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Using Outcome Trajectory Evaluation to Assess HarvestPlus' Contribution to the Development of National Biofortification Breeding Programs

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ABSTRACT

While the key role that policy plays in sustainable development has long been recognized, rigorously documenting the influence of research on policy outcomes faces conceptual, empirical and even political challenges. Addressing these challenges is increasingly urgent since improving policies—broadly defined—is at the heart of the structural transformation agenda. This paper describes the use of a new evaluation method—outcomes trajectory evaluation (OTE), based on both evaluation and policy process theory—to explore the influence of HarvestPlus, a large and complex research for development program focused on improving nutrition, on a specific policy outcome, namely the establishment of crop biofortification breeding programs in national agricultural research institutes in Bangladesh, India and Rwanda. The findings support claims of significant HarvestPlus contributions to the establishment of the programs while also raising issues that need to be monitored moving forward to ensure sustainability. The paper also discusses the pros and cons of the OTE approach in terms of both methodological rigor and program learning. In particular, the fact that HarvestPlus is a long-running program allows us to reflect on how a "backward looking" approach such as OTE builds on and complements the more "forward looking," theory of change-based approaches that informed HarvestPlus programming and evaluation during its earlier, highly-successful phases. Such a long-run perspective is rare in development evaluation and it offers important lessons for how to think about and plan for evaluation over the course of a complex agriculture research for development program.

Keywords: theory-based evaluation, policy process evaluation, middle-range theory, biofortification

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ACRONYMS

A4NH	Agriculture for Nutrition and Health
AICRP-PM	All India Coordinated Research Project on Pearl Millet
BMGF	Bill and Melinda Gates Foundation
BRRI	Bangladesh Rice Research Institute
BSMRAU	Bangabandhu Sheikh Mujibur Rahman Agricultural University
BINA	Bangladesh Institute of Nuclear Agriculture
CAADP	Comprehensive Africa Agriculture Development Programme
CCAFS	Climate Change, Agriculture, and Food Security
CIAT	International Center for Tropical Agriculture
CRP	CGIAR Research Program
FPO	Farmer production organization
GAIN	Global Alliance for Improved Nutrition
ICAR	Indian Council of Agricultural Research
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IPM	Iron pearl millet
IRRI	International Rice Research Institute
MELIA	Monitoring, evaluation, learning, and impact assessment
NARES	National Agricultural Research and Extension Systems
NGO	Nongovernmental organization
OPV	Open-pollinated variety
OTE	Outcome trajectory evaluation
PABRA	Pan-Africa Bean Research Alliance
PMHPRC	Pearl Millet Hybrid Parents Research Consortium
ppm	Parts per million
RAB	Rwanda Agriculture and Animal Resources Development Board
RTB	Roots, Tubers and Bananas
SAU	State agricultural university
ToC	Theory of change
XRF	X-ray fluorescent

1 INTRODUCTION

While the key role that policy plays in sustainable development has long been recognized, rigorously documenting the influence of research on policy outcomes faces conceptual, empirical and even political challenges. Addressing these challenges is increasingly urgent since improving policy is at the heart of the structural transformation agenda in international development. This paper describes the use of a new evaluation method—outcome trajectory evaluation (OTE)—to explore the influence of HarvestPlus, a large and complex research for development program focused on improving nutrition through agriculture, on a specific policy outcome, namely the establishment of crop biofortification breeding programs in national agricultural research institutes in Bangladesh, India and Rwanda. By building on both evaluation and policy process theory, OTE seeks to improve the rigor of policy influence evaluation by ensuring that the evaluation covers all factors that are hypothesized to influence policy outcomes, not only those factors targeted by the program. By systematically considering all factors that potentially contribute to policy change, the approach reduces the risk of overstating program influence on an observed policy outcome.

The objectives of the paper are to describe a new approach to understanding and evaluating policy outcomes, provide an example of its use in a specific context, and reflect on some advantages and disadvantages of the approach that may be relevant to potential users. The paper is organized as follows. Section 2 describes the HarvestPlus program and Section 3 presents the OTE approach. Section 4 summarizes the key findings of the evaluative review and Section 5 reflects on the approach. Section 6 concludes with recommendations for program implementers, evaluators, and for further research.

2 OVERVIEW OF THE HARVESTPLUS PROGRAM AND ITS POLICY INFLUENCE EFFORTS

CGIAR and national agricultural research and extension systems (NARES) have collaborated on crop improvement programs for decades.[1] Starting in the late 1990s, CGIAR breeders began looking at the potential for breeding to increase the micronutrient concentration in staple crops (a.k.a. biofortification) in an effort to contribute to a reduction in micronutrient malnutrition, also known as hidden hunger. In 2003, the HarvestPlus program was established to work on biofortification at the CGIAR system level.[2] Once technical feasibility was established, the focus moved to breeding and testing varieties in practice and then to disseminating the varieties at scale and institutionalizing biofortification in national and international programs and policies. In 2016, four researchers behind biofortification were awarded the World Food Prize (World Food Prize Foundation).

From the beginning, HarvestPlus also invested systematically in understanding, estimating and tracking the impact of biofortified crop varieties on nutrition outcomes. The goal was to build an evidence base to convince not only the agricultural community but also the public health nutrition community that biofortification could be a cost-effective nutrition intervention (Bouis and Saltzman 2017; Johnson et al. 2017). Initial *ex ante* economic impact studies (Meenakshi et al. 2010) were followed by nutritional efficacy studies, by studies of factors affecting uptake by producers and consumers, by effectiveness studies and ultimately, by documenting the dissemination, adoption and consumption of biofortified varieties at scale (see for example Saltzman et al. 2017; HarvestPlus 2014; HarvestPlus 2019). HarvestPlus' initial core research areas—crop breeding, nutrition, impact and policy, and reaching end

[1] For the purposes of this paper, CGIAR and HarvestPlus are used interchangeably to describe the work with NARES on breeding programs for biofortified crops. HarvestPlus was established as a joint venture between two CGIAR Centers, the International Food Policy Research Institute (IFPRI) and the International Center for Tropical Agriculture (CIAT), in 2003. HarvestPlus is part of the CGIAR Research Program (CRP) on Agriculture for Nutrition and Health (A4NH) and is based at IFPRI. HarvestPlus' crop research and breeding work draws on the expertise and resources of partner CGIAR Centers for breeding the respective biofortified crops, which for the focus of this evaluation are the International Rice Research Institute (IRRI), (zinc rice for Bangladesh), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), (iron pearl millet for India), and CIAT (iron beans for Rwanda).

[2] https://www.harvestplus.org/

users—were increasingly complemented by efforts designed to build capacity, establish partnerships, jump start dissemination, and engage with and influence policy.[3]

Consistent with Renkow (2018, p. 2), policy was broadly understood to include different types of policy-oriented outcomes to which CGIAR research contributes:

- **Changes in laws and regulations** governing economic incentives in agriculture or natural resource management—for example, agricultural, macro, trade, nutrition/health, and environmental policies;
- **Creation of institutions**—for example, the formation of the Ethiopian Commodity Exchange or the agreement between India, Nepal, and Bangladesh to share rice varietal evaluation data among their respective countries to facilitate more rapid release and commercialization;
- **Changes in government investment priorities and budget allocations**—for example, increases in the share of budgets devoted to agricultural research associated within the Comprehensive Africa Agriculture Development Programme (CAADP);
- **Innovations to the operations and management for government agencies and programs**—for example, monitoring and evaluation activities associated with operating social safety net programs like the Mexican PROGRESA conditional cash transfer program or the Ethiopian Productive Safety Net Programme;
- **International treaties, declarations, or agreements among parties reached at major policy conferences**—for example, contributions of the International Food Policy Research Institute (IFPRI)'s trade policy research to the Doha Round of trade negotiations among the World Trade Organization membership or the substantial involvement of the CGIAR Research Program (CRP) on Climate Change, Agriculture, and Food Security (CCAFS) in crafting international climate treaties.

[3] For details on the African context, refer to the Special Issue of the African Journal of Food, Agriculture, Nutrition and Development devoted to biofortification - https://www.ajfand.net/Volume17/No2/index.html#gsc.tab=0.

Over the course of the program, HarvestPlus sought to influence policy outcomes from all these categories, from influencing regional and national agricultural and nutrition policies (Baral and Birol 2020; HarvestPlus no date; Foley et al. 2021) to contributing to the establishment of a definition for biofortification under Codex Alimentarius (Bouis and Saltzman 2017; Saltzman et al. 2017) to mainstreaming breeding for nutrition in CGIAR (Rijsberman 2014; Baral and Birol 2020).

As mentioned earlier, the most recent phase of HarvestPlus' program was focused on scaling up biofortified varieties in target countries. To achieve this HarvestPlus worked with and supported breeders in NARES to develop, test, and release biofortified varieties. For biofortification breeding to become sustainable, these programs would need to become institutionalized meaning that they were no longer special projects funded by external donors but rather core parts of the national breeding strategies and programs. This is the outcome that the CRP on Agriculture for Nutrition and Health (A4NH), led by IFPRI, sought to assess when it commissioned an evaluative review of HarvestPlus' contribution to the development of national biofortification breeding programs in Bangladesh, India and Rwanda (Douthwaite 2021).[4] Since HarvestPlus funding to the programs ended in 2018, it was possible to assess the status of those programs, three years later in 2021.

[4] The study was part of a series of evaluative studies and reviews to document lessons from both phases of the CRP (2012-2021). The studies were designed to inform future research and development efforts, mainly but not exclusively in CGIAR. Findings can inform both what the programs do and how they work. This study looked at lessons learned from HarvestPlus' work with NARES to develop and implement sustainable biofortification breeding programs. HarvestPlus was part of both phases of A4NH.

3 EVALUATION APPROACH

Conceptual framing

Influencing policy is important for development, in particular sustainable development and structural transformation, however documenting policy influence is hard. This is not because it is hard to know whether a policy change occurred, but rather because it is difficult to determine what factors led to the change. Quantitative methods for impact evaluation use statistical approaches to make causal claims, however, they require large sample sizes which are usually not possible in the case of policy influence. Thus, qualitative or theory-based approaches are often recommended (White and Phillips 2012).

Theory-based approaches to evaluation are based on the program's theory of change (ToC) in order to draw conclusions about whether or how the program's activities led to the observed outcomes. While there is no explicit "control" against which to compare outcomes, the approach recognizes the need for a counterfactual and emphasizes the importance of considering alternative explanations for an observed outcome that are beyond the program's hypothesized contributions. Examples of theory-based approaches to evaluation include process tracing (Beach and Pedersen 2019) or contribution analysis (Mayne 2012).

We have identified two shortcomings to the use of theory-based approaches in policy evaluation. Firstly, theories of change used in theory-driven evaluations are usually built from 'stakeholder theory' – the implicit or explicit ToCs held by those close to the program (Donaldson 2007; Breuer et al. 2015). Putting this theory at the centre of an evaluation risks overestimating the causal power of the program and underestimating other causal factors. As a result, some evaluators prefer more inductive approaches that do not start with theory (Carden 2009; Van Wessel 2018), for example outcome harvesting (Wilson-Grau 2019). Secondly, Scriven (1994), one of the best-known critics of theory-driven evaluation, argues that most evaluators lack the ability to develop a good ToC to evaluate because doing so requires state-of-the-art subject matter expertise.

To address these issues, this study uses a new hybrid approach called outcome trajectory evaluation (OTE, Douthwaite et al. forthcoming). OTE is hybrid in the sense that it uses both existing, published theory and stakeholder theory. The approach was first developed in an outcome evaluation carried out for the CRP on Roots, Tubers and Bananas (RTB) and A4NH (Douthwaite 2020; Douthwaite et al., forthcoming).

OTE is based on two core concepts. The first is the idea that outcomes, such as the establishment of a biofortification breeding program, are not single, one-off events, but rather are generated and sustained over time by an interacting and co-evolving system of actors, knowledge, technology and institutions. These systems are called *outcome trajectories* (Paz-Ybarnegaray and Douthwaite 2017). Outcome trajectories are different from impact pathways (as defined, for example, by Mayne and Johnson 2015) in their starting point. The former are constructed by working backwards from existing outcomes while the latter generally begin with project activities and outputs to describe how they are expected to produce outcomes and impact in the future. Impact pathways tend to be program-centric and look to the future while outcome trajectories are built by first looking backwards. OTE adopts the outcome harvesting definition of an outcome: "A change in the behaviour, relationships, actions, activities, policies or practices of an individual, group, community, organization or institution" (Wilson-Grau 2019).

The second key concept in OTE is the idea of *middle-range theories* (Pawson 2010; Pawson 2013) that are positioned between universal social theories and more location- and context-specific program theory and/or ToC. Middle-range theories apply to clusters of similar programs and can therefore help develop program ToCs that are comparable at cluster level, and so can aid cross-case learning and insight. A number of broadly-applicable theories exist in the policy realm (Sabatier 2007) that have been simplified and described such that policy advocates and evaluators: 1) can choose which will best help their understanding and navigation of the policy processes in which they are involved (Stachowaik 2013; Resnick et al. 2018); and, 2) can specify them so as to function as middle-range theories applicable to clusters of projects. In the case of an evaluation of policy influence, starting with an existing policy

process theory and adapting it to the specific program context can ensure that the evaluation is rooted in accepted understanding of how policy influence happens and that it considers the contributions of a program through this lens. The subsequent middle-range theory developed in the specification process can be used in subsequent evaluations of similar projects, saving the respective evaluators from the need to develop a ToC from scratch. Instead, their task is to use evidence and stakeholder theory to challenge, validate and/or further specify the selected middle-range theory, and in so doing alleviating the two constraints identified above.

Implementation

Operationalizing OTE in an evaluation involves six steps which are described below for the case of the HarvestPlus study. Before describing the steps, we briefly describe the focus and scope of the evaluative review.

The main evaluation question addressed using OTE was how and to what extent did HarvestPlus contribute to the establishment and implementation of sustainable biofortification breeding programs in Bangladesh, India and Rwanda.[5] The outcome trajectories to be described, modeled and evaluated are the establishment and implementation of three biofortification breeding programs, namely:

- Zinc rice in Bangladesh with the Bangladesh Rice Research Institute (BRRI);
- Iron pearl millet (IPM) in India with the All India Coordinated Research Project on Pearl Millet (AICRP-PM); and
- Iron beans in Rwanda with the Rwanda Agriculture and Animal Resources Development Board (RAB).

These 'crop x country' combinations were selected by HarvestPlus. The idea was to look at mineral crops (iron and zinc) in different crop x country contexts. In all cases, the programs were considered successful,

[5] The full evaluative review (Douthwaite 2021) included other more forward-looking evaluation questions. While these built on the results obtained using OTE they were not addressed using the OTE method so are not reported here.

and it was felt that sufficient information would be available on which to base the study. Details on how trajectories were constructed, including selection of interviewees, is described below in Step 2.

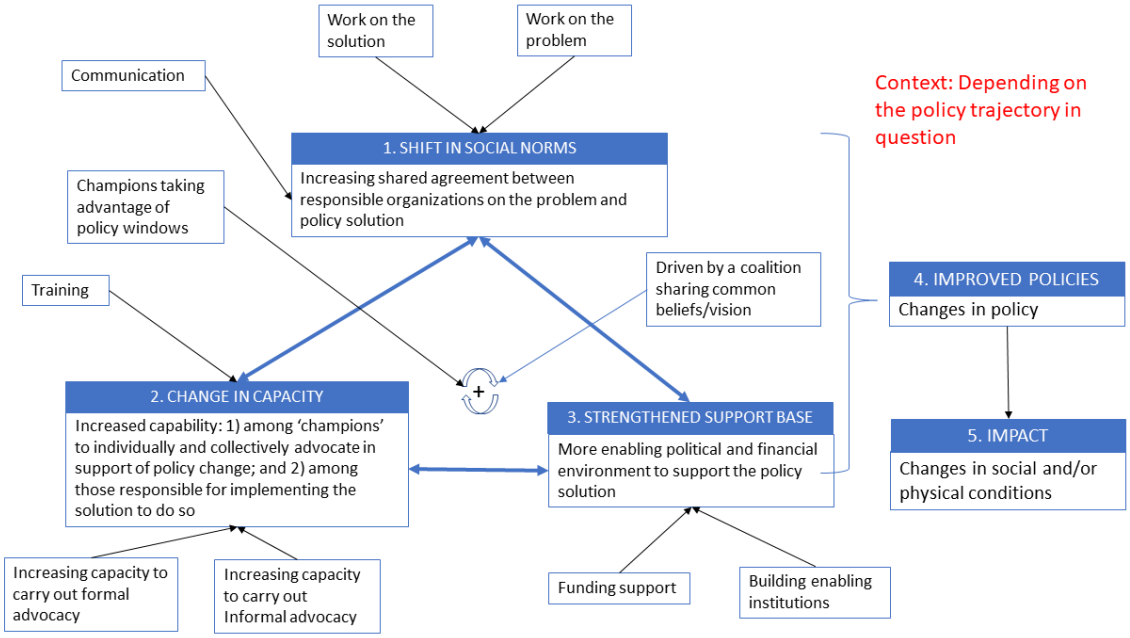
Step 1: Select existing theory to focus description and understanding of the respective outcome trajectories

Accordingly, the first step in the evaluative review was to select an existing theory to provide a framework to help construct and make sense of the three outcome trajectories (crop x country breeding programs) and the contexts in which they operated. We chose an existing middle-range theory that was adapted and specified in a recent, similar evaluation conducted for RTB and A4NH (Douthwaite 2020; Douthwaite et al. forthcoming) to describe how CGIAR contributed to four policy outcome trajectories (Figure 3.1). One of the outcome trajectories was on biofortification, specifically on the development of a Continental Declaration on biofortification developed by the African Union Commission. The broad theory adapted by the RTB-A4NH evaluation was Kingdon's (1984) Policy Window theory, as interpreted by Stachowiak (2013). The theory proposes that changes in policy-related outcomes occur during *windows of opportunity*, which help champions successfully connect two or more components of the policy process. The components are the way a *problem* is defined; the *policy solution* to the problem; and the *politics* surrounding the issue (Stachowiak 2013; Zahariadis 2008). Windows of opportunity are moments when progress can be made. They can be created by natural events such as pandemics, droughts, or earthquakes. They can also be changes in government, budget cycles, or landmark meetings and summits held as part of ongoing national, regional, and global processes. Policy windows are often short in duration and may or may not be predictable.

The attraction of using a middle-range theory specified and adapted from a similar previous study was that it allowed us to learn from and build on it. We would be able to use the results to identify the specific strategies that had proven useful to achieve outcomes numbered 1 to 3 (Shift in social norms, change in capacity, strengthened support base) in Figure 3.1, in different contexts for different types of policy-related outcomes (i.e., establishment and functioning of biofortification breeding programs in three

countries). Our expectation was that this would make our modified version of Figure 3.1 more broadly generalizable for future outcome evaluations of policy-oriented outcomes of CGIAR and partner research.

Figure 3.1 A middle-range theory describing how CGIAR and partner interventions contribute to changes in policy-related outcomes



Source: Douthwaite et al. forthcoming.

Step 2: Identify and describe the outcome trajectory that has led to the respective biofortification breeding programs being in existence

Desk review and key informant interviews began in June 2021 to develop timelines for the three respective outcome trajectories, based on interviews and reviews of available data, reports and online publications (Douthwaite 2021). Included in the data gathering was a detailed review of project documents carried out by HarvestPlus staff so as to identify:

- The investments made into the respective breeding programs over the study period, including but not limited to investments in technical capacity;

- The main outputs of the breeding programs in terms of the release of new biofortified varieties and provision of breeding material to other breeding programs; and
- Information relating to the three components of sustainability:
    - The competitiveness of new varieties released, measured in farmer and consumer preference and rates of adoption, e.g., adoption studies;
    - Political support in terms of awareness raising, extension and advocacy activities and outcomes associated with these, e.g., identification of policy documents that support biofortification; and
    - Technological progress, such as advances in ability to test for micronutrients, e.g., the arrival of a new X-ray fluorescent (XRF) machine.[6]

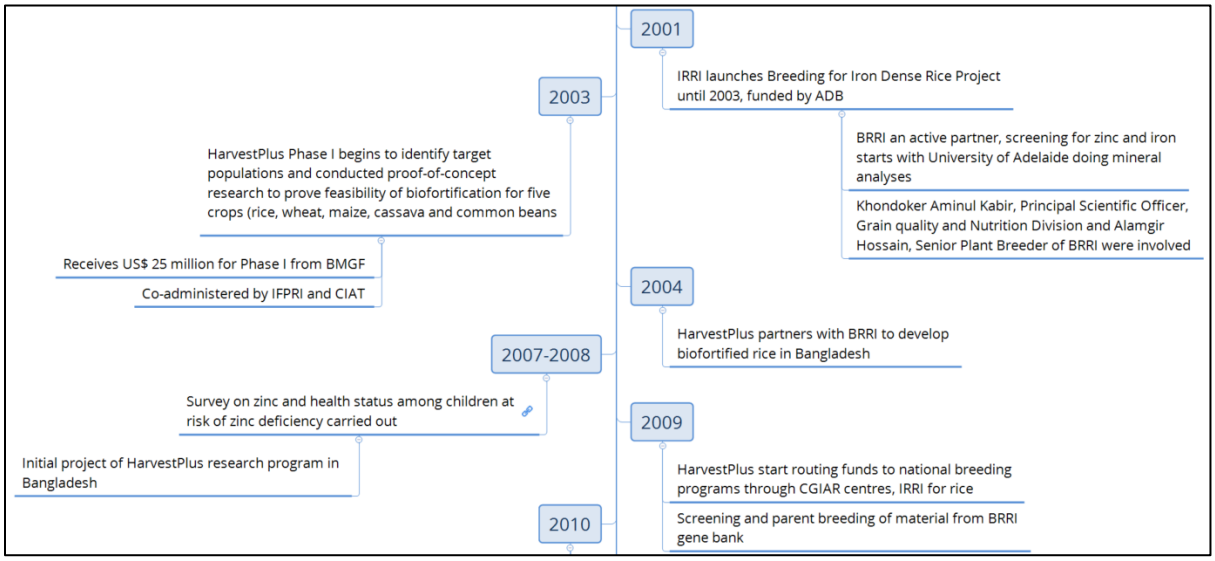
In developing the timelines, we wove together information from interviews, reports and papers provided by HarvestPlus, and web-based keyword searches, to build a picture of the respective outcome trajectories. The lead author interviewed a total of 18 people about the three cases, six on zinc rice, six on iron beans, three on iron pearl millet and three on all three cases. Interviewees were largely suggested by HarvestPlus on the basis of being the most knowledgeable and representing a variety of perspectives. They represented organizations involved in the respective biofortification breeding programs and/or were individuals knowledgeable of the broader value chain context in which the breeding programs existed. Interviews were recorded and detailed notes made of them. Anonymized, detailed referencing was used to establish an audit trail such that facts and assertions made in the report could be checked back to their sources. Where pieces of data did not appear to fit, further clarification was sought and understanding adjusted.

Our approach was essentially a case study one in which understanding flowed from rich, thick picture descriptions of events gleaned from interviews in particular. We used the middle-range theory shown in

[6] The use of the XRF machine in breeding began in the early 2010s. The XRF machine accelerates the screening process for target minerals and is also used to confirm mineral levels in bred varieties.

Figure 3.1 as the 'theory of the case' (Rule and John 2015) to help focus inquiry as we built annotated timelines of the three respective outcome trajectories. Specifically, we looked for manifestations of the three immediate outcomes – outcomes 1 to 3 shown in Figure 3.1 – together with the events and processes that may have contributed, which were recorded on the timeline, together with notes with regard to their significance (see for example Figure 3.2).

Figure 3.2 Portion of the zinc rice timeline from Bangladesh



Source: Douthwaite 2021, p. 39.

Step 3: Validate the outcome trajectory timelines with key stakeholders

The evaluator sent out the annotated outcome trajectory timelines for each case to the respective interviewees to validate, challenge and add to the timelines. The annotated timelines were adapted based on this feedback.

Step 4: Identify specific strategies used to achieve the immediate outcomes, adapt and validate middle-range theory

Based on the annotated timelines, the rich, thick description from interviews, and document review, we identified the specific strategies used to achieve the general strategies shown in Figure 3.1, i.e., the boxes

linked to outcomes numbered 1 to 3 in the figure. For example, the specific strategies related to 'communication' were: (1) consumer marketing using print, radio, TV and social media and (2) field demonstrations and field days and shows. These two strategies were used in all three cases. The result is a complete list of specific strategies, and how they map—or not—to general strategies (Figure 4.1 lists the specific strategies and shows how they map onto the general strategies).

Secondly, we adapted the generic descriptions of the immediate and intermediate outcomes to apply to the three cases (see Figure 4.1). For example, we refined the description of immediate outcome 3 'strengthened support base' from 'more enabling political and financial environment to support to the policy solution' to 'more enabling political and financial environments to support biofortification breeding programs alongside other efforts to disseminate and promote adoption.'

The evaluation team (the lead evaluator, plus the two evaluation managers, all co-authors of this paper) organized a workshop on 23 September 2021 for interviewees to validate, challenge and add to the specific strategies mapped onto the general strategies.

Step 5: Use the validated timelines and three-case ToC to answer the evaluation question

For each outcome trajectory, the evaluator used the conceptual framing, the case-specific timelines, the adapted ToC, notes from the in-depth interviews, and information from the document reviews to answer the evaluation question.

Step 6: Subject the draft report to review for fact and inference checking before finalizing

A first draft of the full evaluative review was provided to the evaluation managers 13 October 2021 to coordinate a review process to check facts and the legitimacy of inferences made. Comments and suggestions from reviewers outside the evaluation team were collated and considered. The changes made and not made were recorded and explained. The final evaluation was published in the following month (Douthwaite 2021).

4 EVALUATION FINDINGS AND RESULTS

Overview of outcomes and other key characteristics of the trajectories

Key information on HarvestPlus activities in each country, including outcomes achieved, is summarized in Table 4.1. In all three, the policy-oriented outcome sought was a national biofortification breeding program established in each country for each crop.

Table 4.1 Characteristics of the three biofortification breeding programs

	ZINC RICE IN BANGLADESH	IPM IN INDIA	IRON BEANS IN RWANDA
POLICY-ORIENTED OUTCOME SOUGHT	Sustainable zinc rice breeding program at BRRI	IPM mainstreamed into the Indian Council of Agricultural Research (ICAR), (through AICRP-PM) and private sector breeding programs	Sustainable iron bean breeding program at RAB
YEAR TRAJECTORY BEGAN	2004	2004	2009
KEY TRAJECTORY ACTORS	More than 30 Host org: BRRI Research: CGIAR, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Bangladesh Institute of Nuclear Agriculture (BINA), BRRI	More than 40 Facilitating org: ICRISAT Host org: ICAR Research: ICRISAT, SAUs, 37 seed companies, farmer production organizations, nongovernmental organizations for product development and dissemination	More than 30 Host org: RAB Research: CGIAR, RAB
HARVESTPLUS INVESTMENT	US$800,000 from 2010 to 2020	US$1,914,000 from 2009 to 2022	US$1.2 million from 2009 to 2019
BREEDING OUTPUTS	9 high zinc rice varieties released by BRRI (6), BSMRAU (2), and BINA (1)	1 open-pollinated variety (OPV) bred by ICRISAT; 8 hybrids produced by SAUs; 1 hybrid bred by private sector seed company	18 iron bean varieties released by RAB
FUTURE DIRECTION	BRRI to continue with dedicated high zinc (and iron) breeding program before transitioning to the mainstreaming of biofortification breeding in about 7 years (by 2028)	IPM breeding to take place under AICRP-PM umbrella screening varieties for notification and release, while helping to increase benchmark, and push for policies that create a demand for IPM	RAB to continue breeding iron bean varieties and to work to reduce the cost of good quality seed and make it more available, with private sector
OTHER OUTCOMES	Zinc rice varieties reached 2,454,000 households directly from 2013 to 2020	In 2019, 240,000 farmers were growing IPM (largely Dhanashakti)[7]; in 2020, 65,000 farmers were growing IPM[8] High iron (>42 ppm) set as national benchmark for AICRP system.	Biofortification successfully embedded into the country's food system: 15% of beans consumed are high in iron, 20% of beans grown are high in iron; 420,000 households growing iron beans (as of 2018)

[7] From Foley et al., 2021, p. 121. Source of the data was "HarvestPlus Monitoring and Evaluation Team. HarvestPlus database. Published online 2019."

[8] The drop from 2019 was attributed to COVID-19 restricting people's movement.

The level of investment by HarvestPlus in each trajectory fell sharply at the end of the program's third phase in 2018. For example, in Rwanda, HarvestPlus judged that it had met its objectives with respect to promoting and making iron bean seeds available. It reduced the overall investment to fund an ongoing liaison with the government and maintaining the XRF machine to test for iron levels in beans. The number of NARES bean breeders working in the country declined from five in 2018 to two in 2021. Nevertheless, breeding of iron bean varieties remains a priority for the national bean breeding program (Douthwaite 2021). In India, separate biofortified hybrid trials for IPM were stopped in 2018 when the Indian Council of Agricultural Research (ICAR)'s AICRP-PM agreed in its annual meeting to screen all promising varieties and hybrids in national trials for iron and zinc content, set at 42 parts per million (ppm) and 32 ppm, respectively. HarvestPlus funding since 2018 has been used to fund the screening of about 8000 to 9000 lines a year, together with soil, at a cost of US$2.50 per sample (Douthwaite 2021). HarvestPlus funding for IPM in India was much higher than for iron beans in Rwanda and zinc rice in Bangladesh. The difference is that funding was distributed among 30 organizations, including State Agricultural Universities (SAUs) and private sector seed companies.

Identifying strategies and adapting the middle range theory

As described under Step 4, three data sources – the timelines, interviews and document review – were used to adapt and specify the middle-range theory (Figure 3.1). This was done by systematically looking across the data sources for evidence of the use of specific strategies that contributed to the general strategies shown in Figure 3.1. This was a deductive process, driven to a large extent by the evaluator's understanding of how change happens, built on three decades of experience. To help reduce the risk of confirmation bias, the specific strategies identified were validated with the people interviewed, and modified accordingly.

It is important to note that outcome trajectory actors, including HarvestPlus, may not have understood that they were employing those strategies at the time. However, looking back, in the evaluator's view, and

validated by key participants, the specific strategies do a plausible job of explaining how HarestPlus, and other trajectory actors, contributed to the implementation of the respective general strategies.

We made some adaptations to the general strategies, to better match the findings:

- Under 'strengthened support base,' we added 'advocacy' as a strategy to create more enabling political and financial environments for the breeding, dissemination and adoption of biofortified crops.
- Under change in capacity: 'building formal and informal capacity for advocacy' is considered as one strategy. 'Training' is replaced with two general strategies: 'building capacity for advocacy;' and, 'building technical capacity among breeders and value chain actors.'
- Reworded the two strategies—'champions taking advantage of policy windows' and 'driven by coalitions sharing common vision' as 'advocating for enabling policies' and 'holding events to generate policy windows,' respectively, as better descriptions of what happened in practice.

The mapping of specific strategies onto general strategies onto immediate outcomes is shown in Table 4.2. The first column of the table shows the general strategies, organized by the immediate outcomes to which they contribute. The second column shows the specific strategies that map onto the general strategies. The third column specifies the cases that used the specific strategies and the fourth column provides links to summaries of the findings related to the specific strategies found later in the text. The full findings are provided in the evaluative review report (Douthwaite 2021). Taken together Figure 4.1 and Table 4.2 can be considered as a ToC of how HarvestPlus contributed to achieving the outcomes in the three cases. The ToC can serve as middle range theory for future outcome evaluations of similar projects, and so on. In this way, middle range theory offers a way to accumulate insight and learning from one evaluation to the next.

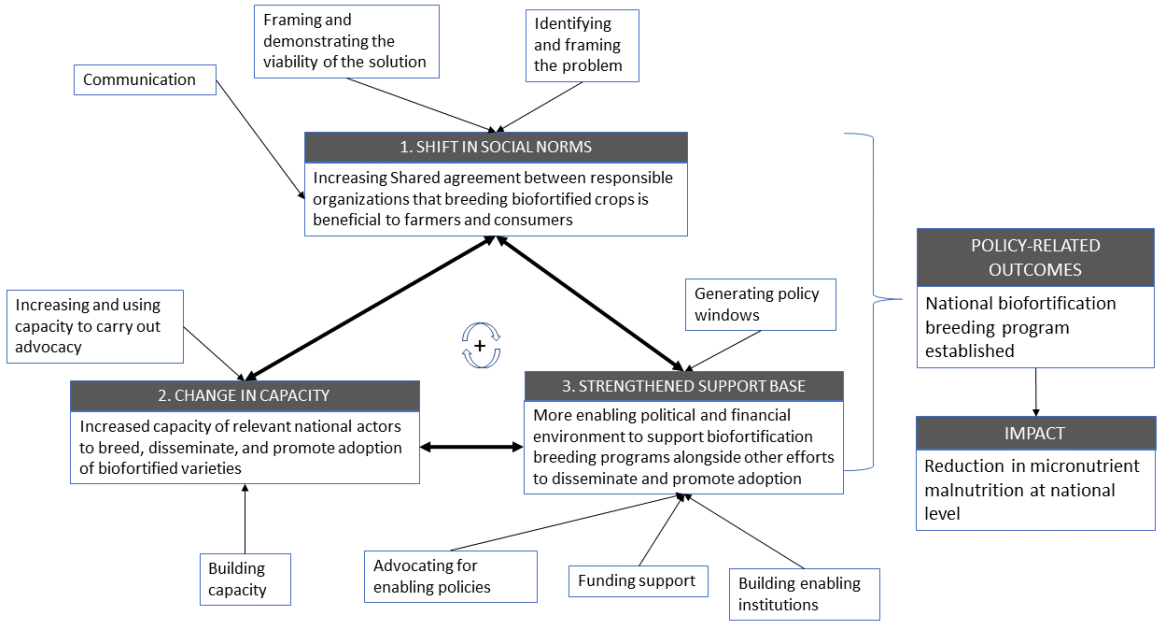
Table 4.2 General and specific strategies used to contribute to changes in the three immediate outcomes in the ToC, by country, with links to relevant findings

GENERAL STRATEGIES	SPECIFIC STRATEGIES USED	CASES THAT USED IT	RELEVANT FINDINGS
FOR STRENGTHENED SUPPORT BASE			
Funding support	Funding biofortification breeding in national programs	All	Finding 1
	Subsidizing the price of seed to allow greater farmer access	Bangladesh, Rwanda	Finding 2
Building and working within enabling institutions	Working with (India) or independently (Rwanda) of existing consortia/multistakeholder platforms sharing a similar objective	India, Rwanda	Finding 3
	Support to biofortification seed systems	All	Finding 4
Advocating for enabling standards and policies	Contribution to policy support for biofortification	All	Finding 5
Generating policy windows	Holding of conferences and crop meetings on biofortification	All	Finding 6
FOR CHANGES IN CAPACITY			
Increasing and using capacity to carry out advocacy	Strengthening the capacity of biofortification champions	No evidence found	Finding 7
	Key trajectory actors using their professional links and expertise to engage in national and international meetings and conferences	All	Finding 8
Capacity development	Capacity development across the respective biofortified crop value chains	All	Finding 9
FOR SHIFTING SOCIAL NORMS			
Framing the problem	Identifying and framing micronutrient malnutrition as a global problem	N/A	Finding 10
Framing and demonstrating the viability of the solution	Framing and demonstrating at a global level the viability of biofortification as a solution to the problem of micronutrient malnutrition	N/A	Finding 11
	Breeding and release of biofortified varieties in-country as proof of concept	All	Finding 12
	Carrying out commercialization assessments and market research for biofortified crops	All	Finding 13 Finding 14 Finding 15
	Carrying out trials to establish the efficacy of biofortified crops in producing positive health outcomes in the target country	All	Finding 16
	Carrying out adoption studies	All	Finding 17
Communication	Field demonstrations, field days and shows	All	Finding 18
	Consumer marketing using print, radio, TV and social media	All	Finding 19

The finding relates to the specific strategy that of "funding biofortification breeding in national programs" which in turn maps onto the general strategy of "funding support." Funding support is one of two general strategies shown to contribute to immediate outcome 3: strengthened support base, in the RTB-A4NH middle-range theory shown in Figure 3.1. If evidence is not found, or if the strategy does not apply to the cases, this is also noted as a finding.

Figure 4.1 is an adaptation of Figure 3.1 to make it specific to the three cases in question.

Figure 4.1 Middle range theory explaining how HarvestPlus contributed to the establishment and implementation of biofortified breeding programs in three countries, showing how general strategies mapped onto the three immediate outcomes



Source: Douthwaite 2021.

5 HOW THE SPECIFIC STRATEGIES WORKED TO INFLUENCE IMMEDIATE OUTCOMES

We consider in turn how the specific strategies, identified and validated in Step 4, worked to bring about the three immediate outcomes across the three cases. The order in which the specific strategies are presented depends on the general strategies they map onto, which in turn depends on the immediate outcomes the general strategies map onto as shown in Table 4.2. Figure 4.1 shows that the immediate outcomes influence each other and can happen at the same time. In the same way, it can be assumed that the general and specific strategies influence each other and may have happened simultaneously.

Summaries of findings with respect to specific strategies are given throughout the following text, to help provide an indication of where links between findings exist. More details of the individual findings can be found in Douthwaite (2021).

Findings relevant to immediate outcome: Strengthened support base

Funding biofortification breeding in national programs

Finding 1: HarvestPlus funded national partners to undertake biofortification breeding starting in 2009 in the three respective countries. Without this funding, it is highly unlikely that the biofortification breeding programs would have ever been set up.

Subsidizing the price of seed to allow greater farmer access

Finding 2: Once the biofortified varieties were approved for release, HarvestPlus subsidized the price of biofortified seed to allow greater farmer access in Rwanda and Bangladesh. While initially very successful in Rwanda, this led to a gap in the market when the indirect HarvestPlus subsidy was removed, and criticism that HarvestPlus should have worked to support value chain actors rather than become one itself. However, if HarvestPlus had been less interventionist, it may not have achieved such high adoption levels in a such a short period of time. In Bangladesh, HarvestPlus also initially guaranteed a market for a portion of the private sector production and subsidized the price for any seed that the private sector marketed directly to consumers.

Working with or independently of existing consortia/multi-stakeholder platforms sharing a similar objective

Finding 3: HarvestPlus took different approaches to engaging with other trajectory actors depending on the size and governance structure of the country. In India, to reach the states growing pearl millet, HarvestPlus worked through the umbrella of ICAR's AICRP-PM, a consortium of 12 SAUs involved in breeding pearl millet. HarvestPlus also worked through the ICRISAT-led PMHPRC that included 30 seed companies. In Rwanda, HarvestPlus could have worked through the long-established International Center for Tropical Agriculture (CIAT)-led Pan-Africa Bean Research Alliance (PABRA) network, but chose instead to work directly with RAB, taking a more interventionist approach to ensure rapid iron bean seed distribution and uptake in Rwanda.

Support to biofortification seed systems

Finding 4: In Rwanda, HarvestPlus supported the development of a specification for iron beans to be used as part of iron bean seed certification. In India, the program was party to the decision by AICRP-PM to set the threshold of 42 ppm of iron and screen all new hybrid IPM candidate varieties to equal or exceed the level before promoting to the next level of testing and approving their release. HarvestPlus supported the varietal release process in Bangladesh and Rwanda by helping to implement and fund necessary multi-locational trials and their analysis.

Contribution to policy support for biofortification

Finding 5: Biofortification and the three case crops are supported in policy documents in all three countries. Perhaps not surprisingly, the direct contribution of HarvestPlus to the policy process appears to have depended on the size of the country. In India and Bangladesh – two large countries – the main policy conduits were the national lead organization for biofortification, that is, ICAR's AICRP-PM for India and BRRI for Bangladesh. In Rwanda, a much smaller country in which the HarvestPlus intervention was much more significant, HarvestPlus appears to have had more direct influence, together with RAB. Promotion of iron beans are supported more often and more specifically in Rwanda's policy documents than in the other two countries.

Holding a global conference on biofortification and crop meetings

Finding 6: This review did not have the resources to identify specific policy windows that led to the policy support described under the previous finding. Policy windows for biofortification will likely have resulted from working collaboratively with country networks. In Rwanda, it is likely that they were generated by the Second Global Conference on Biofortification in 2014, which was held in Kigali. Respondents flagged the importance of crop meetings in influencing policy in all three countries.

Findings relevant to immediate outcome: Change in capacity

Strengthening the capacity of biofortification champions

Finding 7: The review found no evidence of an overt strategy to build the capacity of champions in either of the three cases, as Policy Window theory might suggest.

Key trajectory actors using their professional links and expertise to engage in national and international meetings and conferences

Finding 8: Senior researchers working on the three respective breeding programs, and working for HarvestPlus globally, were supported by HarvestPlus to make the case for biofortification at conferences and in meeting with senior government officials and other key stakeholders, using and building their innate capacities in the process.

Capacity development across the respective biofortified crop value chains

Finding 9: HarvestPlus facilitated training and capacity development in two main areas: for breeding and for value chain actors. Much of the capacity development targeting end users (producers and consumers) happened as part of the communications strategy (see Finding 18 and Finding 19).

Findings relevant to immediate outcome: Shifting social norms

Identifying and framing micronutrient malnutrition as a global problem

Finding 10: This general strategy did not apply to the three cases because by the time HarvestPlus began funding the three biofortification breeding programs, micronutrient malnutrition had already been established as a priority global health concern, in particular for women and children.

Framing and demonstrating at a global level the viability of biofortification as a solution to the problem of micronutrient malnutrition

Finding 11: As with the previous finding, the general strategy did not apply to the three cases. Biofortification had been established globally as a solution to micronutrient malnutrition prior to 2009, in part through HarvestPlus running a 'gold standard' effectiveness study on orange flesh sweetpotato in Mozambique and Uganda and the resonance the results found, manifest in the Copenhagen Consensus ranking biofortification as the fifth best investment to tackle the world's most pressing development issues.

Breeding and distributing biofortified crops in country as proof of concept of delivery at scale

Finding 12: At country level, the most important step to establish biofortification as a viable solution to micronutrient malnutrition in the minds of trajectory actors was to breed and distribute biofortified crops and demonstrate that farmers and consumers would find them acceptable (more in Finding 17). Of the three cases, the first release of an approved biofortified variety was in Rwanda in 2010. One of the five varieties released, MAC-44, went on to become the most widely distributed high iron climbing bean variety in the region.

Carrying out commercialization assessments and market research for biofortified crops

Finding 13: In India, HarvestPlus and the Global Alliance for Improved Nutrition (GAIN) commissioned the global consultancy firm Dalberg to carry out a commercialization assessment (Dalberg 2019). Although it was too late to influence the establishment of the breeding program, it was potentially relevant to its sustainability. The report estimated that by 2024, about 60 percent of on-farm consumption and 85 percent of rural and urban consumption will be of varieties with greater than 42 ppm of iron. The fact that all 17 of the pearl millet varieties released through government channels since 2017 have greater than 42 ppm of iron supports the estimate. HarvestPlus' own global baseline to qualify as IPM is 47 ppm of iron and the breeding target is 77 ppm of iron. In India, the baseline and breeding targets are currently 42 ppm and 72 ppm of iron, respectively.

Finding 14: The barrier to commercialization identified in the Dalberg report that no competitive biofortified alternatives exist for farmers using open-pollinated varieties (OPVs) would appear to be at odds with the launch and promotion of the Dhanashakti OPV by HarvestPlus as the first IPM, which performed better than the variety it was bred from. Moreover, the adoption of IPM reported by HarvestPlus was largely of this variety. Adoption of nine hybrid varieties supported by ICRISAT/HarvestPlus, was delayed by difficulties in licensing public sector-bred varieties to the private sector, a high-level issue that deserves further attention. The value of ICAR's relatively low iron threshold of 42 ppm may be to signal that the government seed system will set more and higher thresholds in two or three years and seed companies would do well to start breeding accordingly.

Finding 15: HarvestPlus took a much more proactive commercialization approach in Rwanda because of the challenges faced in distributing iron bean varieties to farmers. The program intervened directly in the seed value chain, becoming the largest seed distributer in the country for a period of time. The HarvestPlus Rwanda team experimented with a number of options to rapidly produce and distribute seed to farmers. Two of the most successful were swapping farmers' seed with iron bean seed and providing seed alongside agronomic training and the NARES.

HarvestPlus' approach was very successful in providing iron bean seed to farmers. By 2018, an estimated 420,000 farmers were growing iron beans with 15 percent of the population of Rwanda eating them. This took place in the context of a very low seed replacement rate among bean farmers. However, becoming a large institutional buyer and then leaving the market created, or at least led to the return of, a number of seed value chain issues, not least poor communication between institutional buyers and seed producers and the high cost of certified seed, unaffordable to most farmers.

Carrying out trials to establish the efficacy of biofortified crops in producing positive health outcomes in the target country

Finding 16: HarvestPlus supported at least four efficacy trials in the three cases, carried out either by Cornell University or the Swiss Federal Institute of Technology. Only two studies provided links to

published results, both of which found significant positive health effects. Of the other two studies, no mention of their existence was found in the information HarvestPlus has made easily available online. In contrast, much mention is made by HarvestPlus of the two positive studies, to help frame biofortification as an effective solution to hidden hunger.

Carrying out adoption studies

Finding 17: In each case HarvestPlus conducted adoption studies in part to document and understand the popularity of the respective biofortified crops. In all three cases, multiple studies were conducted in each country and adoption rates varied from one study to the next. For example, in Bangladesh, published estimates in 2018-2019 of farmers who had ever grown zinc rice ranged from 250,000 to 500,000 to 1.5 million. In Rwanda, published papers and reports were more in agreement that about 15 percent of the population was eating iron beans in 2018, a level of adoption that is an order of magnitude higher than in Bangladesh or India.

Field demonstrations, field days and shows

Finding 18: While field demonstrations, field days and shows were important communication and awareness building strategies in all three cases, how they were run and by whom differed from country to country in terms of the role of the public versus the private sector, and the level of direct engagement by HarvestPlus.

Consumer marketing using print, radio, TV and social media

Finding 19: HarvestPlus employed consumer marketing using print, radio, TV and social media in all three cases. As with the previous finding, the specific strategies used varied from case to case. Bangladesh made most use of print media and television. India relied heavily on the private sector, and on one company in particular. In Rwanda, much of the marketing happened in local markets, helped by celebrity endorsement.

Summary of how the strategies worked to contribute to the outcome

The findings allow for the following summary description as to how HarvestPlus contributed to setting up biofortification breeding programs in the three countries. The numbers refer to the three immediate outcomes involved – shift in norms (1); changes in capacity (2); and strengthened support base (3). Biofortification was established as a viable solution to micronutrient malnutrition prior to and during HarvestPlus' first phase (1). During HarvestPlus' second phase that started in 2009, in each of the three cases, HarvestPlus provided funding support (3) and capacity development (2) to support national programs to work on biofortified breeding with CGIAR centers. As varieties were developed and released, HarvestPlus engaged with trajectory actors in the value chain, including seed systems, to build capacity (2) and strengthen the support base for biofortification at scale (3). HarvestPlus did this through capacity development (2), advocating for policies to support biofortification (3), securing funding to support biofortification (3), and building enabling institutions with other trajectory actors (3). These efforts at building institutions were complemented by efforts to build capacity (2) of key trajectory actors within their institutions to carry out and to advocate for biofortification (3). These actions led to changes in how trajectory actors viewed biofortification as a viable solution to micronutrient malnutrition (1). These widespread changes in awareness and perception influenced the enabling environment for the technology (3). The three trajectories were also driven forward by results-focused interventions by HarvestPlus backed by its main donors.

6 DISCUSSION

The starting assumption that outcomes emerge from a system – an outcome trajectory – to which HarvestPlus contributed, proved useful. It helped broaden the scope of the review and in countering the tendency to assign too much causal power to the program being reviewed, rather than the system to which the program contributed.

OTE encourages the evaluator to look at the broad range of factors that might have influenced the outcome. This was certainly important in this evaluative review. In the original proposal for this study, the desired focus was on the role of capacity building in the NARES, what would have been one set of strategies relevant to only one immediate outcome that contributed to setting up the biofortification breeding programs. Instead, in the end, by using OTE, the evaluative review results unpacked specific strategies HarvestPlus used that were relevant to three immediate outcomes that influenced the outcome of interest.

Using an existing theory also identified some generalizable findings. For example, identifying and building the capacity of "champions" is often considered an essential part of policy influence. However HarvestPlus does not appear to have used that strategy to support the establishment of NARES-led biofortification breeding programs. A possible interpretation is that for types of policy influence that are more technical in nature, people who are already considered experts (e.g., crop breeders) can be more effective in this role and just need more venues in which to exert their existing influence. They may already have good 'soft skills' without having been trained in them, nor even knowing they possess them. Another possible interpretation is that the enabling environment was already primed or aware that micronutrient malnutrition was a problem and biofortification was a potential solution. Even if it wasn't explicitly employed for this policy change, HarvestPlus had engaged champions in complementary outcome trajectories that had a positive effect on this outcome trajectory (Douthwaite 2020).

In a case like HarvestPlus, with a long history of careful monitoring, evaluation, learning, and impact assessment (MELIA) activities , information was available with which to assess the outcomes. The

systematic way that the program went about building its research, advocacy and MELIA agenda over time resulted in the production of information that was relevant for this case. In addition, the amount of information available online made it easier for the evaluator to corroborate information given by interviewees, and vice versa.

OTE is for looking backwards, and is probably best to use in cases where the trajectory is long and somewhat complex. Program evaluators should invest in OTE when it is needed to make the case and where there is an opportunity for lessons that can be generalized. For programs that are not ongoing for multiple years without interruptions or lack the thorough documentation and evidence generation modelled by HarvestPlus, OTE could be more challenging.

A shortcoming of the approach is that it doesn't necessary allow us to say whether all strategies were necessary. It might have been possible for HarvestPlus to achieve the outcomes with fewer strategies, however as noted above most of the strategies were not undertaken for the purpose of this policy outcome but rather for other outcomes. Therefore, questions related to "cost effectiveness" are not necessarily relevant in OTE.

Having said that, there are lessons from OTE for future studies focused on other outcomes. For example, the issues identified with incomplete or inconsistent findings from efficacy or adoption studies emphasizes the importance of being transparent about reporting results because it could have consequences beyond simply accounting for those results to the immediate stakeholders in the studies.

The study conclusions (Douthwaite 2021, p 34 – 36) show that OTE was able to answer three questions relating to contribution: how did the program contribute, was the contribution necessary and was it sufficient? An OTE approach begins with the premise that program outcomes emerge from an outcome trajectory made of up of more than the program. Hence it will nearly always find that program contribution was insufficient.

7 CONCLUSIONS

This paper describes the experiences of using OTE to assess the contribution of HarvestPlus to the establishments of NARES biofortification breeding programs. Use of the method resulted in a much broader and more detailed understanding of the program's contribution than would have been the case if the study had focused only on the most proximate program activities, namely building capacity of NARES breeders and programs.

The paper also identifies advantages and disadvantages of OTE, including where it might best be used and how it could be improved.

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