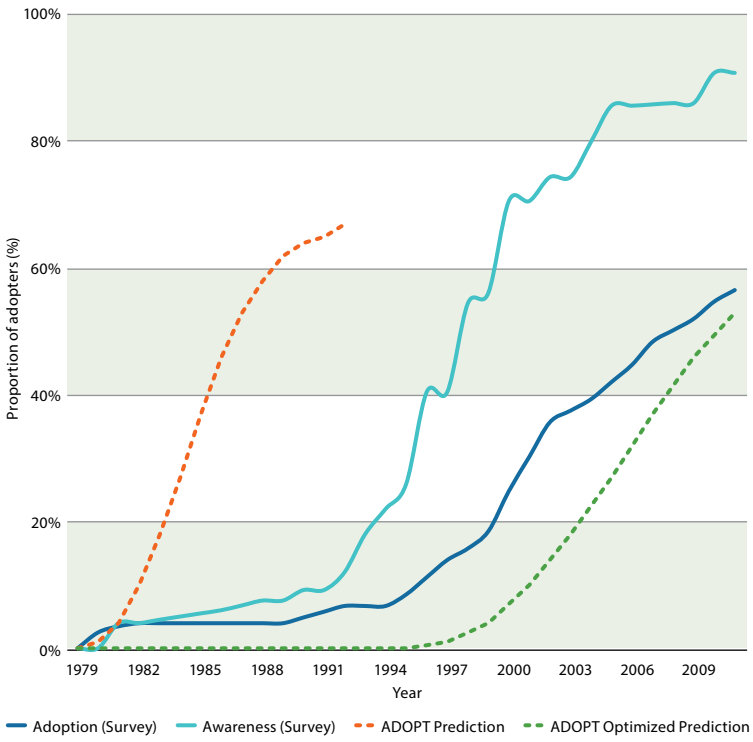
Machine	Diesel Centrifugal Pump (for ground water)	Location	Rajshahi	Base Year	1980

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	About half have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	Almost none have benefits to their community/village as a strong motivation
3. Risk orientation	A minority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Difficult to trial
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Large initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Moderate reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	69%	67%	2%	65%	4%
Time to Peak Rate	38 years	12 years	26 years	41 years	-3 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Rajshahi the Diesel Centrifugal Pump (for ground water) was widely and steadily adopted over the course of more than 5 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 3. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A25

DIESEL CENTRIFUGAL PUMP (FOR GROUND WATER) [LOCATION: DINAJPUR - BASE YEAR: 1987]

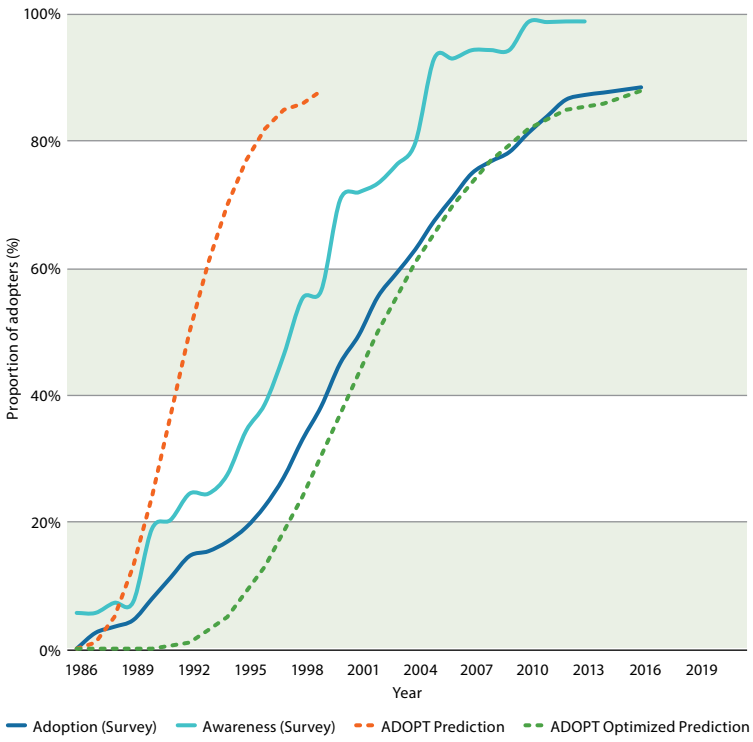
Machine	Diesel Centrifugal Pump (for ground water)	Location	Dinajpur	Base Year	1987

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	Almost none have benefits to their community/village as a strong motivation
3. Risk orientation	A minority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Difficult to trial
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	Almost none regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Large initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Moderate reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	89%	88%	1%	88%	1%
Time to Peak Rate	29 years	12 years	17 years	31 years	-2 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Dinajpur the Diesel Centrifugal Pump (for ground water) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of nearly 3. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A26

DIESEL CENTRIFUGAL PUMP (FOR GROUND WATER) [LOCATION: RANGPUR - BASE YEAR: 1980]

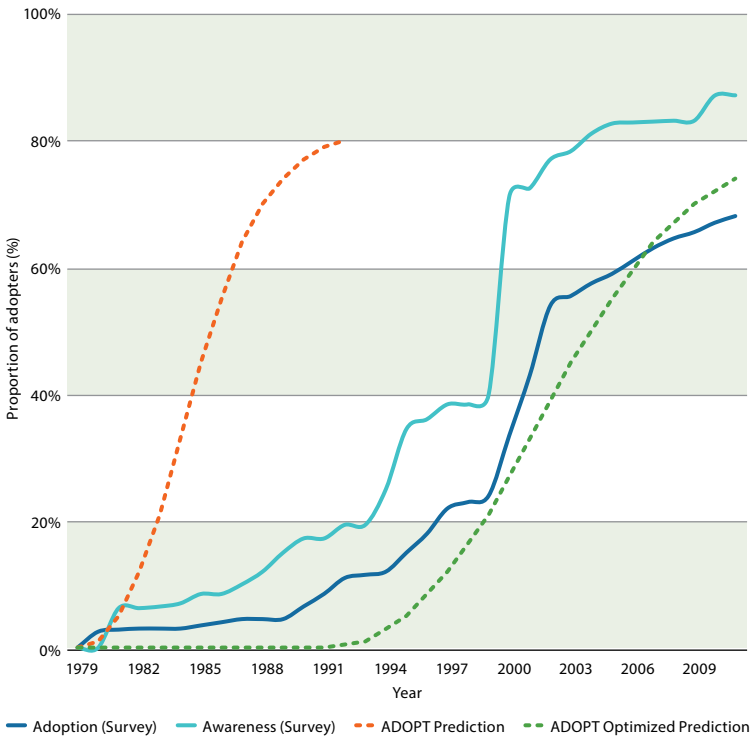
Machine	Diesel Centrifugal Pump (for ground water)	Location	Rangpur	Base Year	1980

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	About half have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	Almost none have benefits to their community/village as a strong motivation
3. Risk orientation	A minority have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Difficult to trial
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	Almost none have regular contact
11. Group involvement	Almost none regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Large initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Moderate reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	84%	80%	4%	80%	4%
Time to Peak Rate	39 years	12 years	27 years	39 years	0 years

Adoption Curves



Observations and Notes

The Diesel Centrifugal Pump revolutionized access to water in Bangladesh, especially enabling intensification of cropping practices. In Rangpur the Diesel Centrifugal Pump (for ground water) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 3. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A27

GRID ELECTRIC PUMP (FOR GROUND WATER) [LOCATION: RAJSHAHI - BASE YEAR: 2014]

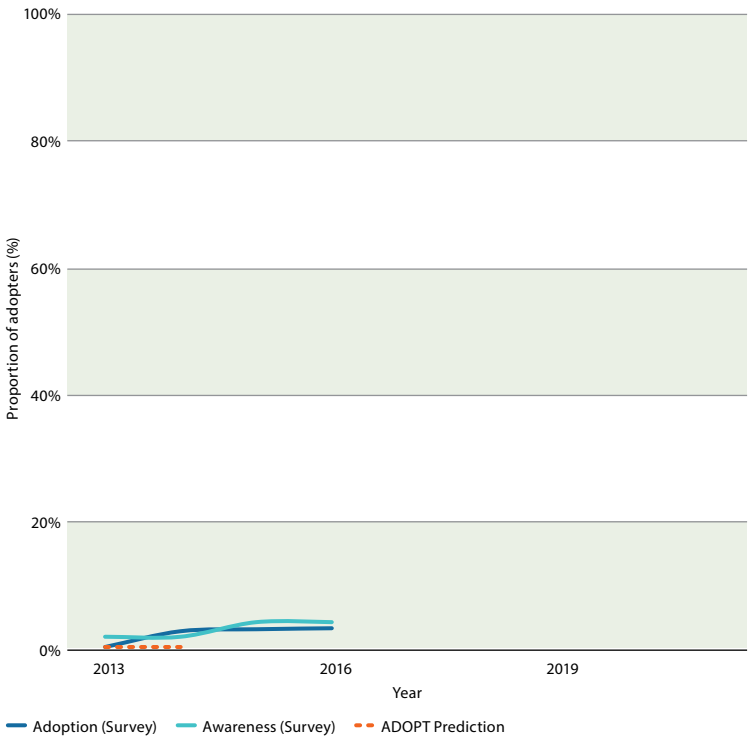
Machine	Grid Electric Pump (for ground water)	Location	Rajshahi	Base Year	2014

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	Almost all have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A minority have benefits to their community/village as a strong motivation
3. Risk orientation	About half have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	A majority depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Difficult to trial
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	About half have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Large initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	No productivity (or profit) advantage or disadvantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	No increase in risk
22. Ease and convenience	No decrease in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	95%	94%	1%	94%	1%
Time to Peak Rate	21 years	8 years	13 years	24 years	-3 years

Adoption Curves



Observations and Notes

The Power Tiller (attached to a two wheel tractor) is a land based tillage machine that transformed agriculture in Bangladesh though mechanizing traditional tillage practices. In Patuakhali the Power Tiller (attached to a two wheel tractor) was widely and steadily adopted over the course of more than 4 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of nearly 3. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A28

GRID ELECTRIC PUMP (FOR GROUND WATER) [LOCATION: DINAJPUR - BASE YEAR: 1995]

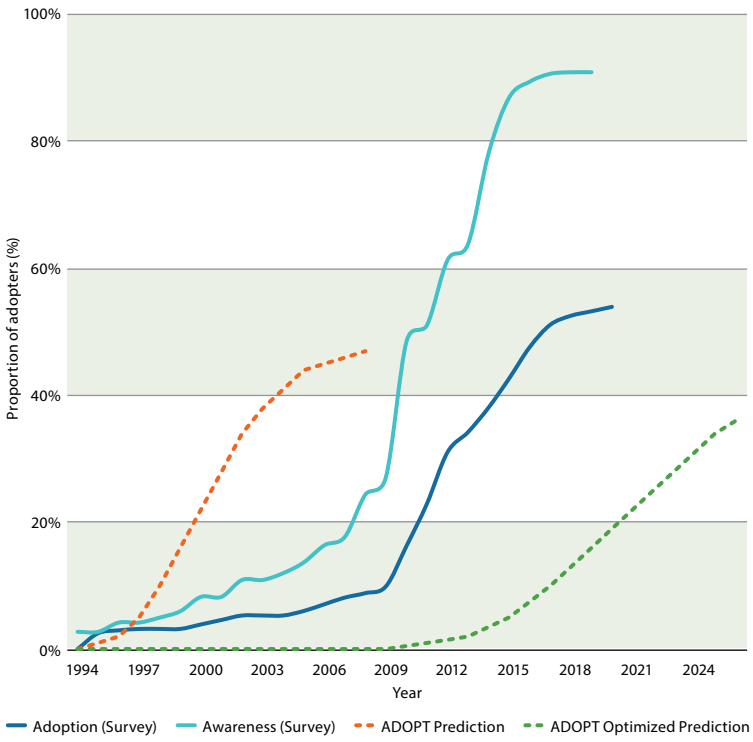
Machine	Grid Electric Pump (for ground water)	Location	Dinajpur	Base Year	1995

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	Almost none have benefits to their community/village as a strong motivation
3. Risk orientation	About half have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	A majority depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A majority are currently affected by a severe short-term constraint
7. Trialable	Difficult to trial
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	A minority will need new skills and knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Large initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Large productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Moderate reduction in risk
22. Ease and convenience	Small increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	54%	47%	7%	46%	9%
Time to Peak Rate	25 years	13 years	12 years	41 years	-16 years

Adoption Curves



Observations and Notes

The Grid Electric Pump is a more recent introduction in Bangladesh, in theory driven by an expanding and increasingly reliable electrification network. In Dinajpur the Grid Electric Pump (for ground water) was moderately and steadily adopted over the course of more than 3 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of 2. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A29

POWER THRESHER [LOCATION: PATUAKHALI - BASE YEAR: 2000]

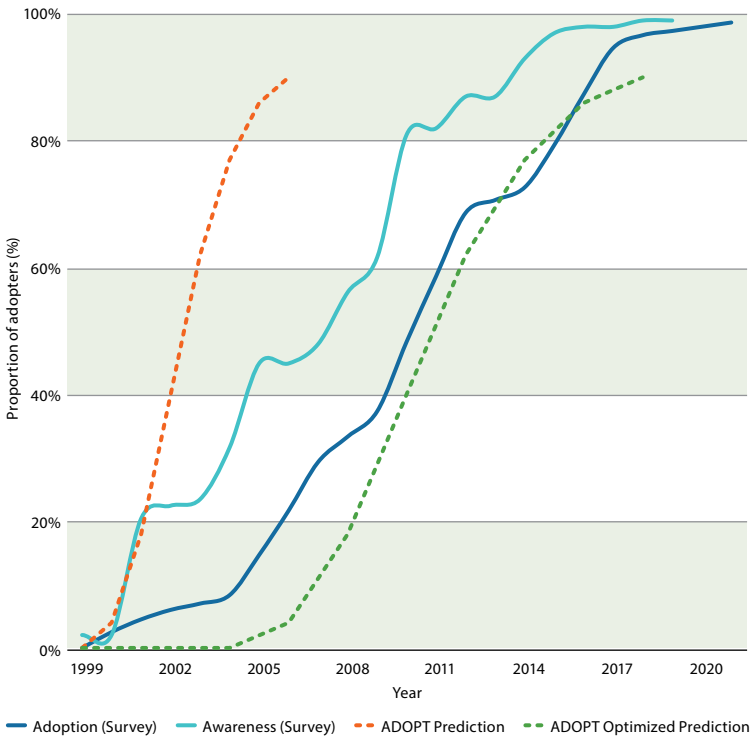
Machine	Power Thresher	Location	Patuakhali	Base Year	2000

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	Almost all have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	About half have benefits to their community/village as a strong motivation
3. Risk orientation	Almost all have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	A majority depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Easily trialable
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	About half regularly participate
12. Relevant existing skills & knowledge	Almost none will need new skills or knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Small productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Very large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	99%	90%	9%	90%	9%
Time to Peak Rate	21 years	6 years	15 years	20 years	1 years

Adoption Curves



Observations and Notes

The Power Thresher is a machine that enables the mechanization of the heavy labor-intensive practice of rice threshing. In Patuakhali the Power Thresher was widely and steadily adopted over the course of 2 decades. The original ADOPT model accurately predicted the rate of peak adoption, but overestimated the time taken to reach peak adoption by a factor of more than 3. This likely reflects the longer term socioeconomic constraints that are not likely to be factored in, as well as a slower diffusion of information process given that the ADOPT prediction is substantially faster than experienced awareness in this case. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction can be made.

TABLE A30

POWER THRESHER [LOCATION: MAGURA - BASE YEAR: 2002]

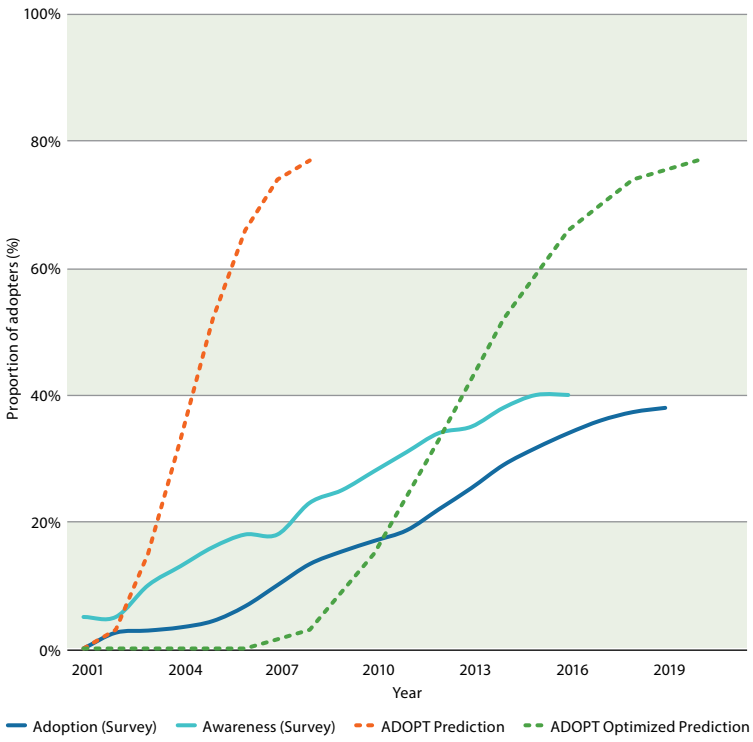
Machine	Power Thresher	Location	Magura	Base Year	2002

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	Almost all have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	About half have benefits to their community/village as a strong motivation
3. Risk orientation	Almost all have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	A majority depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Easily trialable
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	A minority regularly participate
12. Relevant existing skills & knowledge	Almost none will need new skills or knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Small productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Very large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	38%	77%	-39%	77%	-39%
Time to Peak Rate	17 years	6 years	11 years	20 years	-3 years

Adoption Curves



Observations and Notes

The Power Thresher is a machine that enables the mechanization of the heavy labor-intensive practice of rice threshing. In Magura the Power Thresher was moderately and steadily adopted over the course of 2 decades. The original ADOPT model did not accurately predicted either the peak rate or time to peak rate of adoption. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction is still not made. The reasons for less power thresher adoption in Magura warrant further investigation.

TABLE A31

POWER THRESHER [LOCATION: NATORE - BASE YEAR: 2010]

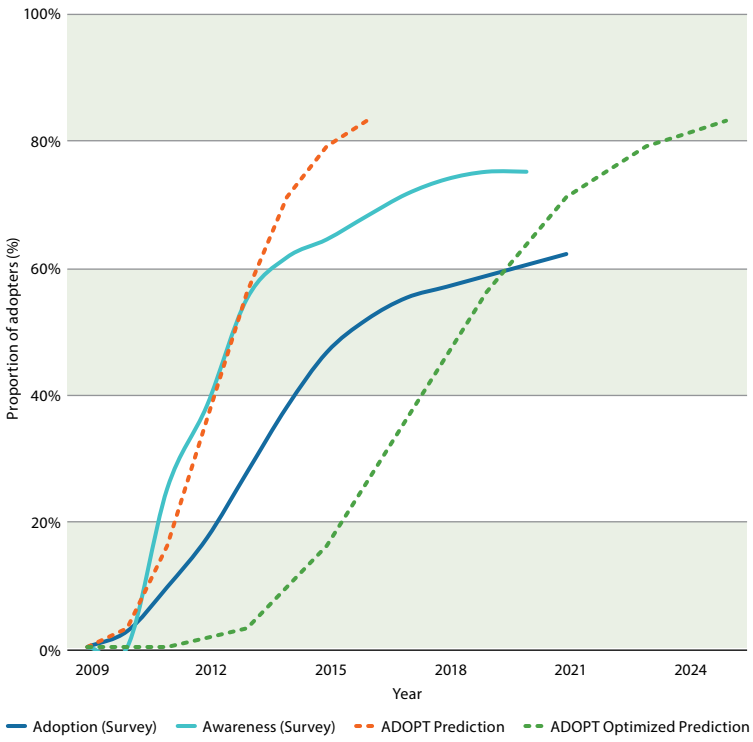
Machine	Power Thresher	Location	Natore	Base Year	2010

ADOPT Question	Inputted Response
1. Productivity (or profit) orientation	A majority have maximizing productivity (or profit) as a strong motivation
2. Local community benefit orientation	A minority have benefits to their community/village as a strong motivation
3. Risk orientation	About half have minimizing the risk of production (or profit) losses as a strong motivation
4. Enterprise scale	Almost all depend highly on the activity that the innovation will affect
5. Management horizon	Almost none consider it very important
6. Short term constraints	A minority are currently affected by a severe short-term constraint
7. Trialable	Easily trialable
8. Innovation complexity	Not at all difficult to evaluate full implications and effects of use
9. Observability	Very easily observable
10. Advisory support	A minority have regular contact
11. Group involvement	About half regularly participate
12. Relevant existing skills & knowledge	Almost none will need new skills or knowledge
13. Innovation awareness	A minority are aware that it has been used or trialed in their local area
14. Relative upfront cost of innovation	Minor initial investment required
15. Reversibility of innovation	Very easy to dis-adopt
16. Productivity (or profit) benefit in years that it is used	Small productivity (or profit) advantage in years that it is used
17. Future productivity (or profit) benefit	No productivity (or profit) advantage or disadvantage in a future period after it is used
18. Time until any future productivity/profit realized	Not Applicable
19. Local village/ community costs & benefits	No advantage or disadvantage to local community or village
20. Time to local village/ community benefit	Not Applicable
21. Risk exposure	Small reduction in risk
22. Ease and convenience	Very large increase in ease and convenience

Data Comparisons

	Survey Data	ADOPT Prediction	Difference	Optimized ADOPT Prediction	Difference
Peak Rate	62%	83%	-21%	83%	-21%
Time to Peak Rate	11 years	6 years	5 years	17 years	-6 years

Adoption Curves



Observations and Notes

The Power Thresher is a machine that enables the mechanization of the heavy labor-intensive practice of rice threshing. In Natore the Power Thresher was moderately and steadily adopted over the course of 2 decades. The original ADOPT model did not accurately predicted either the peak rate or time to peak rate of adoption. By adjusting the start year of the prediction and slowing the rate by half, a close match between survey and ADOPT prediction is still not made. The reasons for less power thresher adoption in Natore warrant further investigation.