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REVIEW

Applications of implementation science in integrated conservation + health programs: Improved learning to achieve environmental and health objectives

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Abstract

One Health is an interdisciplinary approach that advocates for programs and policies that integrate governance, conservation, agriculture, disease ecology, and global health to achieve desired health outcomes. However, rigorous research around integrated One Health programming is limited and/or in very early stages, especially concerning counterfactual-based studies focused on the effectiveness of integrated conservation and health programming, including those focused on the intersection of zoonosis spillover risk in the context of land-use change. We argue that filling these knowledge gaps requires an implementation science approach. This requires evaluation through a counterfactual lens, but also requires a new approach to donor funded program design and the entire project cycle. We present benefits, challenges, and lessons learned from three case studies of efforts at applying an implementation science approach to integrated conservation and health programming in Madagascar, Zambia, and Ghana and Côte d'Ivoire. We demonstrate the value of integrating an implementation science approach at program inception, and the importance of building the evidence base on the effectiveness of integrated conservation and health programming. We demonstrate that despite significant challenges, it is possible to pursue an implementation science approach for cross-sectoral conservation and health programs, including studies on zoonosis spillover risk in the context of efforts to improve environmental outcomes.

Introduction

'One Health' is an interdisciplinary approach that advocates for programs and policies that integrate governance, conservation, agriculture, disease ecology, virology, and global health to achieve desired health outcomes. One Health is based on the assertion that improved health outcomes must consider the connections between human, animal, and environmental health.

However, a One Health approach that relies on strong integration and linkages between different sectors, including conservation and health, is challenging to implement in practice, and rigorous research around integrated programming in these sectors is limited and/or in very early stages.

Indeed, significant knowledge gaps exist with respect to the linkages between ecosystem and human health. This includes a dearth of studies on the influence of development interventions to improve forest condition and biodiversity and thereby improve human health outcomes, along with a limited understanding of the ecological and sociological drivers of zoonoses. Many standard conservation interventions have little to no evidence of impact for deforestation and forest degradation([1, 2]), and biodiversity outcomes are significantly understudied ([3]). There are limited counterfactual-based studies focused on the effectiveness of integrated conservation and health programming, and virtually no studies on the effectiveness of interventions to mitigate the risk of zoonotic disease spillover.

Therefore, we do not have sufficient confidence that standard development interventions improve ecosystem condition nor do we have evidence of flow down effects on human health outcomes. These are time sensitive development challenges that require the allocation of scarce resources for maximum impact. There is a critical need to understand the effectiveness of nature-based solutions and flow down consequences for human health outcomes, in order to improve the design and implementation of programs and policies. These are time sensitive development challenges that require the allocation of scarce resources for maximum impact.

As a follow-up to Ferraro (2006) and (2009), which sounded the call for counterfactual thinking in environmental programs and coined the term 'implementation science', this paper explores the frontiers of implementation science to improve One Health policies and programs. Implementation science is focused on improving program and policy effectiveness by understanding whether programs are working, why, and for whom. The paper examines applications of implementation science in the context of integrated conservation and health programs. These are development programs that seek to improve both environmental and health outcomes. They are based on a theory of change that improved health outcomes will follow from programs that improve conservation and biodiversity, including those focused on mitigating the negative effects of land use change. The expected human health benefits that are under exploration through implementation science approaches range from reduced diarrheal diseases through improved water quality to reduced risks of zoonotic spillover after forest restoration.

In-line with Ferraro (2006) and (2009), we argue that a counterfactual-based approach to research is critical to quantify and evaluate the effectiveness of programs or policies aimed to improve environmental outcomes. Impact evaluations are one such counterfactual-based approach, which aim to measure the causal impact of programs, or in other words, the difference in outcomes caused by the program and not due to other external factors. This includes both (1) experimental approaches, which measure the causal impact of programs through randomized assignment (e.g., randomized control trials), and (2) quasi-experimental approaches, which also attempt to measure causal impacts but without randomization (e.g., difference-in-difference, statistical matching, etc.). Both experimental and quasi-experimental approaches require defining a valid counterfactual—a comparison group which does not receive the program but for which outcomes are still measured—which, when well-defined, allows researchers to infer what would have happened in the absence of the program and control for external factors correlated with the timing and location of programs (e.g., weather, economic trends, etc.) that might also influence outcomes. In the absence of counterfactual-based approaches, many evaluations risk being heavily biased and therefore drawing incorrect conclusions about program effectiveness, upon which further programming decisions are based.

This paper explores three case studies of integrated conservation and health programs that are attempting to apply an implementation science approach across the life cycle of the program and evaluation. This includes a new class of impact evaluations that include a study of environmental and health outcomes, including those focused on the intersection of land-use change and zoonotic spillover risk. The paper is informed from almost a decade of experience conducting applied impact evaluations for natural resource governance programs and the feedback from workshops and reports received from donor partners, government contractors, conservation organizations, local NGOs, and academics.

This paper discusses learning opportunities and benefits to a counterfactual-based research perspective in the context of One Health. We summarize lessons learned and recommended best practices from an implementation science approach to evaluations that study the linkages between land-use change and health.

Beyond more rigorous research designs, this manuscript reiterates that implementation science requires better designed programs, with more attention to the content and context of development interventions at the design stage by donors and implementing partners.

We highlight that major challenges remain in learning and adaptation across the project cycle—especially in areas of localization, research translation and data dissemination. However, we also seek to discuss practical recommendations for overcoming these challenges for implementing partners, donors, and other stakeholders interested in pursuing implementation science to improve the effectiveness of integrated health and conservation programming.

Literature review

This section has three main objectives. First, we summarize the growth of integrated conservation and health programming and expected linkages between the environment and health outcomes, including the linkages between land-use change and zoonotic spillover risk. Second, we describe the state of evidence on the effectiveness of conservation and health programs and highlight the dearth of rigorous studies of these integrated development initiatives. Third, we discuss and describe implementation science as an approach to facilitate improved program design and better evidence.

Linkages between conservation and health

Conservation, biodiversity, and land and resource governance programs employ a variety of interventions to reduce habitat conversion and forest degradation, including (1) to improve the enabling environment for conservation, (2) to change behavior and reduce the threat of deforestation or degradation, and (3) to relieve direct stress on species and ecosystems through strengthened land, water and wildlife management. Common conservation and biodiversity interventions include protected area management, conservation enterprises, payment for ecosystem services, reforestation, law enforcement, wildlife demand reduction and behavior change campaigns, conservation planning, education and training, and institution strengthening, as well as market-based and direct economic payment schemes (Although not directly related to land-use change, another increasingly important category of interventions for biodiversity and zoonoses objectives center on wildlife trade. These interventions aim to halt or reduce the farming, killing, butchering, trade, transport, and consumption of live and freshly killed birds and mammals in provincial towns and metropolitan cities, while not undermining the health and well-being of subsistence hunters.). Similarly, land and resource governance interventions include land-use planning, natural resource management, clarification of rights, policy and legal reform, awareness raising, and many others. Reforestation is an increasingly popular development intervention, and is the subject of a growing number of current and planned research and evaluation initiatives. In 2021 at COP26 in Glasgow, world leaders committed to conservation and restoration of forests by 2030. Increasingly, private corporations and donors have committed to planting trees and restoring forests.

Theoretical and lab-in-the-field evidence strongly suggests that avoided deforestation will improve ecosystem health and have flow down benefits for human health. Correspondingly, forests and wetlands provide ecosystem services that help maintain water quality, and there is a small but growing body of evidence about the impact of improved watershed health on human health outcomes. Studies have shown that forested watersheds may reduce waterborne sediments and contaminants, and thus improve raw water quality in ways that moderate the effectiveness of water quality treatments. In a multi-country study, Herrera et al. 2017 find that higher upstream tree cover is associated with a lower probability of diarrheal disease. Thus, deforested watersheds could undermine the effectiveness of water, sanitation, and hygiene interventions—with the implication that improving forest conditions can have a positive effect on related health outcomes [4, 5].

Correspondingly, ecological restoration, through natural forest replanting versus monoculture tree plantations, is increasingly presented as a nature-based and cost-effective solution to mitigate climate change, biodiversity loss, and emergence of novel zoonotic pathogens [6]. Ecologists have shown that restoration of degraded forest habitat, habitat creation, or actions to improve connectivity between isolated fragments can change the size, structure, and density of wildlife populations [7] and the movement of individual animals [8], which suggests cascading implications for pathogen transmission. Forest restoration could also benefit human health by increasing biodiversity (in particular species that do not amplify viral zoonotic disease risk), lowering disease prevalence in reservoir populations, and reducing reservoir host-human contacts and hazard.

Similarly, studies have highlighted human population density, mammalian diversity, active conversion to land cover, and recent loss of forest as important drivers of zoonotic disease emergence [9, 10]. Zoonotic pathogen spillover is especially associated with the conversion of tropical broadleaf forests [9–12]. Land-use change and habitat conversion effect many of the risk factors for zoonotic disease spillover such as biodiversity loss, changes in the distribution of zoonoses host species, and increased human-wildlife contact. Land-use change alters the interface between recipient human hosts and reservoir hosts, and can lead to increases in cross-host exposure to viruses. Land conversions can increase stress and reduce immune responses among wildlife, increasing their pathogen load. Intensification of certain agricultural practices can increase resources for certain animal hosts of zoonotic diseases and decrease resources for others. Even the structure of farms impacts viral spillover risk, as smallholder farmers increase their forest access as a result of more interface or contact points.

Conversion of natural habitat to agriculture or other land uses leads to biodiversity loss [13], changes in the distribution and abundance of zoonotic disease host species [14], and increased exposure, frequency, and intimacy of contact between wildlife [15], humans, and domesticated species [16]. Thus, there is a strong reason to expect if deforestation is prevented, drivers of zoonotic disease risk such as contact between humans and wildlife and infection prevalence in wildlife will be reduced. Improving biodiversity of habitats can serve as a disease buffer, and virus shedding by wildlife hosts will be reduced in areas where they have less stress and sufficient nourishment.

Limited counterfactual evidence

However, significant evidence gaps exist about the impact of development interventions to improve forest outcomes, along with the downstream effects of improved ecosystem health on human health outcomes [17]. There are a number of conservation interventions that have little to no rigorous empirical evidence about intervention effectiveness on conservation and biodiversity outcomes, including interventions focused on alternative livelihoods, forest restoration, wildlife demand reduction, resource protection, conservation enterprises, eco-tourism, among others [3]. Thus, we are missing an understanding of whether most conservation initiatives even have the expected 'first-order' effects. In most cases data is not collected on biophysical and health outcomes that would enable rigorous study of whether and how environmental outcomes link to health outcomes.

Impact evaluations offer an approach to rigorously evaluate the effectiveness of conservation programs or policies. Impact evaluations rely on a counterfactual to measure the causal impact of a program, or the difference in outcomes caused by a program or intervention and not by other external factors. With the exception of the program of interest, the counterfactual areas should be as similar to the treatment areas as possible. The designation of an evaluation as an impact versus performance evaluation ultimately depends on the validity of the control group or counterfactual.

Impact evaluations employ experimental and quasi-experimental methods to identify treatment effects. Experimental approaches measure the causal impact of programs through randomized assignment (e.g., randomized control trials (RCT); (2) quasi-experimental measure causal impacts but without randomization (e.g., difference-in-difference [DID], regression discontinuity, and statistical matching).

Impact evaluations can be prospective where the research design is embedded in the intervention. The most rigorous prospective method for constructing the counterfactual is through random assignment (i.e. RCT). Impact evaluations can also be retrospective, in which the control is constructed after the intervention has begun or concluded and the opportunity for pre-intervention baseline data collection has passed).

Finally, impact evaluations can be designed to measure causal impact for a combination or 'package' of interventions or seek to isolate the impact of one or more interventions. Conservation programs typically include a bundle of interventions not easily disentangled, such resource protection, alternative livelihoods, tenure, and knowledge/outreach raising.

RCTs are an experimental approach to impact evaluation (While some methods are deemed "quasi-experimental" because they attempt to replicate a randomized design, RCTs are experimental because they are based on random assignment.). In this approach, random assignment, such as through a coin toss or random number generator, determines who may participate in the program so that those assigned to participate in the program are, on average, the same as those who are not. RCTs are a powerful tool for providing robust evidence regarding program effects, as well as for testing causal theories to inform program decisions and to justify resource allocations.

Quasi-experimental methods utilize a counterfactual group that is not determined through a randomized process. The comparison group is purposefully selected or constructed to create the best and most credible comparison for treatment areas. Thus, quasi-experimental methods ultimately represent data-driven methods for evaluating the causal effect of a program; a large-scale data collection effort and econometric methods must be employed to ensure that selection bias between treatment and counterfactual groups is minimized. In theory, a well-designed quasi-experimental method can be a powerful statistical tool to minimize selection bias between treatment and control groups. However, they require stronger assumptions than randomized selection, and there are several methodological limitations because of bias in the selection of treatment areas.

Quasi-experimental methods are more common for conservation and land and resource governance interventions. For evaluating forest condition outcomes, projects apply a matching approach to develop synthetic controls of forest pixels. Comparison areas and settlements are identified from non-intervention areas that are matched on key biophysical and human population characteristics.

A counterfactual approach is critical for generating evidence about whether interventions achieve their expected objectives as well as identifying potential unintended, negative consequences that can undermine the goals of the project. In 2006, a working group led by the Center for Global Development argued that impact evaluations were underutilized in international development for three main reasons: (1) high up-front costs and long-term, diffuse benefits (public goods problem); (2) pressure to design and procure programs (action bias); and (3) difficulties for funders and other stakeholders to adapt in response to evidence contrary to expectations or perceived 'truths' (confirmation, inertia, and optimism biases). Despite these challenges, many development sectors have embraced impact evaluations, including global health, education, and, increasingly, tenure and governance [18].

Coined by Ferraro (2009), 'implementation science' is a more recent term that encompasses the impact evaluation approach. Implementation science focuses on interventions that lack rigorous evidence to determine whether these interventions are working, why, and for whom. It aims to overcome some of the challenges noted above that are faced by proponents of impact evaluations by putting the focus on using rigorous evidence to improve program effectiveness. The term moves away from perceptions of judgment or academic aloofness denoted by 'evaluation science' [1]. By pairing 'implementation' (action) with 'science', 'implementation science' seeks to bridge the artificial divide between researchers and practitioners committed to achieving positive outcomes for conservation and biodiversity.

Yet, the application of an implementation science approach through counterfactual-based research remains rare in conservation [2]. Evidence on the effectiveness of conservation strategies is vastly inadequate, with poor design, lack of scope, and too few examples [19]. RCTs have not been applied to the evaluation of conservation interventions and are limited in research on land and resource governance [20]. There is little data on biodiversity outcomes. Many studies involve the simple monitoring of indicators or case studies, and there is an over reliance on self-reported behavioral indicators [21]. These approaches are insufficient to establish cause-and-effect relationships [22, 23].

Recent reviews have found very few counterfactual studies on the impact of tenure interventions on biodiversity conservation, forest condition, and forest conservation, and none on wildlife trafficking [24]. Unfortunately, there is even less rigorous empirical evidence about the effectiveness of wildlife demand reduction campaigns. Studies on effectiveness of demand reduction lack rigor, with selection, data quality and design challenges. While there have been more recent advances to understand the impact on demand reduction such as before-after study designs using survey data, the lack of robust research designs make it difficult to draw insights to inform future efforts [25]. Finally, at present, no impact evaluations have been completed on the effectiveness of interventions to mitigate the risk of zoonotic disease spillover.

Wildlife conservation through the protection and restoration of ecosystems has the potential to reduce the risk of zoonotic disease spillover [26–28]. However, this concept has yet to be demonstrated on a large scale in a real-world setting, and evidence specific to the outcomes from programs designed to support forest restoration is currently absent. A 2012 review of research on land use, land use change, and infectious disease found 302 papers published on the subject [12]. However, more than one third of these papers were themselves reviews, and the underlying studies remain fairly poor due to the challenges of obtaining data at the wildlife-human interface. Most studies are cross-sectional surveys of land use classes. Only two studies [29, 30] focus on reforestation and zoonoses risk. Although reforestation or restoration are core components of many countries' climate change mitigation commitments, the implications for zoonoses risk are unclear, with results likely dependent on the type of reforestation and biodiversity species richness.

Counterfactual or causal studies are not prioritized in the conservation space, relative to other development sectors, for a variety of reasons [24]. Measuring impact on biodiversity is thought to be methodologically challenging and expensive [1, 21]. Frequently cited challenges include: large variability in ecological outcomes; long time lags between intervention and ecological response, programs with multiple interventions, complex spillover effects (e.g., due to species movement); large spatial scales of environmental processes; and data constraints, including a lack of reliable biodiversity measures. Studies of the wildlife trade face similar challenges, including multifaceted drivers of demand that complicate the study of consumption, lack of data on actual behavioral change, and delayed responses for long-term behavior change.

Overall, despite the strong theoretical foundations for a One Health approach, very few studies have evaluated the impacts of integrated conservation and health programs using a rigorous counterfactual framework. There is a significant knowledge gap in our understanding of (1) what interventions will most effectively support improved forest outcomes and biodiversity, and (2) whether and how targeting those interventions will impact health outcomes and the risk of zoonotic disease spillover. These gaps limit our ability to design effective evidence-based programs.

Methods—Case studies from Madagascar, Zambia, and West Africa

The insights from this paper are built on lessons learned from three case studies where researchers and practitioners are collaborating to put implementation science for conservation and health into practice. Specifically, these case studies are drawn from USAID's Health, Ecosystems, and Agriculture for Resilient Thriving Societies (HEARTH) Activity portfolio, which engages private sector partners to collaboratively implement integrated development programs that aim to conserve high-biodiversity landscapes and improve the well-being and prosperity of communities that depend on them. Across the HEARTH portfolio, USAID has made a strong commitment to rigorous monitoring, evaluation, research, and learning, which has provided the necessary foundation for impact evaluations to be designed and conducted.

The first case study of Health In Harmony's work in Madagascar is not a HEARTH activity, but it has informed USAID's approach to integrated One Health programming. The second and third case studies are from designing impact evaluations for two HEARTH programs, which were selected for impact evaluations based on a variety of factors, including buy-in from key stakeholders, and after undergoing an in-depth assessment of the feasible evaluation design options. Overall, these case studies highlight an implementation science approach to conservation, biodiversity, and integrated conservation and health programs, and all three provide examples of counterfactual-based studies to ground the theory in the previous section.

In addition to the three specific cases highlighted in this paper, the authors' understanding of implementation science has benefited greatly from almost a decade of designing and conducting impact evaluations for integrated and cross-sectoral programs in the fields of tenure, governance, health, among others. The paper also draws heavily on feedback and findings from workshop series, seminars, and reviews commissioned by USAID over the past two years related to improving implementation science for integrated conservation and health programs, including the evaluation feasibility assessments for the two HEARTH case studies, a presentation of lessons learned from designing cross-sectoral impact evaluations at USAID's internal Environmental and Natural Resource Management (ENRM) speaker series in 2024, and a panel at the 2023 annual conference of the American Evaluation Association (AEA). This includes feedback from donor partners, government contractors, conservation organizations, local NGOs, and academics.

The case studies for this paper were selected because—at present—they are the only known examples of integrated conservation, climate, and health projects that adopt an implementation science approach. The authors of this manuscript represent researchers and practitioners who are collaborating on the two HEARTH cases that are funded by USAID, and through the process of preparing the assessments, webinars, and presentations mentioned above have created space for the authors to collaboratively reflect on their experiences with the case studies and identify lessons learned relevant for a broader audience of donors, practitioners, and evaluators. The methods that were used to develop this manuscript drew loosely on the "pause and reflect" approach taken at USAID to support adaptive management of programs, and are distinct from methods that are required for designing and conducting counterfactual-based research and evaluation. The case studies of focus are as follows:

Health-In-Harmony, Manombo forest of Madagascar. Health In Harmony's work—and associated research effort—in the Manombo Forest of Madagascar (and especially in fragmented edge areas) represents a case study of a comprehensive implementation science approach to understanding environment and health, especially zoonosis spillover risk. Health In Harmony (HIH) is applying a One Health approach in a long-term, prospective study to monitor the impact of reforestation and community-designed forest conservation interventions on spillover risk, coincident with surveillance of biodiversity and human and wildlife health. The work and research around this project is scheduled to occur over a 10-year period. The research involves data collection across a diverse and comprehensive set of indicators related to biodiversity, forest condition, wildlife health and human health. Their primary research objective is to understand the following:

> Do community-designed solutions for forest conservation in Manombo, Madagascar restore biodiversity, improve wildlife and human health, and reduce the risk of zoonotic spillover?

The HIH Madagascar research team is comprised of an interdisciplinary team of researchers with expertise in public health, epidemiology, disease ecology, wildlife health, veterinary medicine, and anthropology. The research relies on strong collaboration with local universities and researchers with an implementation plan that includes training and equipping local technicians and field agents for the required data sources, such as wildlife sampling. All of this requires dedicated management to a complex set of logistics—to enable high-frequency field-based data collection for wildlife and human health, as well as forest condition, across multiple data sources.

The HIH approach highlights the high cost of lab analysis for epidemiological data that is required for a long term and comprehensive study. The total anticipated cost of the entire research effort for a 10-year period, including data collection, at the desired frequency, is approximately 34 million USD. About half of these costs (15 million) are for DNA sequencing, which the HIH team has secured through an in-kind donation from the National Institutes of Health to perform the sequencing. Given these costs, HIH's model of multiple funding streams is likely necessary for a 'gold standard' conservation and health evaluation.

Eastern Kafue Nature Alliance, Zambia. The second case is the mixed methods evaluation design for the Eastern Kafue Nature Alliance (EKNA) Activity in Zambia (a five-year project, beginning in late 2023). The EKNA Activity will be implemented in several Game Management Areas and conservancies that border the eastern side of Zambia's Kafue National Park, by a consortium of public and private sector partners led by The Nature Conservancy.

High poverty rates in the area lead to a dependence on natural resources and income from forests for many households, contributing to deforestation and forest degradation from wood extraction, agricultural expansion, and fires.

To address these issues and impact both conservation human well-being outcomes, the project includes several overlapping strategic approaches, including strengthening natural resource compliance and management systems, developing inclusive ecosystem-based markets for local prosperity, strengthening community Maternal and Child Health, improving access to clean water, and developing effective land and resource-use planning, tenure, and governance systems.

The EKNA Activity presents a unique opportunity to measure the effect of integrated programming on conservation and biodiversity outcomes. EKNA provides an example of the potential for an impact evaluation of an intervention that is centered on improving conservation and biodiversity through standard conservation interventions—but without a public health component that is directly linked to conservation. The EKNA project presents an opportunity to capitalize on the potential for additional learning about human health in the context of a project that is designed to improve ecosystem indicators.

The EKNA project is undergoing a mixed-methods evaluation that includes impact and performance components. The evaluation leverages a large amount of biodiversity monitoring that will take place as part of the program implementation, in combination with supplemental biophysical and biodiversity monitoring that will be supported through the evaluation. This includes forest and water quality sampling, as well as biodiversity monitoring that will take place as part of the program implementation (e.g. camera traps, SMART or "Spatial Monitoring and Reporting Tool" wildlife monitoring). The evaluation design calls for baseline data collection in 2023, endline data collection in 2026, and a follow-up round of data collection in 2031.

The research partners scientists with practitioners to design and implement a scientifically rigorous program with applied conservation and health goals. The EKNA Activity impact evaluation provides an opportunity for a multidisciplinary team of political scientists, ecologists, economists, and nurses to focus on the impact of the EKNA Activity on four growing health threats—respiratory illness, malnutrition, water-borne illness, and vector-borne disease. It examines key health threats from a multidimensional approach that combines environmental data, health reports, and physiologic measures. As a zoonosis-related research element, the research will evaluate the impact of the EKNA Activity on vector-borne disease through an investigation of the frequency of water-related diseases in local communities.

Resilient Ecosystem and Sustainable Transformation of Rural Economies (RESTORE), Ghana and Côte d'Ivoire. The purpose of the RESTORE Activity is to demonstrate a scalable and regionally replicable model for community-led governance, natural resource management, and biodiversity conservation that aligns with regional and government priorities in cocoa production landscapes in the Guinean forests of Ghana and Côte d'Ivoire. The RESTORE Activity envisions that in partnership with multinational chocolate companies, farmer cooperatives, and local partners, it will establish the technical capacity, policy implementation approaches and economic incentives to bring cocoa producing families, governments and private sector together in a joint endeavor to secure improved livelihoods from cocoa farming, socially inclusive additional economic opportunities, increased tree cover and a scalable contribution to national and corporate emission reductions targets. The activity works at both farm and landscape scales, and seeks to support an inclusive landscape management governance body in selected target areas to drive resilient economic growth, with expanded opportunities for women and youth based on sustainable resource use.

The RESTORE Activity's specific objectives include increasing tree cover on and off farm in the cocoa production in four landscapes in the Guinean forest in Ghana and Côte d'Ivoire). At present, the conservation and biodiversity indicators for the off-farm forest restoration activity are anticipated to be amenable to evaluation through an impact evaluation. The data collection in sites with ongoing forest restoration and paired comparison sites without restoration efforts would provide essential data for understanding the effectiveness of forest restoration for improving environmental and health outcomes.

The planned RESTORE evaluation in Ghana and Côte d'Ivoire provides a different model for a zoonoses impact evaluation. The RESTORE evaluation is still in the design phase, and, thus the extent of the data collection, final research design, and associated cost implications are still to be determined. However, RESTORE provides an example of the potential for an impact evaluation of an intervention that is centered on improving conservation and biodiversity through forest restoration but without the public health component that is seen in the HIH study. Forest restoration could also benefit human health by improving water quality and changing reservoir host-human contacts and hazard.

In line with the discussion in the sections above, the RESTORE impact evaluation presents an opportunity for a human health and 'zoonosis add-on' through supplemental data collection for indicators of interest from a health and zoonoses standpoint. Although improving human health and reducing zoonotic spillover is not the primary objective of the RESTORE Activity, the impact evaluation presents an opportunity to capitalize on the potential for additional learning about health and environmental linkages in the context of forest restoration in tropical landscapes.

FINDINGS: Benefits of an implementation science approach for integrated conservation and health programming

The first takeaway from the growing body of studies included in this review is the feasibility of applying an implementation science approach to integrated conservation and health programs.

Conservation and biodiversity programs are overcoming the methodological concerns about applying counterfactual evaluation methods. Many methodological challenges about applying a counterfactual evaluation to conservation and biodiversity programs apply equally to tenure, governance, and other sectors that have managed to adapt impact evaluation designs to the realities of those sectors. For example, there is a common misconception that biodiversity conservation outcomes will take decades to observe, limiting their utility. In fact, at least in some cases, ecological outcomes (e.g., reduced annual adult mortality, avoided deforestation, and restoration) could be observed within 10 years as a long-term outcome of interest. Further, short-term outcomes at earlier steps along the causal pathway can be measured within one to two years after interventions are completed. Understanding whether people are responding and changing behavior along the lines of the program's theory of change, will help determine whether long-term impacts will reasonably be achieved.

A conservation and health impact evaluation can be interpreted as an extension of an impact evaluation of conservation, biodiversity, or wildlife demand reduction programs. An implementation science approach to understanding the impact of conservation and health, including zoonosis spillover risk, can be approached in the same way that one would approach designing a standard impact evaluation depending on the interventions/strategic approaches under investigation. A wildlife trafficking or demand reduction campaign could randomize an educational or behavioral component across communities. A reforestation program could use quasi-experimental methods to compare landscape level changes—and within the treatment area, the research team could randomize incentives associated with improving resource protection. A conservation and health evaluation does not imply a never before implemented/tested intervention or program. Instead, it implies standard evaluation approaches—but (1) with an expanded set of outcomes and the data sources to measure those outcomes, (2) the requirement for an interdisciplinary team, including a diverse team of researchers and policy professionals to integrate sociological, economic, and ecological drivers and (3) an expectation of a long-term research effort. These requirements do not differ from a well-designed conservation impact evaluation or longitudinal health study.

This extends to incorporating a study of 'zoonosis' within an implementation science approach and conservation and health impact evaluation which need not focus on determining the impact of a program on pandemic occurrence. Pandemics are rare events and impact evaluations assume statistical power to identify treatment impacts from an intervention—this would not be the case in something as rare as a global pandemic. Instead, including a study of zoonosis could be focused on measuring outcomes related to the risk factors for spillover—and ideally, it would also create a viable measure of spillover risk to understand the mechanisms by which viral pathogens emerge to better design interventions to more effectively mitigate future pandemics [31, 32]. When the focus is on risk factors for spillover versus pandemic occurrence, an impact evaluation that examines risk factors for zoonosis spillover becomes more manageable and can be approached, designed, and implemented in the same manner as other development evaluations.

For example, in areas where forest clearance is ongoing, there is an opportunity to demonstrate how varying the location and rate of clearance impacts viral zoonotic risk. A well-designed and comprehensive zoonosis impact evaluation requires all of the data collection needed for a conservation or biodiversity impact evaluation—with the addition of wildlife and health data sources to examine additional outcomes. Thus, in pursuing a zoonosis impact evaluation, you necessarily include a conservation or biodiversity evaluation; the data required for zoonosis can be seen as a supplement to a planned conservation or biodiversity evaluation. As part of a zoonosis impact evaluation, the research team will be conducting counterfactual research for a number of outcomes along the way, in addition to producing rigorous research to support knowledge about preventing zoonosis spillover. And, the opposite of the above argument also applies. If donors are pursuing programming or research with a focus on zoonoses, preventing emerging zoonoses in changing landscapes can provide simultaneous benefits to biodiversity and conservation sectors.

Thus, in addition to the feasibility of the approach, there are several key benefits associated with conservation and health implementation science. These benefits include the ability to measure impact to guide programming, better designed programs, and generating data to support broader research and knowledge building. A primary direct benefit of a conservation and health implementation science approach is to assess the impact of a program on achieving overlapping environmental and health outcomes. Longitudinal and counterfactual data is necessary to identify causal relationships between land-use conversion and health outcomes. Data collected in the context of an impact evaluation is based on an underlying research design (with a counterfactual) and often for a longitudinal time frame; this represents improved data sources to facilitate our understanding of the effectiveness of interventions to achieve conservation and health objectives and the mechanisms through which these work.

As noted above, there is very limited/no rigorous counterfactual evidence on many conservation and biodiversity interventions—and improving conservation and biodiversity as part of climate change initiatives are stated priorities for many donors. Thus, the pursuit of implementation science implies an expansion of counterfactual based studies of conservation, biodiversity, and/or wildlife demand reduction interventions. Many of these interventions link to policy priorities for climate change mitigation research and evaluation. Beyond the actual assessment of impact indicators, the very process of subjecting a program to an implementation science approach has numerous benefits. These benefits begin accruing early in the process and include a better designed program and better M&E. Implementation science adds value by strengthening a program's theory of change and connecting interventions to the evidence base during the feasibility stage. And baseline data can challenge assumptions and promote more effective, adaptive programming.

Beyond assessing the causal impact of programs, implementation science can shed light on a number of related research questions and provide data to help develop models to better quantify the linkages between ecosystem health and human health in changing landscapes. This would be a public service of improving general scientific knowledge. As described above, there is a significant knowledge gap across a number of research questions related to environment-climate-health linkages and especially for zoonotic spillover risk. In the context of zoonosis research, longitudinal and counterfactual data in focal regions would help identify key mechanisms affecting the emergence and establishment of zoonoses in human populations that can be applied beyond a particular study area [28]. The collection of overlapping environmental and health data sources will refine our understanding of how (and on what timescale) changes in host species richness, composition, and relative abundance impact disease prevalence [33].

Implementation science for conservation and health requires a comprehensive amount of data, including integrated economic, sociological, and ecological data. These data can feed into other ongoing mitigation and surveillance efforts on climate change and zoonosis that are occurring in or near the study area. This data can also feed into efforts to refine risk mapping and modelling, especially at local scales. Local risk maps have the potential to more accurately identify high risk locations for zoonotic spillover. Such an effort could complement and coordinate with next generation immunological surveillance and metagenomics [34]. Broader research can also enable targeted surveillance, educational activities and various governance, tenure, conservation, agricultural, and health interventions to prevent zoonoses. These risk maps could incorporate future land use planning and be used to mitigate risks posed by new infrastructure development.

FINDINGS: Best practices for an implementation science approach to integrated conservation and health

Based on the case studies, workshops, and recent technical reports reviewed to-date, we compile the following lessons learned and practical recommendations for implementing partners, donors, and other stakeholders interested in pursuing implementation science. Fig 1 summarizes these best practices.

Early MEL engagement and due diligence

An implementation science approach should be integrated into program design at project conceptualization. Independent third-party MEL experts should be embedded in design teams at the concept stage (activity start-up workshops) as well as throughout the design and procurement process to assist in the development of MEL plans and their implementation, as well as during inflection points (pause and reflect workshops) to adapt the program in response to evidence and data. Engagement at the project design stage can help manage expectations early on for implementing partners and other stakeholders regarding the time and resources needed for an effective learning approach.

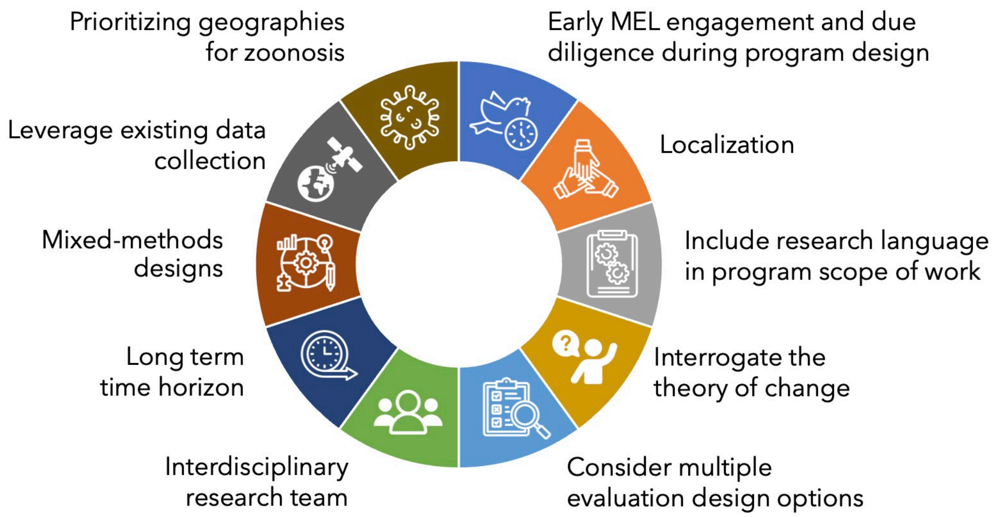

Fig 1. Best practices for integrated conservation and health implementation science.

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Evaluation design teams typically conduct a due diligence scoping trip to the program area well after a program is procured. In parallel with local qualitative data collection, the evaluation experts on the design team should conduct a literature review to reduce information asymmetries and constrain systematic human biases in program design. The findings from this due diligence, along with baseline data, then inform evaluation technical feasibility and adaptive management of the program. However, due diligence conducted earlier in the design process could inform not only technical feasibility but design of the program itself, saving the need to adapt after the fact. Indeed, during the initial stages of program procurement, many development interventions do not have detailed implementation details, as workplans are at a high level. But those more detailed, community-level implementation plans are necessary in order to identify the feasibility of various evaluation designs, as well as assess critical program design components, such as weaknesses in the theory of change and problems of co-location for integrated programs.

Include research language in the program scope of work

An effective way to promote change is to include appropriate language about the integration of a counterfactual approach into program implementation design and roll-out in the legal agreements for funding recipients. The program scope of work should clearly signal to offerors that a program may be subject to an evaluation and will be required to incorporate evaluation findings in work planning and pause-and-reflects to adapt the program as needed. To the extent possible, MEL specialists should work with donors on providing design specifics to facilitate rigorous research and evaluation as part of a program scope of work.

Not every program should be subjected to an evaluation. But for those programs for which it makes strategic sense to use evaluation methods, the evaluation team can help develop a MEL plan in partnership with the program implementers. In this way the underlying program benefits from evaluation findings through adaptive management and the evaluation team leverages M&E data collected by the program. To manage expectations, the solicitation should include as a technical requirement the evaluation-implementer partnership and the requirement of adaptive management in response to evaluation data.

Localization

There are significant information asymmetries between many policy makers and practitioners and local people and communities [35]. As early as possible in the design process local communities should be engaged to overcome information asymmetries and improve program design. This can be achieved through a co-production or co-creation process in collaboration with local beneficiaries. Due diligence should help build the interventions from the local context, based on listening sessions with the relevant beneficiaries. Additionally, there remains a tremendous need to improve the quality of the data captured through implementing partners' MEL systems. This requires setting up the necessary MEL protocols early in the program design process in collaboration with the research and evaluation team. In some cases, this might also require improving or supporting the technical skills for some implementing partners. It also requires contract and budget considerations, as local partners much have the logistical capacity and budget support that is necessary to produce high quality research and to consistently collect, manage, and share data. In the context of conservation, donors and evaluation teams are supporting local capacity and networks for a more sustainable approach to monitoring forest conditions and biophysical conditions, using free and accessible tools, such as Global Forest Watch tool. This supports monitoring throughout the lifetime of the activity.

Among donors, there is clear demand for more localization and distribution of more of the workshare for MEL to local firms. Traditionally, development evaluations are very extractive —firms or universities are hired to collect data—but analysis and reporting is completed almost entirely in the Global North, despite growing capacity in the Global South. However, MEL firms are pivoting to an approach that attempts to delegate parts of analysis, such as qualitative coding, descriptive statistics and contextual analysis, to local firms in low and middle income countries. One major challenge to this is the tension between the timeline for local capacity building and the quality expectations from donors. Some solutions could include relaxing some quality or "polishing" requirements for research products produced through localization, supporting timelines that enable additional time to train, review, conduct quality assurance checks, etc., or expand budgets to facilitate significant capacity building while holding to typical timelines and the production of 'polished' products.

Interrogate the theory of change

The project design team should refine the theory of change based on the qualitative data from due diligence as well as the literature review results. An implementation science approach adds value by strengthening a program's theory of change and connecting interventions to the evidence base during the feasibility stage. Baseline data is used to challenge assumptions and promote more effective, adaptive programming. The theory of change should be specific to the very local context of the program, including the interventions to be implemented. Part of the theory of change should cover how the treatment units are expected to respond to the resources offered by the program and thereby change their baseline perceptions, incentives, norms, or behaviors.

For the Zambia EKNA program, as part of adaptive management, the theory of change is continually revisited throughout activity design and implementation, including pause and reflect workshops that have participation from local community members and that were informed by baseline needs assessments with local communities. In the case of the Zambia EKNA evaluation, the research team worked closely with the implementing partner and USAID to evaluate the validity of the theory of change based on feedback and findings from the adaptive management process. This process revealed several weaknesses in the project design that the implementing partner corrected. For example, one issue encountered upon community mapping for baseline data collection was a lack of geographic co-location for certain conservation and health interventions that were expected to work in concert as part of an integrated program. The adaptation was to change the implementation plans to include co-location, greatly increasing the learning potential about the benefits of integrated programming. Another challenge that was uncovered during the field scoping and interviews with potential beneficiaries was the risk of unintended negative consequences of sustainable agriculture interventions leading to increased land clearing. The adaptation was the introduction of requirements to prohibit land clearing.

Consider multiple evaluation design options

The counterfactual-based evaluation approach to integrated conservation and health can take on multiple forms. The case studies highlight that quasi-experimental methods can be considered, in combination with a mix of impact and rigorous performance evaluation methods for a single program. In the case of landscape level projects (including many conservation and biodiversity projects), a whole of project RCT is obviously not feasible. However, specific activities or interventions within a project's strategic approach might be amenable to evaluation through an RCT. This could include many community or individual level activities, such as alternative livelihoods, behavioral change, or knowledge and awareness raising interventions designed to reduce wildlife trafficking.

Another form is to approach the human health component as an 'add-on' to explore as part of a planned evaluation of a conservation, biodiversity, or wildlife demand project. This is highlighted by the RESTORE case study where health is not part of the intervention package but the evaluation will explore a number of environmental and health linkages. In the case of projects seeking to understand the influence of land-use change on zoonotic spillover risk, this would not require fundamentally different programming—it can instead focus on collecting additional data sources and measuring additional data sources and outcomes for interventions related to land-use change or wildlife demand reduction. This means that—if there is sufficient funding—modules to measure health outcomes can be tacked onto a conservation or biodiversity intervention where we anticipate improvements to ecosystem health. This could also include adding on modules to measure zoonotic risk factors, in cases where we expect improvements in habitats for wildlife with a greater risk of zoonotic spillover.

Interdisciplinary research team

Interdisciplinary research teams are needed, including human health professionals, epidemiologists, wildlife disease ecologists, forest ecologists, veterinarians, and social scientists. This is an especially clear theme in many recent policy and synthesis papers on zoonoses. A long term counterfactual-based research program to identify causal relationships between land-use conversion and human health outcomes requires a diverse team of researchers and policy professionals to integrate sociological, economic, and ecological drivers.

Mixed-methods designs

As per best practices with other prospective large-scale research efforts, an implementation science approach to conservation and health programming should be designed as a mixed-method study. A mixed-method study integrates two or more research methods, usually drawing on both quantitative and qualitative data sources. Generally, mixed methods evaluations can provide a deeper understanding of why change is or is not occurring and capture a wider range of perspectives. Mixed-method evaluations may use multiple evaluation designs, for example incorporating both randomized controlled trial experiments and case studies. The qualitative strategy serves two primary purposes, 1) to add a social context within which to situate the statistics, and 2) to add depth to the overall study and the descriptive data. Quantitative data answers "what" and "whether" programs had an impact, whereas the qualitative data addresses critical questions about "how" and "why" interventions are having an effect.

Leverage innovative and existing data collection

Implementation science requires comprehensive data collection—and this will have significant cost implications for monitoring conservation, biodiversity, and health outcomes. To help mitigate costs, research and evaluation efforts should leverage existing data sources from implementing partners, along with the increasing availability of high-resolution satellite imagery. Moreover, citizen science—which involves the data collection and analysis by local communities and the general public—could provide an innovative source of cost-effective and higher frequency data. Building off of the advanced monitoring that many conservation partners are using, both implementing partners and research teams can consider leveraging on-going or planned monitoring as part of research efforts. This includes the utilization of camera traps and remote-sensed data (and machine learning applications to process and analyze the data), efforts at zoonotic monitoring and surveillance, increased field observation coupled with field-appropriate data collection technologies (e.g. SMART monitoring), and drone flyovers or aerial surveys (where possible). If these monitoring initiatives are increasingly a part of the standard conservation programming, then USAID can focus on funding similar monitoring in comparison sites to reduce research costs while increasing the rigor of the research.

Some new technologies and datasets require advanced skills for data processing and analysis. Increased collaboration with universities that have ecology labs with the skills and expertise to conduct and analyze biophysical data can provide a more cost-effective model. Universities are interested in high quality research and data collection opportunities, along with training and publication opportunities for students and faculty.

Prioritizing geographies for zoonosis

If the focus is on understanding and mitigating the risk of zoonotic spillover, it would make the most sense to target limited resources on areas with the highest risk of zoonotic spillover. Not all projects in all geographies make sense for applying an implementation approach to studying land-use conversion and zoonotic spillover. The heterogeneity in zoonotic host and pathogen distributions, as well as landscape conversion, creates opportunities for focusing resources and research at times and areas at highest risk.

Tropical areas are high priorities for biodiversity conservation: ecosystems in these regions support diverse species assemblages, often with endemic species found nowhere else. In some countries, these ecosystems face increasing deforestation pressure that destroys or degrades habitat and leads to biodiversity loss. Biodiversity in tropical forests harbors a high diversity of pathogens, including many viruses, bacteria, and parasites that can infect humans. The disturbance of these ecosystems, primarily through deforestation of tropical broadleaf forests, has been linked to zoonotic outbreaks.

In particular, one option is to focus on tropical areas within regions highlighted as high risk for zoonotic emergence: including, but not limited to, Central American tropical forests, coastal West Africa, the African Great Lakes Region, India, and eastern China [9]. These include landscapes with certain types of animals (e.g., bats, rodents, primates, ungulates, and certain carnivores) that are the source for the majority of zoonotic pathogens [34] In general, if the focus in on studying zoonotic spillover risk, priority geographies and interventions can be selected based on the following considerations:

- The probability or risk of animal-to-human pathogen emergence is concentrated in regions where key animal hosts (e.g. bats, primates, and rodents), pathogens, human behavior and ecological conditions align to increase likelihood of spillover.
- Sites can prioritize fragmented edge regions and areas undergoing intermediate levels of land conversion (e.g. degraded forests) given that the risk of land use-induced zoonotic spillover is particularly high in areas undergoing intermediate levels of land conversion.
- Areas where there is greater human community interaction with wild ecosystems. Close contact between wildlife and humans is a prerequisite for spillover. Interventions can consider a focus on areas where wildlife markets exist, communities engage in pervasive hunting, and/or forest/edge areas with frequent forest entry/activities within forests by community members.
- Areas that are already slated for a forest conservation or biodiversity impact evaluation and ideally also overlapping with a relevant health intervention (see the HIH case description above for an example).
- Areas where zoonosis surveillance and monitoring are already occurring. Given the cost and complexity of wildlife and health data collection efforts for zoonosis, donors can consider leveraging and/or supporting other projects where research is already underway.

FINDINGS: Challenges for conservation + health implementation science

There are a number of challenges to an implementation science approach to conservation and health. These include cultural or systemic problems related to project design and implementation, along with methodological and logistical challenges to high quality counterfactual based research in the conservation and health sectors. Many of the constraints originally highlighted by Ferraro over ten years ago [1, 22] remain.

Personal bias and counterproductive incentives

Personal bias and counterproductive incentives continue to pose major challenges. Adapting (or abandoning) a program that one designed and championed for years is hard. Traditionally, funders have emphasized 'success' rather than learning to improve program design and implementation. Funders as well as implementing partners have incentives to reduce risk in conservation programs. This risk mitigation incentive may in some circumstances result in weak MEL that consists of input and output indicators—but lacks the ability to effectively assess key outcomes. The current development context does not foster a culture of deliberate, rigorous evidence-based design that embraces uncertainty and mixed or null results. To avoid the misallocation of scarce resources in environment programming, it is absolutely critical to understand why a null result or negative impact is observed and adapt programs and policies accordingly.

Common misconceptions of counterfactual methods lead to under investment and use of implementation science. While there is always a commitment to "evidence", this does not translate to a commitment for rigorous evidence. Common misconceptions include a belief that implementation science is too costly, too slow to produce results, and will not lead to adaptive management on meaningful timescales given the scale of the conservation and climate crises.

Stronger evidence should be used to actively challenge design and promote real adaptation. However, once programs are designed—and processes set in place for implementation—there is path dependence and a resistance to altering course, even in the face of baseline or contextual data that challenges baseline assumptions. This is a significant challenge. One practical solution would be to include criteria for adaptive management as a performance indicator in contracts. This would prompt more attention from donors and implementing partners if positive performance is bench marked against active adaptations and course corrections following data collections and pause and reflect sessions. Instead of making adaptation seems like a 'failure', this would reframe the process as a positive—similarly incentivizing the active use of baseline data.

Methodological challenges

Research designs need to contend with long time lags between intervention and ecological response, complex spatial spillover effects (including from species movement), bundled interventions, and large spatial scales of environmental processes. Many standard threats to integrity would need to be considered, including the historical legacy of prior interventions, multiple bundled interventions, and selection bias. Certain interventions will be more likely to achieve the statistical power required for an impact evaluation.

Many of these challenges also apply to those encountered in governance and other sectors that have managed to adapt impact evaluation designs to the realities of those sectors. Conservation and the link between governance, conservation, and global health could follow suit. A long running program is not necessarily an impediment to a rigorous research agenda but rather an opportunity for rigorous research to add value.

Survey-based measures are appropriate for answering particular questions. In some cases, credible measures to uncover conservation and health linkages will need to move beyond self-reported behavioral indicators. For example, survey experiments, such as list and conjoint experiments, are increasingly used as an option to reduce bias for survey-based measures. The suitability of the method depends on the question being asked.

Ideal study designs will require human and wildlife biological sampling. Moreover, developing appropriate measures of the risk of zoonotic spillover is especially challenging. Appropriate measures require integration of multiple fields, including biology, virology, conservation science, anthropology, and more. Risk of emergence can be measured as spatio-temporal variation in (1) likelihood of human-wildlife contact (including contract with livestock or other bridge hosts), and (2) reservoir hazard or likelihood of infection given a contact (a function of disease prevalence and intensity and reservoir host abundance) [36, 37].

Better integration of M&E

Despite progress, the EKNA and RESTORE case studies highlight that there is room for improvement in terms of better integrating the M and E in M&E. Although these two projects were slated for an implementation science approach, the evaluations are barely mentioned in the MEL plan. Also, MEL plans are often focused only on the monitoring indicators they need to report to donors, rather than the full suite of rich data that is often collected, but which only the implementing partners are aware of and have access to. For example, in the EKNA Zambia case, an extensive household M&E survey was conducted that included a number of food security, socio-economic status, and human well-being indicators, however, only a fraction of those indicators are included in the MEL plan. Even in cases where indicators are being collected in addition to those required by the contract, there are challenges with integrating those into evaluation efforts. This could be driven by the extra time and resources required to report out on additional indicators—and incentives to focus on a more limited set of indicators for performance and accountability.

Cost and logistics

Although feasible, a comprehensive impact evaluation that includes all of the measures necessary to measure the linkages between environment and human health outcomes has cost implications and is logistically challenging. In the context of interventions to affect land-use change and forest condition, a comprehensive study will need to take into consideration measures for forest condition, biodiversity, wildlife health and human health. And, as discussed in previous sections, although there have been improvements in conservation and biodiversity evaluations over the past ten years, we still have a long way to go to implementing successful and comprehensive evaluations in these fields.

Priority outcomes (and not just intermediate or related outcomes) often take a longer time to manifest than in most other sectors for two reasons. First, biophysical changes often take longer themselves (not always, but in most theories of change). Second, the logic we are looking at in cross sectoral programs requires a link between human outcomes leading to biophysical (or vice versa) which then takes even longer to occur. This long time period reduces the benefits of evaluation and makes it more challenging both methodologically (maintaining controls) and logistically (time frames of donors).

Integrated conservation and health research will require a 10+ year time horizon, with data collected at key points versus the current 5-year timeline that coincides with the program cycle for many donor-funded projects. There are long time lags between interventions and ecological response. Primary biophysical outcomes of interest—including impacts on forest regrowth, biodiversity and impacts on human well-being from improved watershed health—will take a longer time period to materialize than the standard donor program cycle. In addition, long-term data on well-being, livelihoods, and health will answer important questions about the sustainability of program impacts.

Although some biodiversity and conservation outcomes will take decades to observe, behavioral change will be observable within one to two years after interventions and provides an indication of future program efficacy. For zoonosis, depending on the species, adult annual mortality and host viral dynamics (e.g., propensity to shed virus and viral load), might be observable within 10 years.

Long term research time frames have long been used for health and education programming and are increasingly being used by donors for sectors such as land and resource tenure and democracy and governance. Using publicly available geospatial datasets, which are increasingly available for a wider variety of outcomes and at a higher resolution, are one way to reduce costs and track forest condition outcomes across a 10-year period. As is currently becoming a standard/best practice for conservation impact evaluations, research designs in this field should propose project endline, as well as long-term follow-up data collection and analysis about five years after the end of the activity. Earlier rounds of data collection can examine key short-term behavioral outcomes in cases where enough time will not have passed to measure a meaningful change in more distal biophysical indicators. For example, if there is no evidence that people are changing threat reduction behavior at endline, it is unlikely that long-terms impacts would be achieved.

Research translation and data dissemination

Beyond counterfactual and rigorous research, we need more consideration of ways to improve research translation and dissemination. Improved research translation and dissemination will help promote broader use of the data generated through partnerships with universities, local researchers, and others.

The Zambia EKNA case study shows the use of baseline data to help inform current and future agricultural interventions. It also facilitated rich discussions about local health issues and potential solutions at pause and reflect sessions.

However, there are numerous cases of a lack of adaptive management taking place, including cases where baseline data is not examined or cases where the project fails to adjust programming despite findings from baseline data collection that indicate that the planned intervention does not address the source of the development challenge of interest. Using baseline data to challenge assumptions, perceived truths, or conventional wisdom cuts against the grain of systematic human biases. There must be dedicated time and space for stakeholders to interrogate the baseline data and the project's theory of change to determine which assumptions hold or not and where adaptive management may be needed.

Conclusion

The next 10 years represents a window of opportunity to improve the effectiveness of integrated conservation and health programs. A number of development initiatives are based on the assumption that human well-being and conservation/biophysical outcomes are linked and have the potential to impact each other positively. Generating rigorous evidence about these relationships and how human well-being and conservation/biophysical outcomes impact each other—and what conditions might contribute to the realization of positive outcomes—is of primary interest for the broader development sector. Determining the effectiveness of a conservation program requires a counterfactual approach paired with rigorous quantitative and qualitative data. Conservation interventions are best viewed as hypotheses or theories to be tested rather than good ideas to be applied broadly.

The biophysical outcomes from 'natural climate solutions' and 'nature-based solutions', such as forest restoration and avoiding deforestation, [38, 39] will only occur if effective interventions are applied to address the underlying human drivers of deforestation and low rates of restoration. However, the lack of robust impact evaluations makes it difficult to draw insights to inform future efforts. A number of studies over the past decade have emphasized the need for more rigorous experimental and quasi-experimental impact evaluations related to conservation outcomes [2, 40].

There is a small but growing body of studies (both impact and performance evaluation) seeking to use an implementation science approach to learn about the effectiveness of integrated conservation and health programming, including those seeking to understand interventions that are best suited to mitigate zoonoses spillover risk. Implementation science requires evaluation through a counterfactual lens, yet, it also requires better designed programs, with more attention to substance and context at the design stage. More rigorous evaluations for integrated conservation programs are needed to learn which approaches are most effective.

Consistent with an implementation science approach, a project's interventions should be designed in part based on a review of extensive high-quality existing evidence, along with qualitative data collection through participatory rural appraisal. Projects should be designed based on sound evidence, with resources allocated towards overcoming information asymmetries with project participants, learning focused on impact rather than merely inputs and outputs, and with a clear use case for adaptive management.

Implementation science will improve the evidence that is being fed into the program design process. In many instances, initiatives have a structured and well-thought-out design process, but rely on limited evidence and/or evidence with a high risk of bias. By producing better evidence that can be fed into the design process—we improve the policy recommendations and program guidance for decision-makers. However, this does not go far enough, it is not just about producing high quality learning about a program's impact—to really improve design and impact, we need to ensure a better design process, including the integration of evaluation and MEL learning and baseline data collection, into routine pause and reflect sessions.

Thus, in addition to answering important learning questions about impacts of integrated, cross-sectoral programming, higher quality MEL data and important contextual information can be used to promote more effective, adaptive programming. The implementation science process can help strengthen the theory of change and promote a deeper understanding of where to focus on intervention integration and quality. Project funders should use the learnings to scale the more effective interventions.

Combining forest, health, household, and community-level outcomes is a novel and important contribution to the evidence base. Barriers exist, but many can be overcome by embracing collaboration, complexity, and flexibility.

Supporting information

S1 File.
(BIB)

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