Integrated Natural Resource Management (INRM)

HEARTH Monitoring and Evaluation Toolkit:

Biophysical

APRIL 2022

Integrated Natural Resource Management (INRM)

Sound management of natural resources is central to long-term development and resilience. Faced with an urgent need to reduce environmental degradation while improving human well-being, solutions that effectively integrate investments in natural resource management with economic and social development are increasingly urgent. INRM promotes integrated programming across environment and non-environment sectors and across the Program Cycle. INRM supports USAID to amplify program impacts, strengthen gender equality and social inclusion, and identify best practices for integration.

For more information:
https://land-links.org/project/integrated-natural-resource-management-inrm-activity/

Contents

Acronyms

AFOLU	Agriculture, Forestry, and other Land Use
DNA	Deoxyribonucleic Acid
EBV	Essential Biodiversity Variables
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
GCC	Global Climate Change
GFW	Global Forest Watch
GhG	Greenhouse Gasses
GIS	Geographic Information System
GLAD	Global Land Analysis and Discovery
GPS	Global Positioning System
HEARTH	Health, Ecosystems, and Agriculture for Resilient Thriving Societies
INRM	Integrated Natural Resource Management
IP	Implementing Partner
LandPKS	Land Potential Knowledge System
LCC	Land Capacity Classification
MERL	Monitoring, Evaluation, Research, and Learning
PIRS	Performance Indicator Reference Sheet
SDG	Sustainable Development Goals
STARR II	Strengthening Tenure and Resource Rights II
USAID	United States Agency for International Development
USD	United States Dollar
USG	United States Government
WHO	World Health Organization

Overview

Together, Health, Ecosystems, and Agriculture for Resilient Thriving Societies (HEARTH) and INRM have created the HEARTH Monitoring and Evaluation Toolkit, a suite of indicators and guidance that will help United States Agency for International Development (USAID) Missions and implementing partners (IPs) monitor progress and aggregate common metrics to build the evidence base around the effectiveness of integrated strategic approaches. This document is an individual module from the toolkit, presented separately to facilitate use by individual HEARTH activities. Before using this module, we recommend first accessing the full toolkit and reviewing the list of sectors covered by each module, and determining which are most relevant for your activity:
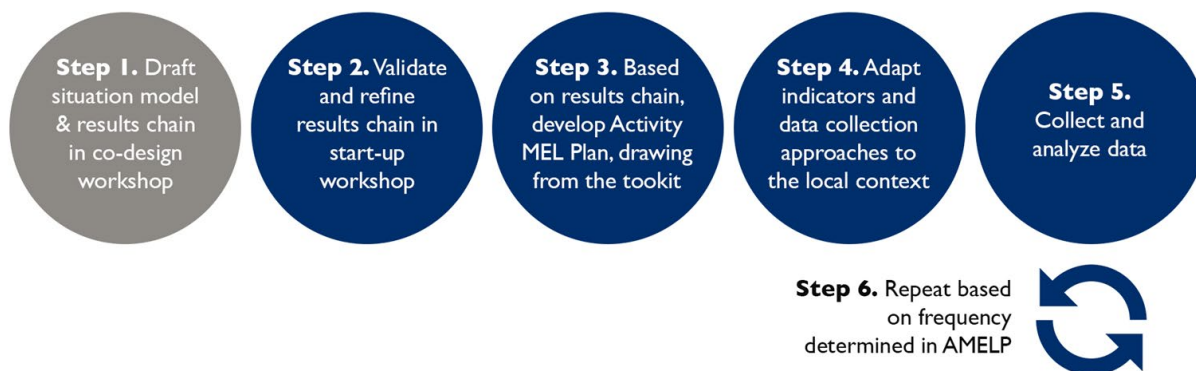
Access Full Toolkit on Biodiversity Links Here.

How To Use This Toolkit

This toolkit presents a **menu of options** for outcomes and recommended indicators across the HEARTH activities. Before using this toolkit, activities should have developed a robust theory of change – through first drafting their situation model and results chains during the co-design workshops, many of which have been completed already, and then validating and refining those results chains during start-up workshops.

Based on the activity theory of change, HEARTHs should develop their Activity Monitoring, Evaluation, Research, and Learning (MERL) Plan, which should draw directly from the toolkit. It is not expected that all outcomes or indicators will be relevant for all activities, but that activities should select those in line with their results chains and activity theory of change. Additionally, there might be activity-specific outcomes not included in this toolkit because they were not generally applicable across the HEARTH portfolio, and Missions and IPs should therefore include additional indicators in their MERL plans, as relevant.

When developing activity MERL plans, the indicators in this toolkit are intended to be used both to **standardize reporting for monitoring data, as well as a basis for evaluation data collection**. While monitoring trends in these indicators over time may be important for some activities, USAID anticipates that Missions and IPs will also identify important questions about the causal impact of their activities during the start-up activities, best answered using evaluation approaches. Which indicators will be part of monitoring systems, and which will be used to answer evaluation questions, will affect how the toolkit is operationalized. In addition, it is expected that MERL plans will likely include **qualitative data sources**, important to further explaining monitoring and evaluation results and exploring learning questions in more depth, in addition to the quantitative data collected using the approaches from the toolkit.

Step 1. Draft situation model & results chain in co-design workshop

Step 2. Validate and refine results chain in start-up workshop

Step 3. Based on results chain, develop Activity MEL Plan, drawing from the tookit

Step 4. Adapt indicators and data collection approaches to the local context

Step 5. Collect and analyze data

Step 6. Repeat based on frequency determined in AMELP

Outcomes and Indicators for Biophysical

Table 1: *Overview of Outcomes and Recommended Indicators for the Biophysical Sector.*

Outcomes	HEARTH Portfolio Indicators
Population status of target species maintained or improved	• Change in presence/absence of target species(s) across target area over a set time interval • Change in abundance of target species(s) across target area over a set time interval
Improved or maintained condition of natural ecosystems	• Change in presence/absence of target species(s) across target area over a set time interval* • Change in abundance of target species(s) across target area over a set time interval* • Change in total area of one or more classes of vegetation, e.g., forest class, across the defined spatial unit(s) • Change in Land Capability Classification (LCC) *Target areas selected here should reflect areas that indicate change to ecosystem condition, e.g., areas important for wildlife movement.*
Reduce loss of habitats for biodiversity	• Change in total area of one or more classes of vegetation, e.g., forest class, across the defined spatial unit(s)

Outcomes	HEARTH Portfolio Indicators
Pollution of water sources reduced	• Turbidity of natural aquatic environments (surface, freshwater sources) near agricultural activity sites • pH of natural aquatic environments (surface, freshwater sources) near agricultural activity sites • Presence / absence of E. coli bacteria in drinking water sources (freshwater, surface) around agricultural activities sites • Change in concentration of nitrites and nitrates in natural aquatic environments (surface, freshwater sources) near agricultural activity sites
Reduced greenhouse gas (GhG) emissions from focal enterprise activities	• GhG emissions, estimated in metric tons of CO2 equivalent, reduce sequestered, or avoided in full or in part by USG assistance • Number of hectares under improved management expected to reduce greenhouse gas emissions as a result of USG assistance

Biophysical

Overview

HEARTH activities engage private sector partners to co-design activities that conserve high-biodiversity landscapes and improve the lives of local communities. Measuring progress towards achieving targets for biodiversity, ecosystems, and environments across HEARTH projects requires robust design of indicators and approaches grounded in standards of practice and best available science. Measuring biophysical indicators is a cross-sectoral activity as interventions with explicit biophysical objectives as well as those acting on other parts of the system (e.g., human well-being) will have biophysical impacts. This is particularly salient given the alignment of HEARTH projects global biodiversity and climate change frameworks such as the Sustainable Development Goals[1], the Post-2020 Biodiversity Framework[2] (to be finalized at the 15th Conference of Parties of the Convention on Biological Diversity), as well as Nationally Determined Contributions under the Paris Agreement[3]. This module is intended to provide guidance for measuring a range of relevant indicators across these critical areas.

Framework for Biophysical Outcomes

In this module, biotic (e.g., biodiversity, communities, ecosystems) and abiotic (e.g., climate, water, air) components are referred to collectively as "biophysical" outcomes. Biophysical outcomes can be conceptualized as both immediate outputs, intermediate, and ultimate outcomes from an intervention. Intermediate biophysical outcomes emerge as a product of immediate changes from the intervention (e.g., planting trees), which can then have downstream impacts on ecosystem services and human well-being. Biophysical outcomes can also emerge as an eventual change (or a *downstream outcome)* from more immediate changes to human activity (e.g., change in agricultural practices, or decreased harvest volume).

Global efforts have been undertaken to standardize the collection and framing of these metrics to ensure comparability of data. The Essential Biodiversity Variables (EBV) framework[4] was used to develop categories of indicators, which defines classes of derived measurements required to 'study, report, and manage biodiversity, focusing on status and trend in elements of biodiversity that aim to provide a connection between primary observations and high-level indicators of biodiversity. The EBV is the standard framework for tracking biodiversity and ecosystem metrics at a global level. Using this framework aligns HEARTH metrics to global tracking and monitoring standards. The EBVs aim to provide information to populate indicators to assess progress toward global targets for biodiversity and sustainability. The existing 6 EBV classes were

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[1] https://sdgs.un.org/goals

[2] https://www.cbd.int/doc/c/abb5/591f/2e46096d3f0330b08ce87a45/wg2020-03-03-en.pdf

[3] https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs/nationally-de termined-contributions-ndcs

[4] GEO BON. (n.d.). What are Ebvs? Group on Earth Observations. Retrieved from https://geobon.org/ebvs/what-are-ebvs/.

consolidated into 3 broad EBV classes—species, communities, and ecosystems—given their relevance for HEARTH. The framework was further customized to capture biophysical aspects, i.e., climate and the abiotic environment (**Table 2**). This framework is used to ground the indicators and measurement approaches outlined in this module.

Table 2: Modified EBV Framework of Variables as a Guide for Indicator Development

Class	Variables
Species	Diversity (intraspecific), distribution, abundance, migration/dispersal/gene flow, morphology/traits of a species
Communities	Diversity (interspecific, trophic, functional), species relationships and interactions within a community (a group of species)
Ecosystems	Productivity, extent, size, cover of ecosystems, including habitat for species of conservation interest; biophysical processes (e.g., soil, water, nutrients, structure); change in forest cover extent
Environment + Climate	Air quality and emissions, hydrology and flows, temperature and precipitation, chemical composition, weather, fire, shrink/swell of soils, change in greenhouse gas emissions

Data Standardization, Structure, And Management

In biodiversity science and ecology, there are significant and focused international efforts for standardizing data collection to ensure data quality and maximize interoperability to facilitate robust global monitoring and tracking towards global biodiversity and sustainability targets (e.g., Aichi Targets, Sustainable Development Goals, Paris Climate Accords).[5,6] The impetus behind these global efforts for data standardization (e.g., Group on Earth Observations Biodiversity Observation Network, Global Biodiversity Information Facility, Ocean Biogeographic Information System, Organization for International Standardization) is to ensure data quality, transparency, interoperability, and reusability. As part of this module, guidance is provided on site-specific data collection and management to maximize reusability and interoperability so that data can be used to inform future projects and link to global databases.

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[5] Navarro, L. M., Fernández, N., Guerra, C., Guralnick, R., Kissling, W. D., Londoño, M. C., Muller-Karger, F., Turak, E., Balvanera, P., Costello, M. J., Delavaud, A., El Serafy, G. Y., Ferrier, S., Geijzendorffer, I., Geller, G. N., Jetz, W., Kim, E.-S., Kim, H. J., Martin, C. S., … Pereira, H. M. (2017). Monitoring Biodiversity Change Through Effective Global Coordination. Current Opinion in Environmental Sustainability, 29, 158–169. https://doi.org/10.1016/j.cosust.2018.02.005.

[6] Tittensor, D.P., Walpole, M., Hill, S.L.L., et al. (2014). Amid-term analysis of progress toward international biodiversity targets. Science,346, 241-244.

Recommended Outcomes and Indicators

As the potential suite of biophysical indicators is quite broad, their applicability and utility will depend on the scope and scale of individual HEARTH projects. As HEARTH supports a diverse set of projects in several countries and sectors, and because all of USAID's Standard Indicators are required as applicable, relevant indicators for monitoring progress for HEARTH projects should be chosen in a bespoke fashion. Lastly, the indicators listed are primary indicators that can then be used to conduct secondary analyses to investigate different learning questions.

This module covers five outcomes of interest related to the four EBV classes. Outcome 1 is improvement of population status of target species (EBV Class Species and Communities). Outcomes 2 and 3 are related to EBV Classes Communities and Ecosystems as they cover improvements to ecosystems for biodiversity. Outcomes 4 and 5 are related to EBV Class Environment, covering improvements to water quality and climate change mitigation.

General Note: Target area should be defined by each project as a set of clear, contiguous spatial units.

Outcome	Description	Recommended Indicator
Population status of target species maintained or improved	Recording presence/absence allows for comparison across areas with an ecosystem and across ecosystems if observations are made using regular spatial and temporal intervals. HEARTH activities aiming to target biodiversity outcomes should track changes to species presence/absence at the minimum across their target area. Choice of species should be guided by the evaluation questions and the ecology of the site. Proper baseline data should be collected as a comparator and if possible, data from other areas that can serve as an appropriate counterfactual. Multiple temporal and spatial sampling sites are suggested for rigor and controlling for influence of contextual variables and observation heterogeneity. In a five year program cycle, it may not always be possible to observe meaningful change in this indicator. See the discussion on *Species Occurrence and Abundance* to determine when this indicator is most appropriate.	**Indicator:** Change in presence/absence of target species(s) across target area over a set time interval **Additional Guidance:** Species Monitoring
	Recording abundance of species allows for calculation of diversity indices such as species richness and species evenness.	**Indicator:** Change in abundance of target species(s) across target

Outcome	Description	Recommended Indicator
	HEARTH activities aiming to target biodiversity outcomes can track changes to species abundance across spatial units in their target area. Choice of species should be guided by the evaluation questions and the ecology of the site. Proper baseline data should be collected as a comparator and if possible, data from other areas that can serve as an appropriate counterfactual. Multiple temporal and spatial sampling sites are suggested for rigor and controlling for influence of contextual variables and observation heterogeneity.	area over a set time interval **Additional Guidance:** Species Monitoring
Improved or maintained condition of natural ecosystems	Recording presence/absence allows for comparison across areas with an ecosystem and across ecosystems if observations are made using regular spatial and temporal intervals. In this case, specific indicator species should be selected that signal change to desired ecosystem conditions. See more details above.	**Indicator:** Change in presence/absence of target species(s) across target area over a set time interval **Additional Guidance:** Species Monitoring
	This indicator should measure the change in number of individuals (abundance) OR presence/absence of target species(s) observed within defined areas/spatial units that are important for wildlife movement (e.g., migration corridor, game trail, breeding or other seasonal aggregation area). The important distinction between the other species indicators is the focus on areas important for movement compared to any target landscape. If the indicator focuses on presence/absence of multiple species, the indicator should be presented as a total species count.	**Indicator:** Change in abundance of target species(s) observed within defined areas/spatial units (target area) over set time interval OR Change in presence/absence of target species(s) observed within defined areas/spatial units (target area) over a set time interval **Additional Guidance:** Species Monitoring

Outcome	Description	Recommended Indicator
	Maintaining (or increasing) the total extent of natural ecosystems across the intervention area is a frequent outcome in HEARTH and other programs with an environmental component. This guidance focuses on forests because (1) they are a biodiversity focal interest in many HEARTHs and (2) there is a spatially explicit and globally coherent dataset that allows for data aggregation across geographies. HEARTHs interested in other ecosystem types can adapt this guidance and use other data sources to estimate the extent of these ecosystems over time. HEARTH activities located within forested landscapes and that include an intermediate result or result related to habitat degradation, habitat destruction, or deforestation require a metric of forest cover loss. The Global Land Analysis and Discovery (GLAD) Global Forest Change dataset provides a globally consistent, periodically updated, and open access database of forest cover loss that eliminates the need for individual HEARTHs carrying out analyses based on raw satellite images. It should be noted however that forest loss data are not equal to deforestation, but can be used as a proxy.	**Indicator:** Change in total area of one or more classes of vegetation, e.g., forest class, across the defined spatial unit(s) **Additional Guidance:** Geospatial Data
	Land potential is the long-term potential of the land to sustainably generate ecosystem services, which fall into four general categories: (1) provisioning, such as the production of food and water; (2) regulating, such as the control of climate and disease; (3) supporting, such as nutrient cycles and crop pollination; and (4) cultural, such as spiritual and recreational benefits. Understanding land potential is important both for human uses, such as agriculture and livestock keeping, but also for conserving biodiversity and natural resources.[7] The Land Capability Classification (LCC) is a land evaluation ranking that groups soils based on their potential for agriculture and other uses and is useful for HEARTHs that include a focus	**Indicator:** Change in LCC **Additional Guidance:** Soil Quality

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[7] Feed The Future. (2018). Feed the Future Survey Implementation Document Agriculture Interviewer's Manual Zone of Influence Survey. Section 7.2 "Land potential assessment overview." Retrieved from https://docs.google.com/document/d/1FpvRuoCH2V3UGPnnyRtFNDR3k7VtTwT4/edit#.

Outcome	Description	Recommended Indicator
	on improving sustainable agriculture or the agricultural productivity of land.[8]	
Reduce loss of habitats for biodiversity	Maintaining (or increasing) the total extent of natural ecosystems across the intervention area is a frequent outcome in HEARTH and other programs with an environmental component. This guidance focuses on forests because (1) they are a biodiversity focal interest in many HEARTHs and (2) there is a spatially explicit and globally coherent dataset that allows for data aggregation across geographies. HEARTHs interested in other ecosystem types can adapt this guidance and use other data sources to estimate the extent of these ecosystems over time. HEARTH activities located within forested landscapes and that include an intermediate result or result related to habitat degradation, habitat destruction, or deforestation require a metric of forest cover loss. The GLAD Global Forest Change dataset provides a globally consistent, periodically updated, and open access database of forest cover loss that eliminates the need for individual HEARTHs carrying out analyses based on raw satellite images. It should be noted however that forest loss data are not equal to deforestation, but can be used as a proxy.	**Indicator:** Change in total area of one or more classes of vegetation, e.g., forest class, across the defined spatial unit(s) **Additional Guidance:** Geospatial Data
Pollution of water sources reduced	A change in the turbidity of natural aquatic environments is one of the most immediately apparent indicators of soil erosion, for example, when runoff from heavy rain causes nearby natural waters to become muddy or appear dirty. Turbidity is an important aspect of water quality for several reasons. Soil particles suspended in water are unpleasant to drink, and they also provide attachment sites for pathogenic microorganisms to proliferate. Further, when water turbidity increases, i.e., light transmits less readily through the water, it can reduce the growth rates of aquatic plants and animals, make them more vulnerable to disease, and reduce overall ecological productivity.	**Indicator:** Turbidity of natural aquatic environments (surface, freshwater sources) near agricultural activity sites **Additional Guidance:** Water Quality Data

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[8] LandPKS Knowledge Hub. What is Land Capability Classifcation? Retrieved from https://landpotential.org/knowledge/what-is-land-capability-classification/

Outcome	Description	Recommended Indicator
	A fundamental aspect of water chemistry, pH strongly influences plant and animal growth and reproduction in natural aquatic environments. Minerals and other elements of soil that may erode from agricultural sites and be transported to natural aquatic environments can significantly influence the water's pH.	**Indicator:** pH of natural aquatic environments (surface, freshwater sources) near agricultural activity sites **Additional Guidance:** Water Quality Data
	Most strains of *E. coli* are harmless and live in the intestines of people and warm-blooded animals, but some strains can cause illness. The presence of *E. coli* in drinking water usually indicates recent fecal contamination, which means there is a good chance that pathogens are present. It is considered unsafe to drink water that contains any amount of *E. coli*. According to the World Health Organization (WHO), *E. coli* is considered the most suitable indicator of fecal contamination in drinking water.[9]	**Indicator:** Presence / absence of *E. coli* bacteria in drinking water sources (freshwater, surface) around agricultural activities sites **Additional Guidance:** Water Quality Data
	Nitrate is a common constituent of most commercial fertilizers, and it also is commonly produced by chemical oxidation of ammonia (NH3) found in organic fertilizers such as animal waste. Nitrate readily dissolves in water and can reach high levels, sometimes an order of magnitude greater than background levels, near agricultural activity sites that are treated with fertilizer. Chemical oxidation of ammonia also is a major source of nitrite in natural aquatic environments, and use of organic fertilizers such as animal waste may increase nitrite concentrations in aquatic environments near agricultural activity sites. Because nitrite in soil and water may further oxidize to nitrate when oxygen is available, it is recommended to test water samples for both nitrite and nitrate.	**Indicator:** Change in concentration of nitrites and nitrates in natural aquatic environments (surface, freshwater sources) near agricultural activity sites **Additional Guidance:** Water Quality Data

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[9] Guidelines for drinking-water quality, second edition, addendum to volume 1: Recommendations. (1999). Chemistry International -- Newsmagazine for IUPAC, 21(2). https://doi.org/10.1515/ci.1999.21.2.49a.

Outcome	Description	Recommended Indicator
Reduced greenhouse gas (GhG) emissions from focal enterprise activities	Reducing, sequestering, or avoiding GhG emissions will slow the rate of climate change and reduce climate change impacts. Reducing GhG emissions can also have strong ancillary benefits for air and water pollution, energy security, health, and gender issues.	**Indicator:** GhG emissions, estimated in metric tons of CO2 equivalent, reduce sequestered, or avoided in full or in part by United States Government (USG) assistance (Global Climate Change (GCC) Standard Indicator - EG 13-6)[10] **Additional Guidance:** [Climate Change]()
	Improved land management is essential for reducing emissions from the land use sector. A spatial indicator is useful for determining the scale and potential impact of sustainable landscapes interventions.	**Indicator:** Number of hectares under improved management expected to reduce greenhouse gas emissions as a result of USG assistance (GCC Standard Indicator - EG 13-8)[11] **Additional Guidance:** [Climate Change]()

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[10] USAID. (2020). 2020 GCC Standard Indicator Handbook: Definition Sheets. Climate Links. Section 13-6. Retrieved from https://www.climatelinks.org/sites/default/files/asset/document/2020_USAID_GCC-Indicator-Handbook-August-2020-Update.pdf.

[11] USAID. (2020). 2020 GCC Standard Indicator Handbook: Definition Sheets. Climate Links. Section 13-8. Retrieved from https://www.climatelinks.org/sites/default/files/asset/document/2020_USAID_GCC-Indicator-Handbook-August-2020-Update.pdf.

Biophysical Measurement Guidance

The following section offers a guidance series for selection, design, and analysis of biophysical outcomes and indicators, including the following guidance:

- Identifying target species for monitoring for biodiversity and ecosystem health
- Accessing and using existing geospatial data for monitoring terrestrial landscape extent and condition
- Collecting and assessing water quality data for agricultural activities
- Collecting and assessing soil quality in agriculture and agroforestry projects using LandPKS
- Guidance on using and assessing Global Climate Change (GCC) Standard Indicators for climate change mitigation

Important factors to consider when choosing site-specific biophysical monitoring indicators and units

There are important factors to consider when choosing which indicators and methods for collection are best suited to each HEARTH's needs. In particular, the scale at which activities are able to observe and detect biophysical change will depend on two factors:

1) The spatial and temporal scale at which the intervention is likely to have impact and at which change is hypothesized to occur; and
2) The spatial and temporal sampling strategy used to monitor change

This is important to keep in mind for determining the appropriate spatial unit(s) and frequency for monitoring. For example, if a project intends to restore habitat important for species movement (e.g., connectivity), a monitoring plan should consider how far the species of interest can move, what areas they are likely to move in, and how frequent movement will occur to identify the size of spatial areas to monitor for species occurrence and how frequently data collection should occur. Scale is also important to consider in terms of when change is expected to occur. For example, if a project intends to monitor forest recovery, a monitoring plan should determine which species are expected to emerge at what stages of forest succession. In tropical rainforests, pioneer species, which are typically fast growing with a shorter generation time, may emerge first, followed by slower growing plants which grow in between the pioneer species. Projects should consider what changes they are likely to observe (e.g., in this example, which species are likely to emerge) to choose appropriate indicators and sampling design within the timeline of their monitoring period.

Identifying Target Species for Monitoring Biodiversity and Ecosystem Health

Background

This guidance illustrates key points for species monitoring in support of HEARTH MERL objectives. Optimal planning and implementation of species monitoring is a widely researched area; thus, this guidance intends to be a primer for core elements for species monitoring and provides a reference list that can be explored for further information.

Many HEARTH activities include outcomes related to improvements or maintenance of biodiversity and overall ecosystem health and provision of ecosystem services. Changes in the abundance and diversity of species have critical impacts on all aspects of biodiversity and ecosystem functioning including community and food web stability and the delivery of ecosystem services.[12] Thus, monitoring the dynamics, distribution, and diversity of different types of species can help answer questions such as:

- Is the intervention associated with changes to species occurrence, distribution, and/or abundance?
- Is the intervention associated with improvements to habitat quality and extent?
- Is the intervention associated with improvements to habitat connectivity for target species?

Monitoring changes to species occurrence and abundance can be useful to make inferences about population and species viability, habitat quality, and overall ecosystem health; however, they *should not* be used in isolation to understand impacts in these areas. Measuring any of these data types will require clear and robust sampling design that is grounded in species and population-specific knowledge (e.g., range, population structure, behavior, ecology, etc.). Data from species monitoring should be integrated into broader assessments that bring together data across relevant components and scales of an ecosystem needed to understand ecosystem stability and resilience. Analytical techniques for evaluating species occurrence data and calculating trends are not within the scope of this guidance.

Broad Overview of Methods

Choosing the type of method to monitor species depends on the time and resources available, appropriate spatial scale for sampling, and types of species being monitored. Below is a summary of types of methods commonly employed along with brief details on resource considerations (**Table 3**).

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[12] Jetz, W., McGeoch, MA., Guralnick, R., Ferrier, S., Beck, J., Costello, MJ., Fernandez, M., Geller, G.N., Keil, P., Merow, C., Meyer, C., Muller-Karger, FE., Pereira, HM., Regan, EC., Schmeller, DS., Turak, E. "Essential biodiversity variables for mapping and monitoring species populations." Nature Ecology & Evolution 3 no. 4 (2019): 539-551.

Table 3: *Brief Summary of Types of Tools and Methods Used to Monitor Species*

Method	Tools required	Considerations for monitoring
Observations	Species identification guides, binoculars, surveying equipment (depending on species and ecosystem), data collection devices (notepads, tablets, phones, etc.)	Simple way to track species presence/absence and/or abundance. Can be collected by experts or non-experts (e.g., citizen scientists, community, or government patrols, etc.). Collection by non-experts will likely require the use of spot-checks or technology-based tools to ensure accurate species identification. Useful in that it is an opportunistic method but not as replicable.
Visual transects	Species identification guides, binoculars, surveying equipment (depending on species and ecosystem), data collection devices (notepads, tablets, phones, etc.)	Can be resource-intensive depending on the target species (e.g., time spent making observations, number of transects), but useful in that it provides a controlled spatial and temporal scale of observation. Requires skilled personnel who can accurately identify multiple species.
Tools to remotely track movements	Different types of technical options for tracking movements of wildlife across ecosystems. Genetic and chemical tagging can be used to determine evolutionary significant connectivity (e.g., dispersal, gene flow) across sites in an ecosystem. Physical tagging (e.g., radio telemetry, banding or Global Positioning System (GPS) collars), radar monitoring	Can be resource-intensive and often difficult to implement over large spatial scales. Different types of data are useful to inform different types of decisions. For example, physical tracking data from satellite tags and radio collars (such as that used in the Tagging of Pacific Predators program)[13] can be used to identify wildlife movement patterns across seasons and key habitat areas for protection and monitoring (e.g., spawning sites). Geochemical and physical tagging can be used to identify individuals returning to habitats over multiple seasons/years or other types of movements. Requires methodological expertise and is best conducted in partnership with research institutions. Genetic tools for estimating genetic connectivity can be used as well, but requires methodological expertise and laboratory access and sufficient funding for

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[13] Tagging of Pacific Predators (TOPP). Census of Marine Life. (n.d.). Retrieved from http://www.coml.org/projects/tagging-pacific-predators-topp.html#:~:text=The%20Tagging%20of%20Pacific%20Predators,animals%20in%20the%20North%20Pacific.

Method	Tools required	Considerations for monitoring
		sequencing. Choice of genetic markers depends on the question.
Environmental Deoxyribonucleic Acid (DNA)	Reagents for preserving genetic material (e.g., RNAlater, ethanol, etc.), equipment for preserving DNA (e.g., dry shippers, storage vials, other types of temperature control), molecular laboratory equipment, data storage, computing software for analyzing data	Environmental DNA (eDNA) can be useful for tracking presence/absence of a wide range of species with little disturbance to habitat. eDNA is a relatively new tool for species monitoring, but has been used successfully in many different contexts, including soils, marine, and freshwater ecosystems. Depending on the physical environment, eDNA may be present from species that have recently occurred in the immediate area (few minutes to few hours). It is relatively cheap and can be replicated across scale. Limitations to eDNA is that they are not well tested and may not be appropriate to be used to monitor species abundance (presence/absence only). They also may likely miss rare occurrences of species and will only capture species that are permanently resident to area or occur in high numbers. Like the genetic tools listed above, eDNA requires access and funding to laboratory resources, analysis, and expertise for analyzing data.
Camera trapping	Camera traps, data storage devices, computing software for analyzing data	Camera traps can be useful for tracking presence/absence of a wide range of species with little disturbance to habitat. However, camera trapping can be resource intensive depending on the objectives (e.g., how many traps, what types of traps).
DNA barcoding	Reagents for preserving genetic material (e.g., RNAlater, ethanol, etc.), equipment for preserving DNA (e.g., dry shippers, storage vials, other types of temperature control), molecular laboratory equipment, data storage,	DNA barcoding can be useful for tracking species abundance and presence/absence, particularly when visual identification of species is either difficult or not feasible. Barcoding uses a conserved sequence of DNA that is present in all species. Each species has a unique DNA fingerprint or barcode that differentiates them from other species. DNA barcoding is particularly useful in monitoring contexts where whole bodies are not present (e.g., meat and fish markets, parts of plants) or where cryptic species may be

Method	Tools required	Considerations for monitoring
	computing software for analyzing data	abundant (genetically distinct species that are not easily distinguished visually). Like genetic tools listed above, eDNA requires access and funding to laboratory resources and analysis and expertise for analyzing data.
Remote sensing	Access to satellite imagery, computing software for analyzing data.	Remote sensing can be a useful tool when aiming to track highly migratory and large species (that can be readily identified by satellite imagery). Existing efforts to track large migratory animals (e.g., elephants) can be leveraged for datasets. Similar types of programs like those used for camera trap data, exist to count individuals from satellite imagery. Analysis often requires technical support from Geographic Information System (GIS) and bioinformatic specialists.
Collection and synthesis of existing data	Species occurrence databases including historical data, expert curated species distribution maps, existing research, spatial distribution modeling	Relies on existing data and reduces cost for additional data collection, however, insights are usually limited to a coarser spatial resolution and may be prone to missing data and gaps depending on how well the species in question has been documented and how reliable the existing data are (e.g., publicly contributed data may have species identification issues).

Generally, a wide range of methods are available to monitor species and the choice of method should be tailored to the question(s), the species, the scale at which monitoring will be deployed, and resources available. Estimates of costs are wide ranging and while cost estimates are not provided here – it is recommended that HEARTH projects not only consider the costs of equipment and personnel, but also costs for data storage, transportation, training, etc.

Choosing Target Species for Monitoring

True monitoring of changes in biodiversity would require accurate species identification and counting to measure changes in species abundance and indices of community diversity across all species within a community or ecosystem. However, this is typically not realistic nor feasible for most projects. Thus, choosing which species to measure is critical and should be grounded in both the desired objectives of the intervention as well as the types of management actions pursued. HEARTH activities are recommended to use a structured decision-making approach for identifying candidate species for monitoring. This is a systematic approach using key concepts from structured decision-making and drawing on ecological and biological knowledge and

stakeholder priorities.[14] For example, a project may aim to reduce species decline within an area by managing threats that are thought to be acting against these species such as the USAID Saving Species Project.

To understand whether these management actions are effective for reducing species decline, the project should identify candidate indicator species (species that are likely indicators of a biotic response to either environmental stress and/or management actions) for monitoring.

Valuable indicator species may be species that can provide early warning of biotic responses to environmental stressors, represent precursors of broader community or ecosystem-wide change, that are well-studied (clear understanding of life history and ecology), and have clear taxonomic distinctions (to avoid issues of misidentification or ongoing speciation). Depending on management objectives, the candidate species for monitoring can include keystone species, area limited umbrella species, dispersal limited species, resource-limited species, process-limited species, flagship/charismatic species, invasive species, and/or species associated with specific habitat features of interest (**Table 4**). For example, in agricultural projects, tracking the presence of native pollinator species across the project area may be important. Ecosystem health can also be measured through monitoring changes in habitat cover.

Table 4: Types of Indicator Species and Definitions[15]

Type	Definition	Examples
Keystone species	Species upon which other species in the ecosystem depend on, as such, if this species were to decline or disappear, the ecosystem would drastically change	Predators (grey wolves, sea otters), prey (Antarctic krill, Canadian snowshoe hares), ecosystem engineers (beavers), mutualists (pollinators), plants (saguaro cactus)
Area-limited 'umbrella' species	Species that require large areas of suitable habitat to maintain viability and whose habitat requirements also cover those for a wider array of associated species	Species with large home ranges (e.g., bears, wolves, large cats)
Dispersal-limited species	Species that are limited in their ability to move from area to area or those with high mortality risk (in moving)	Species restricted to microclimates (e.g., sky islands, humid areas) like amphibians

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[14] Bal, P., Tullock, AIT., Addison, PF., McDonald-Madden, E., Rhodes, JR. "Selecting indicator species for biodiversity management." Frontiers in Ecology and Evolution 16 no. 10 (2018): 589-598.

[15] Carignan, V., Villard, M-A. "Selecting Indicator Species to Monitor Ecological Integrity: A Review." Environmental Monitoring and Assessment 78 (2002): 45-61.

Type	Definition	Examples
Resource-limited species	Species requiring specific resources that might be available on a limited basis	Species that rely on specific habitats or prey species
Process-limited species	Species sensitive to ecological processes (e.g., fire, flood, grazing, competition, etc.)	Species that require fire or flood for germination
Flagship species	Species that attract public support for conservation or are on priority lists (e.g., International Union for Conservation of Nature Red List species)	Giant panda, gorillas, whales
Species associated with specific habitat features	Species that are strongly linked to specific habitat features, such that their persistence is closely linked to the persistence of that feature	Bird species that are closely linked to a habitat type (e.g., overbirds are indicators of a closed-canopy mature forest with a sparse understory)
Invasive species	Species that are non-native to the particular area. Typically, the term 'invasive' species is given to non-native species that grow and reproduce quickly and spread aggressively, with the potential to cause harm to native species and/or ecosystems.	Cane toads, zebra mussel, some carp species, etc.

Deciding which species to measure, the scale and frequency of sampling, and methods to use should be determined by reviews of relevant and reliable published literature and developed in collaboration with implementing partners, stakeholders, and experts knowledgeable about the target ecosystems. The following steps are recommended to define a species monitoring plan:

- HEARTH activities should first consider the relevant ecosystem components that are closely linked to intervention outcomes and determine appropriate scales of impact. They should consult with relevant stakeholders and experts to identify priority species of interest (e.g., culturally and socially important species, indicator and/or keystone species, endangered species, etc.). Triangulating across these sources, projects can come up with a preliminary list of potential species for monitoring.
- Next, they should prioritize species where sufficient information exists regarding their distribution, ecology, and life history – as selecting relatively less-understood species will complicate designing

appropriate sampling protocols. Similarly, priority should be given to species with clear taxonomic boundaries. For example, species complexes and cryptic species may increase the risk of misidentification depending on the sampling method and question – that is, the species of interest should be able to be clearly and easily identified.

- Next, projects should consult with relevant experts and determine which species may likely respond to changes occurring outside the manageable interests of the project and adjust priorities accordingly. For example, species with home ranges far beyond the target area may not be the best choice for monitoring as their abundance will be affected by factors unobservable for the project. Approaches that employ species distribution modeling along with climate and other land-use change models can also be used to predict which species and which locations are most likely to experience impacts under changing conditions for monitoring prioritization.[16] Open-source tools like Wallace can be used for this type of geospatial modeling.[17] These types of confounding variables should be considered in the monitoring and evaluation protocol.
- Next, they should consider whether datasets on target species already exist and are of sufficient quality in their target region, and whether they can be leveraged to answer questions of interest.
- Last, they should consider the time and resources they have available and what types of techniques are needed to track different types of species, and prioritize accordingly.[18, 19]

Species occurrence and abundance

Measuring species presence-absence is the most straightforward and simple biodiversity metric and can help answer questions such as 'is this species present in the target area?' or 'does this species use this target area?' Aggregating species presence-absence data over multiple species can give an overall picture of species diversity (as a measure of species richness). However, often presence-absence data can only provide a limited picture of biodiversity and can often be insufficient to inform questions on population and species viability and overall ecosystem health. For example, rare species and species with large home ranges and absence in data collected may not reflect true reality of occurrence as the probability of observing those types of species is much lower than for common species. Thus, presence-absence data combined with fine-scale spatial and temporal sampling can provide a better understanding of where and when different species occur (or do not occur) across an ecosystem. This type of data can be useful to inform questions such as 'what degree of demographic connectivity occurs between these habitat areas/fragments?' or 'how do species move between protected and non-protected areas?' or 'how does occurrence change over seasons?' Measuring the absolute or relative species abundance, whether alone or with detailed spatial and temporal data, can provide a finer-scale picture of how populations change over time and space, thereby lending insight to the viability of

[16] Blair, ME., Rose, RA, Ersts, PJ., Sanderson, EW., Redford, KH., Didier, K., Sterling, EJ., Pearson, RG. "Incorporating climate change into conservation planning: Identifying priority areas across a species' range." Frontiers of Biogeography 4 no. 4 (2012): 157-167.

[17] Kass, JM., Vilela, B., Aiello-Lammens, M., Muscarella, R., Merow, C., Anderson, RP. "Wallace: A flexible platform for reproducible modeling of species niches and distributions built for community. expansion." *Methods in Ecology and Evolution 9 no. 4* (2018): 1151-1156.

[18] Bal, P., Tullock, AIT., Addison, PF., McDonald-Madden, E., Rhodes, JR. "Selecting indicator species for biodiversity management." Frontiers in Ecology and Evolution 16 no. 10 (2018): 589-598.

[19] Hilty, J., Merenlender, A. "Faunal indicator taxa selection for monitoring ecosystem health." Biological Conservation 92 no. 2 (2000): 185-197.

populations and can be used to calculate likelihood of species survival, particularly for species that may be harvested. For example, data on abundance of native species versus invasive species collected over multiple seasons can be used to understand patterns in recovery of native community composition for invasive species removal and control projects.

How to measure species occurrence and abundance

Given the diversity of possible species that may be chosen for monitoring, this guide cannot provide specific details for each type of species. However, there are numerous standardized methods and guides currently in use by international organizations aimed at biodiversity assessment. HEARTH activities are recommended to use Conservation International's Core Standardized Methods for Rapid Biological Field Assessment as a starting point.[20] This guide identifies a core, at-the-minimum set of standardized methods aimed at making the results of rapid surveys comparable and replicable across sites and time. These methods highlight both methods to record presence-absence as well as relative or absolute abundance.[21] In addition, data from previous Rapid Assessment Program expeditions can be found on the Rapid Assessment Program Bulletin of Biological Assessment. Other good sources of monitoring protocols for specific species can also be found through the International Union for Conservation of Nature Species Programme,[22] for example, for great apes.[23] HEARTH activities are recommended to start with this guidance and ensure that collected data comply with data standards outlined below.

In general, HEARTH activities are also recommended to work to identify potential research partners in-country to collaborate for collecting and assessing biodiversity and ecosystem data. These types of collaborations are critical as they build and sustain local scientific capacity and situate biodiversity monitoring within stakeholder communities within the geographic context – components that are critical for making progress towards equity and long-term sustainability of efforts.[24, 25]

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[20] Core standardized methods - conservation international. Conservation.org. (n.d.). Retrieved from https://www.conservation.org/docs/default-source/publication-pdfs/ci_biodiversity_handbook_lowres.pdf.

[21] Larsen, TH. "Core standardized methods for rapid biological assessment." Conservation International, Arlington, VA (2016).

[22] IUCN SSC Species Monitoring Specialist Group. (n.d.). Retrieved from https://www.speciesmonitoring.org/

[23] Kühl, H., Maisels, F., Ancrenaz, M., Williamson, E.A. (2008). "Best practice guidelines for surveys and monitoring of great ape populations." IUCN.

[24] Barber, PH., Ablan-Lagman, MCA., Ambariyanto, Berlinck, RGS., Cahyani, D., Crandall, ED., Ravago-Gotanco, R., Juinio-Meñez, MA., Mahardika, GN., Shanker, K., Starger, CJ., Toha, AHA., Anggoro, AW., Willette, DA. (2014). "Advancing biodiversity research in developing countries: the need for changing paradigms." Bulletin of Marine Science 90 no. 1: 187-210.

[25] Ahmadia, Gabby N., Cheng, Samantha H., Andradi-Brown, Dominic A., Baez, Stacy K., Barnes, Megan D., Bennett, Nathan J., Campbell, Stuart J., Darling, Emily S., Estradivari , Gill, David, Gress, Erika, Gurney, Georgina G., Horigue, Vera, Jakub, Raymond, Kennedy, Emma V., Mahajan, Shauna L., Mangubhai, Sangeeta, Matsuda, Shayle B., Muthiga, Nyawira A., Navarro, Michael O., Santodomingo, Nadia, Vallès, Henri, Veverka, Laura, Villagomez, Angelo, Wenger, Amelia S., Wosu, Adaoma. (2012). "Limited Progress in Improving Gender and Geographic Representation in Coral Reef Science." Frontiers in Marine Science 8: 1334.

Data Standardization

HEARTH activities are and will be occurring across diverse ecosystems and geographies, thus, it is unlikely that activities will be measuring the same species. However, in order for data from across projects to be combined for portfolio-wide evaluation, population and species data should be collected in a standardized manner that allow for data within and across species to be collated and shared to be used broadly. Given the importance of species occurrence data for tracking impacts of policies and progress toward USAID and international biodiversity goals and efforts (e.g., Sustainable Development Goals (SDGs)), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services assessments) – information on the status and trends of global biodiversity must be available in a form that is easily understood, standardized, scientifically rigorous, and representative of species populations across taxa and regions over time.[26] As such, HEARTH activities are recommended to use the following standard frameworks for measuring and reporting species occurrence data.

HEARTH projects should ensure they collect environmental and ecosystem data along with species data. For example, meta-data to be collected with species occurrence data should include time of observation, climate, location (ideally specific latitude and longitude), altitude or depth, habitat type, ecosystem type, etc. The meta-data should comply with global standards for biodiversity and environmental data. HEARTH activities are recommended to use the standards set forth by the Global Biodiversity Information Facility for sampling event data (using the Darwin Core Standard)[27] and associated ecological meta-data (using Ecological MetaData Language).[28] When possible, data should be published to the Global Biodiversity Information Facility occurrence database.[29]

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[26] Jetz, W., McGeoch, MA., Guralnick, R., Ferrier, S., Beck, J., Costello, MJ., Fernandez, M., Geller, G.N., Keil, P., Merow, C., Meyer, C., Muller-Karger, FE., Pereira, HM., Regan, EC., Schmeller, DS., Turak, E. (2019). "Essential biodiversity variables for mapping and monitoring species populations." Nature Ecology & Evolution 3 no. 4: 539-551.

[27] Introduction to sampling-event data. GBIF. (n.d.). Retrieved from https://www.gbif.org/sampling-event-data

[28] Gbif. (n.d.). GMPHowToGuide · Gbif/IPT Wiki. GitHub. Retrieved from https://github.com/gbif/ipt/wiki/GMPHowToGuide.

[29] Search Occurrences. GBIF. (n.d.). Retrieved from https://www.gbif.org/occurrence/search.

Accessing And Using Existing Geospatial Data for Monitoring Terrestrial Landscape Extent and Condition

Background

Many HEARTH activities include intermediate results related to terrestrial landscape extent and condition. This guidance focuses on forest ecosystems because (1) they are common focal interests in HEARTH activities, and (2) there is a spatially explicit global database that allows for assessment of forest cover dynamics. Similar analyses of total extent and loss are possible for other ecosystem types, but these will need to rely on data collected and analyzed by each HEARTH activity; however, this type of analysis is beyond the scope of this guidance.

Analyses of habitat extent should not be used to assess habitat quality or to assess the odds of the long-term persistence of species, populations, or ecosystems. Ecosystem extent metrics have been used in broader assessments about ecological resilience, but should not be used in isolation to determine an ecosystem's resistance to change or its capacity to bounce back from perturbation.[30]

Data Sources to Estimate Historical Forest Cover Change

This guidance is focused on the use of these indicators using a global dataset of tree cover extent for the year 2000 and annual tree cover loss that is freely available and updated annually.[31] These data can be combined with national and local forest cover classification systems within defined spatial units to assess absolute tree cover loss and the rate of tree cover loss. These data allow HEARTH partners around the world to access and analyze annual tree cover loss statistics without requiring analysis of raw remotely sensed images.

There are two main ways to access these data:

- **Global Forest Watch (GFW)** (spreadsheet output): Raster datasets are available for download from the University of Maryland Global Land Analysis and Discovery (GLAD) laboratory's Global Forest Change Data Download website.[32]
- **Forest cover loss data can be obtained as a spreadsheet from GFW**, which provides a user-friendly web-based interface to access, upload, and download data. Users can upload a spatial unit, visualize baseline tree cover extent across activity sites, and download tabular forest extent and loss area data as a spreadsheet.

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[30] Timpane-Padgham, Britta L., Tim Beechie, and Terrie Klinger. (2017). "A systematic review of ecological attributes that confer resilience to climate change in environmental restoration." PLoS One 12, no. 3: e0173812.

[31] Hansen, Matthew C., Peter V. Potapov, Rebecca Moore, Matt Hancher, Svetlana A. Turubanova, Alexandra Tyukavina, David Thau et al. (2013). "High-resolution global maps of 21st-century forest cover change." science 342, no. 6160: 850-853.

[32] Global Forest Change 2000–2020 data download. Global Forest Change. (n.d.). Retrieved from https://storage.googleapis.com/earthenginepartners-hansen/GFC-2020-v1.8/download.html.

Forest cover loss can be analyzed using either the GFW or the GLAD data, or in Google Earth Engine. Additional details for using these data are in Annex 1.

Choosing Indicators

Activities with intermediate results related to the preservation of forest cover may consider including the forest extent indicator. Absolute measurements of forest cover by themselves may have limited utility in assessing the impacts of an activity. Specifically, forest cover within HEARTH sites could be analyzed with respect to the start of the intervention; in this case, the hypothesis is that sometime after the start of the HEARTH intervention forest loss will be reduced (**Figure 1**). A comparison to a group of similar sites outside the area of influence of the HEARTH activity would provide stronger evidence of impacts. (**Figure 2**). Whenever feasible, a carefully selected group of sites not participating in HEARTH activities should form the basis for comparisons. When such a comparison group exists, statistical testing can be used to determine whether there are significant differences between the HEARTH sites and the comparison group. Selection of an appropriate comparison group is beyond the scope of this guidance.
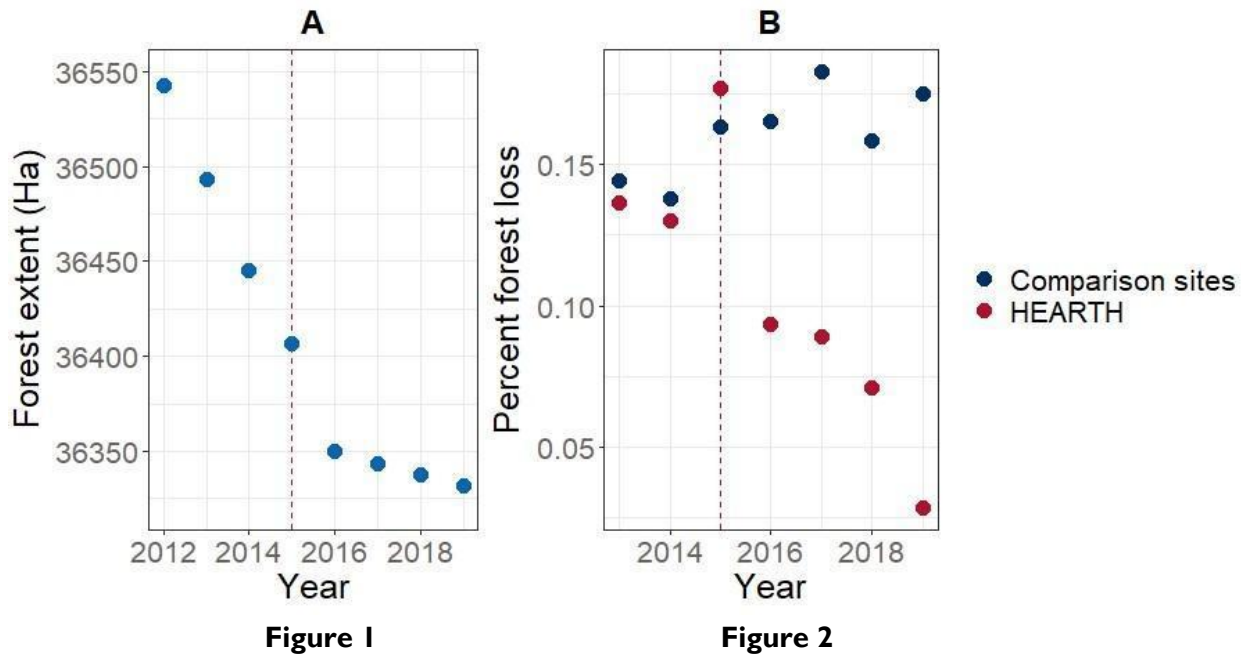

Figure 1: Before and After Comparison of Simulated Forest Extent Data within HEARTH Activity Sites.
(The plot shows that overall forest extent trends diverge after the start of the HEARTH activity [vertical dashed line]).

Figure 2: Simulated Percent Forest Loss Data in HEARTH Activity Sites and a Group of Comparison Sites
(The plot shows that percent loss trends are similar before the start of the HEARTH activity [vertical dashed line] but diverge after).

Habitat Fragmentation

Habitat fragmentation, a process by which a contiguous habitat patch is converted into smaller and often disjunct patches, is a common consequence of human alteration of natural ecosystems. Fragmentation can have important impacts on biodiversity and ecosystem function. The degree of fragmentation in a landscape can be described using several metrics, but there is no consensus on a single metric that is robust and amenable to aggregation across different landscapes.[33] Therefore, we do not include a habitat fragmentation metric in the HEARTH MERL indicators, but instead recommend that HEARTH activities including a fragmentation outcome evaluate including a metric selected upon consideration of local conditions and the activity's theory of change. HEARTH activities interested in measuring habitat fragmentation and needing technical assistance should contact the HEARTH MERL team.

A frequently used, open-source tool for deriving habitat fragmentation metrics is FRAGSTATS.[34] An introduction to FRAGSTATS was produced by Chen and Iannone (2020).[35] FRAGSTASTS metrics can be derived using (1) its stand-alone tool,[36] (2) plug-ins for GIS software, or (3) analytical packages in a statistical programming language (e.g., "landscapemetrics" in R or "PyLandStats" in Python).[37]

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[33] Wang, Xianli, F. Guillaume Blanchet, and Nicola Koper. (2014). "Measuring habitat fragmentation: an evaluation of landscape pattern metrics." Methods in Ecology and Evolution 5, no. 7: 634-646.

[34] University of Massachusetts Amherst. University of Massachusetts. (n.d.). Retrieved from https://www.umass.edu/landeco/research/rmlands/applications/hrv_upl/documents/fragstats_overview.htm.

[35] Chen, Benxin, and Basil V, Iannone III. "FRAGSTATS: A Free Tool for Quantifying and Evaluating Spatial Patterns". (2020). https://edis.ifas.ufl.edu/pdf/FR/FR431/FR431-Dtqvkt8643.pdf.

[36] University of Massachusetts Amherst. University of Massachusetts. (n.d.). Retrieved from https://www.umass.edu/landeco/research/rmlands/applications/hrv_upl/documents/fragstats_overview.htm.

[37] Bosch, Martí. "PyLandStats: An open-source Pythonic library to compute landscape metrics." PloS one 14, no. 12 (2019): e0225734.

Collecting And Assessing Soil Quality in Agriculture and Agroforestry Projects Using LandPKS

Background

Healthy soils are the foundation of sustainable, productive agriculture, but in order to understand the different characteristics of their land (such as how much water or carbon it can store), farmers and land managers need to measure its potential. Land Potential Knowledge System (LandPKS)[38] is a free mobile app that allows users to easily identify soil types, monitor soil health, vegetation cover, composition and height, and track activities and management over time. This section outlines the basic questions HEARTH Activity managers and potential users may ask when considering using LandPKS, with links to resources and training where available. A user guide for project and impact evaluators is also available online.[39]

Should My HEARTH Activity Use LandPKS?

One of HEARTH's Project Outcomes (Project Outcome BP.2) involves restoring or improving landscapes for biodiversity. Because of HEARTH activities' geographic and sectoral variety, LandPKS may not be appropriate for every project. However, if an activity involves agriculture, agroforestry, or a sector dependent upon healthy soils, LandPKS will help to assess baseline soil health and soil potential at the beginning of the intervention and to monitor progress throughout the life of the project.

LandPKS is a free mobile application (or app), that can be downloaded from the Apple App Store for iPhones[40] or on Google Play for Android phones. [41]

LandPKS is primarily meant to be used in the field, to gather data and monitor change. However once baseline data has been set up, information is saved to a Data Portal[42] where reports can be generated in .csv format. LandPKS does not recommend using the app on multiple devices with the same login, so creating a HEARTH Activity-wide account is not advisable unless one person is collecting and managing all of the data. Instead, discrete accounts should be created by individuals who will be able to collect localized field data over time. Farmers or land managers are best positioned to collect data and manage the LandPKS account, given their proximity to sites. They can also make use of the LandManager Module[43] to track land management activities

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[38] Land PKS. Knowledge for Sustainable Land Mass. (n.d.). Retrieved from https://landpotential.org/.

[39] Barnese, D. (2020, December 8). User guide for project and impact evaluators. LandPKS. Retrieved from https://landpotential.org/knowledge/project-and-impact-evaluators-user-guide/.

[40] project, L. P. K. S. (2016, September 18). LandPKS. App Store. Retrieved from https://apps.apple.com/us/app/landpks/id1084892005.

[41] Google. (n.d.). LandPKS - apps on Google Play. Google. Retrieved from https://play.google.com/store/apps/details?id=org.landpotential.lpks.landcover&hl=en.

[42] Land PKS. Knowledge for Sustainable Land Mass. (n.d.). Retrieved from https://landpotential.org/.

[43] Barnese, D. (2021, February 18). Training video: Land Management. LandPKS. Retrieved from https://landpotential.org/knowledge/intro-to-landpks-landmanagement-module/.

(planting dates, yields, pest management, nutrient management, irrigation and rainfall, tillage, crop residue management, erosion control).

Step-By-Step Instructions for Starting Up with LandPKS

1) Download the LandPKS mobile app
   a. Register a Gmail address to use the LandPKS app and access your data on the Data Portal.
2) Click the + to create a new site (You can click on the Map to view possible soils without creating a site)
   a. Name your first site and obtain the GPS coordinates. Multiple plots may be added, if necessary.
3) To create a baseline, data must be collected in the field. Three modules are required.
   a. LandInfo: record slope, texture, color for Soil ID.[44]
   b. Vegetation and LandCover: rapid (20-minute) vegetation monitoring with a measuring implement.[45]
   c. SoilHealth: record and store lab data + field observations aligned with soil health indicators. (More on this below)
   d. One further module may be of use, but has limitations:
      i. Habitat: used to define suitable habitat. However, currently only has data from North America.[46]
4) To back up your data to the cloud and give you access to the Data Portal, click "Synchronize Now" at the top of the data input screen when you have a data connection.
5) View data and results in the Report tab
   a. Soil ID: view your updated site-specific soil ranking, access information about potential vegetation and restoration options through EDIT.
   b. LandManagement & SoilHealth: generate PDF reports.

Guidance For Choosing Indicators

Soil quality, or soil health, is the ability of soil to function as an ecosystem that sustains animals, plants, and humans. A soil's dynamic properties reflect its health, and improved management can increase productivity, biodiversity, and overall sustainability. Once information is gathered in step 3a above, a LCC score may be generated. The LCC score may be used to help identify which soil health indicators may be most useful in tracking improvement.

To record soil health indicators for a specific site, users must input information into the LandPKS Soil Health module. The module records data about the dynamic properties of soil, allowing users to identify sustainable

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[44] Kerchof, C. (2021, January 27). Training videos: LandInfo. LandPKS. Retrieved n.d., from https://landpotential.org/knowledge/landinfo-training/.

[45] Kerchof, C. (2021, April 27). Training videos: Vegetation. LandPKS. Retrieved from https://landpotential.org/knowledge/vegetation-landcover-video-training/.

[46] Barnese, D. (n.d.). Intro to the landPKS habitat module. LandPKS. Retrieved from https://landpotential.org/knowledge/intro-to-the-landpks-habitat-module/.

practices to support soil to grow crops, manage rainwater, or filter pollutants. Soil inherent properties can provide information about ecosystem type and are noted in some of the modules (see Ponding, below).

Assessing Soil Quality in LandPKS

Fourteen short (between 1 and 6 minute) training videos[47] explain the indicators that LandPKS tracks, and a recent webinar also briefly describes the module. In general, it is not necessary to evaluate all the indicators for every project, but only those that are needed to assess soil health at the time. Some indicators will be more representative of soil health than others, depending on site conditions, soil type, landscape position, climate, time of year, and production system. The indicators tracked by LandPKS are:

Soil Cover[48] is the percent of soil surface covered by live plants, dead plant material, or organic mulch. This indicator can be evaluated in 3 different ways:

- Landcover Transect – transfers the completed information the user has reported in the LandCover module to display Total Cover Percent
- Ocular Estimate – allows the user to record multiple ocular estimate observations
- Other – allows for other methods of estimating Cover Percent

Residue Breakdown[49] is the rate of decomposition as indicated by many environmental and soil conditions. These include soil microbial community, chemical and physical characteristics of the residue, soil water content, soil temperature, and soil aeration. The indicator is evaluated by comparison of expectations for similar soil, topography, climate, and residue type, on a scale of "much greater than expected" to "none or very little."

Surface Crusts[50] are thin layers of soil at the soil surface that have different physical and/or chemical characteristics than the underlying soil. There are 3 types of crusts: Biological, Chemical, and Physical. Physical crusts can be either Structural (formed by water) or Depositional (caused by deposited soil particles). Surface crusting is evaluated by:

- Whether crusts are present
- Thickness of layer
- Level of development – determined by applying force to crust sample
- Extent percentage

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[47] Barnese, D. (2021, July 12). Training videos: Soil Health. LandPKS. Retrieved from https://landpotential.org/knowledge/intro-to-the-landpks-soilhealth-module/.

[48] Soil Health trainings 2: Set-up and soil cover. YouTube. (2021, May 20). Retrieved from https://youtu.be/Rogcmd8-fYg.

[49] Soil Health trainings 3: Residue breakdown. YouTube. (2021, May 20). Retrieved from https://youtu.be/puIND54_uPk.

[50] Soil Health trainings 4: Surface crusts (surface crusting). YouTube. (2021, May 20). Retrieved from https://youtu.be/U6aOei0xaEg.

Ponding[51] is the soil characteristic that shows the extended periods that standing water stays on the soil surface. It can be an indicator of crusts, poor soil structure, poor aggregate stability, compaction or inherent soil properties, and/or landscape position. Ponding is measured by duration.

Root Restriction[52] is a near-surface layer of dense soil that is hard for plant roots and water to penetrate. These can be naturally occurring, or human caused. Root restriction measurements can be recorded in 3 ways:

- Measuring using an instrument called a measure penetrometer
- Measure Other – such as wire flag, sharp rod, or shove
- Describe Layer – by entering depth to the top of compaction layer, thickness, level of development, and extent

Aggregate Stability[53] is the ability of soil aggregates to resist collapsing into smaller pieces due to tillage, wind, or water erosion. This indicator is measured by using the Cylinder method, Strainer Method, and/or a Soil Stability Kit.

Soil Structure[54] is the grouping of soil particles into aggregates. These can occur in different patterns, resulting in different soil structures. They influence the pore space in the soil and how easily air, water, and roots can move through the soil. This indicator is evaluated by identifying the soil structure type. Multiple observations can be made:

- Granular
- Subangular Blocky
- Angular Blocky
- Lenticular
- Platy
- Wedge Prismatic
- Columnar
- Single Grain
- Massive

Soil Color[55] is a physical soil property that gives an indication of the various processes occurring in the soil as well as the type of minerals in the soil. The indicator records the Munsell color notation at each depth. This can be determined with a Munsell book, or the app using a camera and white balance card or yellow post-it note as a color reference. Multiple observations can be recorded for each method.

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[51] Soil Health trainings 5: Ponding (Ponding/infiltration). YouTube. (2021, May 20). Retrieved from https://youtu.be/VzYIW385s5g.

[52] Soil Health trainings 6: Root restriction (penetration resistance). YouTube. (2021, May 20). Retrieved from https://youtu.be/EouDj8P7a4U.

[53] Soil Health trainings 7: Aggregate stability (water-stable aggregates). YouTube. (2021, May 23). Retrieved from https://youtu.be/N_Ilu3YEHSc.

[54] Soil Health trainings 8: Soil structure. YouTube. (2021, May 24). Retrieved from https://youtu.be/pHPZWTBXGZs.

[55] Soil Health trainings 9: Soil color. YouTube. (2021, May 24). Retrieved from https://youtu.be/_MX4XBZAuiI.

Plant Roots[56] anchor the plant, absorb water and nutrients, store food and nutrients, and move water and nutrients to the stem. This indicator is evaluated by checking all the root characteristics that apply, such as:

- Whether roots are covered in rhizosheaths (coatings of soil on roots that indicate microbial activity)
- Are part of soil aggregates
- Are healthy, fully branched, etc.

Biological Diversity[57] affects soil structure and therefore water availability by performing many vital functions such as converting dead and decaying organic matter and minerals to plant nutrients. This indicator is evaluated by identifying the amount of soil diversity present, from "numerous" to "none."

Biopores[58] are channels in the soil that are formed by the activity of plant and animal life. They allow air and water to move through the soil and are pathways for root growth. The indicator is evaluated by recording the number of biopores in a 10 x 10 cm area.

Runoff and Erosion[59] reflect soil movement and loss from the site. It can be used to detect excessive runoff, which can reduce the water availability for plants. The indicator is evaluated by identifying the extents of three characteristics found at the site:

- Water Flow Pattern
- Rills
- Gullies

[56] Soil Health trainings 10: Plant roots. YouTube. (2021, May 24). Retrieved from https://youtu.be/YAbmhJ1VZaY.

[57] Soil Health trainings 11: Biological diversity. YouTube. (2021, May 24). Retrieved from https://youtu.be/L_u44M7LriE.

[58] Soil Health trainings 12: Biopores. YouTube. (2021, May 24). Retrieved from https://youtu.be/0XBiloO7_rQ.

[59] SoilHealth trainings 13: Runoff and Erosion. YouTube. (2021, May 24). Retrieved from https://youtu.be/fP8XG1TQBVo.

Soil Smell[60] may indicate numerous inferred characteristics of the soil. This can mean the presence or lack of biological activity and/or poor soil structure. The indicator is determined by selecting one of three distinct scents:

- Fresh, sweet earthy smell
- Little or no smell
- Swampy, stagnant, or mineral smell

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[60] SoilHealth trainings 14: Soil Smell and further resources. YouTube. (2021, May 24). Retrieved from https://youtu.be/fTwioGDvLLk.

Collecting And Assessing Water Quality Data for Agricultural Activities

Background

The HEARTH MERL team aims to aggregate data from activities across multiple geographies and ecological contexts to test the effectiveness and impacts of the HEARTH approach. To do this, USAID and its partners need to collect, analyze, and report data using shared protocols. This guidance highlights key points for monitoring water quality in support of HEARTH MERL objectives.

Many HEARTH activities aim to reduce agricultural pollution of natural water aquatic environments such as lakes, streams, and estuaries. The most common types of agricultural water pollution that HEARTH practitioners are likely to encounter are:

- **Pathogenic microorganisms**. According to the WHO, microorganisms such as bacteria, parasites, and viruses are the most widespread human health risk associated with drinking water.[61] Although many microorganisms naturally occur in soil and water at agricultural sites, and some can be pathogenic, the biggest problems come from human waste or animal waste used as fertilizer. Microorganisms found in human and animal feces cause a variety of serious diseases such as cholera, diarrhea, hepatitis A, and typhoid.
- **Soil erosion.** Soil particles in water provide attachment sites for pathogenic microorganisms to proliferate, and they also reduce water clarity, which can negatively affect aquatic plants and animals and overall ecological productivity. Soil particles in water also can make it unpalatable for drinking.
- **Fertilizer runoff.** Practically all fertilizer contains nitrogen, which is essential for plant survival and reproduction. When people use commercial chemicals or animal waste to fertilize crops, excess nitrogen often runs off into natural aquatic environments, beyond the initial areas of application, via above and belowground pathways. Nitrogen compounds in water can cause a variety of human health problems, and there is some evidence that it might cause several types of cancer. Excess nitrogen in natural waters also may dramatically increase aquatic plant growth—a process known as eutrophication—causing cascading impacts on freshwater ecosystems. In some cases, nutrient-driven increases in aquatic plant productivity, followed by decomposition of the plants after they die, can significantly reduce the amount of oxygen dissolved in the water, thereby killing fish and other aquatic animals.
- **Pesticides**. Among the most harmful agricultural chemicals that pollute natural waters, pesticides are strictly regulated according to USAID's Environmental Procedures (Code of Federal Regulations Part 216.[62] For any activity in a Mission's portfolio that involves assistance for the procurement and/or use of pesticides, the Mission should complete an Initial Environmental Examination and Environmental

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[61] World Health Organization (WHO). 2017. Guidelines for drinking-water quality: fourth edition incorporating the first addendum. Geneva: World Health Organization. Licence: CC BY-NC-SA 3.0 IGO.

[62] USAID. (2007). Environmental Compliance Procedures. USAID-funded projects and activities. Retrieved from https://www.usaid.gov/sites/default/files/documents/2020_Digital_Booklet.pdf.

Mitigation and Monitoring Plan. A Mission's procedures for promoting or using pesticides—including a list of approved chemicals—and for monitoring pesticide pollution in any USAID-funded activity, should be established before the activity is approved. Accordingly, this guidance refers HEARTH practitioners to the Mission's existing pesticide monitoring protocols, as established by the Mission Environmental Officer and DC-based Bureau Environmental Officer. Many of these protocols will already be standardized at a global or regional scale through USAID's Environmental Procedures review and approval process.

Broad Overview of Methods

The table below lists five common indicators for water pollution, organized according to the type of pollution they indicate (**Table 5**). They directly address the human and ecological health issues described above. In the HEARTH water quality Performance Indicator Reference Sheet (PIRS), all the suggested tests for these indicators are simple and inexpensive, and practitioners can conduct them in the field or in an office setting. For most of the indicators, there also are more accurate methods available, and there are additional tests that practitioners could conduct for more comprehensive analysis, but they would require more specialized expertise and instrumentation and would typically be more expensive. None of the indicators listed below require laboratory analysis.

If HEARTH practitioners monitor these indicators regularly over time, they will provide useful measures of three of the most common types of agricultural water pollution and their long-term trends.

Table 5: *Common Indicators for Water Pollution*

Type of Pollution	Indicators	Considerations
Pathogenic microorganisms	E. coli	*Escherichia coli* (*E. coli*) is a type of coliform bacteria. Most *E. coli* are harmless and live in the intestines of people and warm-blooded animals, but some strains can cause illness. The presence of *E. coli* in drinking water usually indicates recent fecal contamination, which means there is a good chance that pathogens are present. It is considered unsafe to drink water that contains any amount of *E. coli*. According to the WHO, *E. coli* is considered the most suitable indicator of fecal contamination in drinking water.[63] Contamination can be measured by either membrane filtration or multiple-well methods.
Soil erosion	Turbidity	Turbidity is a measure of water clarity. It is largely a function of how much particulate matter such as soil is suspended in the water.

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[63] World Health Organization (WHO). 2017. Guidelines for drinking-water quality: fourth edition incorporating the first addendum. Geneva: World Health Organization. Licence: CC BY-NC-SA 3.0 IGO.

Type of Pollution	Indicators	Considerations
		Practitioners can measure turbidity in the field with a hand-held tool called a turbidity tube, aka transparency tube, and visual observation.
	pH	Water pH is influenced by many factors, but one important factor is the amount of positively and negatively charged mineral ions in the water, which will likely have come from rocks and soil nearby. Practitioners can measure water pH with a test strip of indicator paper or hand-held pH meter. pH meters need to be calibrated before measurement.
Fertilizer runoff	Nitrate and Nitrite	Nitrate and nitrite are both simple molecules containing nitrogen and oxygen; they are commonly found in water that is polluted with fertilizer. Practitioners can measure nitrate and nitrite concentrations in water with a test strip of indicator paper.

Guidance On Choosing Indicators

When designing a water sampling program, practitioners need to consider the types of pollution they wish to address, the relevant ecological and social contexts, and the resources available. Perhaps less obvious are considerations of how to establish baseline water quality conditions at the beginning of HEARTH activities, how seasonal changes or changes in HEARTH activity implementation might affect agricultural water pollution, and even how to allocate responsibility for getting the work done. All these factors are relevant to determining which indicators are needed, and which are feasible to track.

USAID has produced several useful Sector Environmental Guidelines to help answer these types of questions, especially those focused on Crop Production,[64] Dryland Agriculture,[65] and Water Supply and Sanitation,[66] which specifically address questions about the potential for agricultural water pollution and water quality monitoring. USAID also has a website focused on water quality assurance that has several useful resources. [67]

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[64] USAID. (2019, March). Sector Environmental Guideline: Crop production. Retrieved from https://www.usaid.gov/sites/default/files/documents/1865/CropProduction_SEG_25Mar2019.pdf.

[65] USAID. (2014). Sector Environmental Guidelines: Dryland Agriculture. Retrieved from https://www.usaid.gov/sites/default/files/documents/1860/SectorEnvironmentalGuidelines_DrylandAgriculture.pdf.

[66] USAID. (2017, August). Sector Environmental Guidelines. Retrieved from https://www.usaid.gov/sites/default/files/documents/1860/Water_SEG_2017.pdf.

[67] Water quality assurance plan (WQAP) template: Special compliance topics: Environmental procedures U.S. agency for international development. U.S. Agency for International Development. (2020, August). Retrieved from https://www.usaid.gov/environmental-procedures/environmental-compliance-esdm-program-cycle/special-compliance-topics/water.

Data Standardization

Water quality analysis is a well-developed, standardized practice with widely recognized methods. The PIRS for the HEARTH water quality indicators recommend commercially available test kits and tools that come with instructions for standardized data collection. The PIRS also includes instructions for data collection and disaggregates.

Guidance On Using and Assessing Global Climate Change (GCC) Standard Indicators for Climate Change Mitigation

Background

USAID frames its work and efforts on climate change in line with the USAID Climate Strategy 2022-2030[68] and three climate-related Executive Orders: EO 13990 - Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis,[69] EO 14008 - Tackling the Climate Crisis at Home and Abroad,[70] and EO 14013 - Rebuilding and Enhancing Programs to Resettle Refugees and Planning for the Impact of Climate Change on Migration.[71] Both mitigation and adaptation are critical strategies to address the climate crisis. However, reducing, sequestering, or avoiding GhG emissions will also slow the rate of climate change and reduce climate change impacts. Furthermore, reducing GhG emissions can have impacts (co-benefits in some cases and tradeoffs in others) for air and water pollution, energy security, health, and gender issues[1].

USAID's climate change indicators were updated in 2020, with excellent templates and guidance sheets. Therefore, this guidance acts as a signpost for HEARTH staff and Implementing Partners, with all climate-indicator-related resources in one place.

Broad Overview of Methods

Changes to GhG emissions are usually measured in metric tons of CO_2 (or CO_2-equivalent). Practically, this means projects need to develop a baseline of emissions (or emissions inventory), and then compare the "business-as-usual" case (i.e., what would have happened without the intervention) to changes in emissions over the life of the activity. Developing a targeted GhG projection is a key step towards developing successful emissions reduction strategies, and effectively reducing emissions in an activity.

On a project level, USAID programs with climate change benefits are required to report against a set of standard indicators, each with its own definition and some with supplementary guidance. Since effective

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[68] https://www.usaid.gov/sites/default/files/documents/USAID-Climate-Strategy-2022-2030.pdf

[69] Biden, J. R. (2021, January 20). Executive Order on Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis. whitehouse.gov. Retrieved from https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-protecting-public-health-and-environment-and-restoring-science-to-tackle-climate-crisis/.

[70] Biden, J. R. (2021, January 27). Executive Order on Tackling the Climate Crisis at Home and Abroad. whitehouse.gov. Retrieved from https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/.

[71] Biden, J. R. (2021, February 4). Executive Order on Rebuilding and Enhancing Programs to Resettle Refugees and Planning for the Impact of Climate Change on Migration. whitehouse.gov. Retrieved from https://www.whitehouse.gov/briefing-room/presidential-actions/2021/02/04/executive-order-on-rebuilding-and-enhancing-programs-to-resettle-refugees-and-planning-for-the-impact-of-climate-change-on-migration/.

performance monitoring starts with a clear view of a project's goals, there are climate change related results frameworks and other materials available to help guide project design and performance monitoring.[72]

On a more strategic level, other projections that have been developed by governments or organizations may be used for several reasons, such as reporting to the United Nations Framework Convention on Climate Change, or as part of a cost-effectiveness analysis to inform decision-making, policy development, or action plans. Assessments of policies and actions are useful for providing a quantitative basis for policy development and can also enable policymakers and stakeholders to assess the impact of various potential policies or actions on GhG emissions.

Guidance On Choosing Indicators

HEARTH's Project Biophysical Outcome 5 (Reduce GhG emissions from focal enterprise activities) should be measured using the GCC Standard Indicators. The most up-to-date versions of GCC Standard Indicator Reporting Templates (as of September 2021) can be accessed online.[73] The handbook walks you through each indicator (many of which are also listed below), with guidance for OUs on how, when, and why (or why not) to include them.

Several HEARTH Activities seek to reduce or avoid deforestation through improved land management, and climate change mitigation may be a result of successful interventions. Indicators EG 13-6 (GhG emissions, estimated in metric tons of CO2 equivalent, reduce sequestered, or avoided in full or in part by USG assistance) or EG 13-8 (Number of hectares under improved management expected to reduce greenhouse gas emissions as a result of USG assistance) may be the most directly relevant to HEARTH Outcome BP.4.

In order to measure a reduction in GhG emissions against a 'business-as-usual' case, project information should be entered into USAID's Agriculture, Forestry, and other Land Use (AFOLU) Carbon Calculator.[74] The AFOLU Carbon Calculator can also be used to generate GhG projections for a variety of land-related activities. Guidance on how to use the AFOLU Carbon Calculator is available online.[75]

If deemed necessary, HEARTH may also refer to the World Resource Institute Policy and Action Standard for guidance on how to generate a 10-year projection,[76] or contact USAID's Natural Climate Solutions Team for additional technical assistance on developing a projection of emission reductions.

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[72] Climate Change Monitoring and Evaluation Resources. Global Climate Change. (2020, August). Retrieved from https://www.climatelinks.org/climate-change-monitoring-evaluation-resources.

[73] USAID. (2020). 2020 GCC Standard Indicator Handbook: Definition Sheets. Climate Links. Retrieved from https://www.climatelinks.org/sites/default/files/asset/document/2020_USAID_GCC-Indicator-Handbook-August-2020-Update.pdf.

[74] GCC standard indicator reporting templates. Global Climate Change. (2019, October 7). Retrieved from https://www.climatelinks.org/resources/gcc-standard-indicator-reporting-templates.

[75] Casarim, F., and Murry, L. (2014). How To Use the AFOLU Carbon Calculator. USAID.org. Retrieved from http://afolucarbon.org/static/documents/How%20to%20use%20the%20AFOLU%20Carbon%20Calculator.pdf.

[76] Rich, D., Bhatia, P., Finnegan, J., Levin, K., and Mitra, A. (2015, July 11). Policy and action standard. World Resources Institute. Retrieved from https://www.wri.org/research/policy-and-action-standard.

What else could HEARTH activities measure?

Some HEARTH activities may also benefit from considering Adaptation, Clean Energy, and Sustainable Landscapes Indicators.[77] Targeted usage of these climate-related indicators can help USAID to capture the human resilience benefits of activities and training, as well as the links from USAID-funded programs to wider sustainability goals. A summary sheet, showing helpful information like category, and disaggregation level is available.[78] Additionally, individual, downloadable, reporting templates for Adaptation, Clean Energy, and Sustainable Landscapes have been created in Microsoft Excel.[79]

Global Climate Change Indicators of Relevance to HEARTH

EG 11: Adaptation

EG.11-1 Number of people trained in climate change adaptation supported by USG assistance

EG.11-2 Number of institutions with improved capacity to address climate change risks as supported by USG assistance

EG.11-4 Amount of investment mobilized (in United States Dollars (USD)) for climate change adaptation as supported by USG assistance

EG.11-6 Number of people using climate change information or implementing risk-reducing actions to improve resilience to climate change as supported by USG assistance

EG12: Clean Energy

EG.12-1 Number of people trained in clean energy supported by USG assistance

EG.12-2 Number of institutions with improved capacity to address clean energy issues as supported by USG assistance

EG.12-3 Number of laws, policies, regulations, or standards addressing clean energy formally proposed, adopted, or implemented as supported by USG assistance

EG.12-4 Amount of investment mobilized (in USD) for clean energy as supported by USG assistance

EG.12-5 Clean energy generation capacity supported by USG assistance that has achieved financial closure

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[77] GCC standard indicator reporting templates. Global Climate Change. (2019, October 7). Retrieved from https://www.climatelinks.org/resources/gcc-standard-indicator-reporting-templates.

[78] Climate Links. (n.d.). Global Climate Change: Standard Indicator Summary Sheet. USAID Security Sector Governance and justice indicators guide. Retrieved from https://www.climatelinks.org/sites/default/files/2019_USAID_GCC_Indicators%20Summary%20Sheet.pdf.

[79] GCC standard indicator reporting templates. Global Climate Change. (2019, October 7). Retrieved from https://www.climatelinks.org/resources/gcc-standard-indicator-reporting-templates.

EG.12-6 GhG emissions, estimated in metric tons of CO_2 equivalent, reduced, sequestered, or avoided through clean energy activities supported by USG assistance

EG. 12-7 Projected GhG emissions reduced or avoided from adopted laws, policies, regulations, or technologies related to clean energy as supported by USG assistance

EG13: Sustainable Landscapes

Indicator EG.13-1 Number of people trained in sustainable landscapes supported by USG assistance

EG.13-2 Number of institutions with improved capacity to address sustainable landscapes issues as supported by USG assistance

EG.13-4 Amount of investment mobilized (in USD) for sustainable landscapes as supported by USG assistance

EG.13-5 Number of people receiving livelihood co-benefits (monetary or non-monetary) associated with implementation of USG sustainable landscapes activities

EG.13-6 GhG emissions, estimated in metric tons of CO_2 equivalent, reduced, sequestered, or avoided through sustainable landscapes activities

EG. 13-8 Number of hectares under improved management expected to reduce greenhouse gas emissions as a result of USG assistance.

Performance Indicator Reference Sheets

INDICATOR TITLE: Change in presence/absence of target species(s) across target area over a set time interval

DEFINITIONS

"Target species" - This can be a single or group of species depending on the evaluation questions and the ecology of the area. The target species should be agreed upon and defined. Choice of target species should be made based on the evaluation question and any available baseline or inventory data.

"Target area" - This will depend on the HEARTH activity and project area; however, the target area should be defined with clear spatial bounds and ideally be ecologically relevant to the evaluation question. For the indicator on areas important for wildlife movement, these areas must be properly bounded based on biologically relevant areas for the species in question. For example, assessment of species range and likely areas for different types of usage can be used to identify areas for monitoring.

"Set time interval" - This is the temporal sampling interval for making observations. The interval and duration will depend on the HEARTH activity and its timeline, target species, and available resources.

DATA COLLECTION:

Data should be collected through observations and recorded with specific spatial and temporal data including latitude and longitude of observation and time of observation. Details on habitat type should also be recorded. Proper species identification is required, and care should be taken for species that are cryptic in nature.

Presence counts per unit area of sampling can be used to calculate species richness across unit areas. Species richness is calculated by totaling the number of species present (out of all species being sampled) over each unit area.

Each HEARTH activity must choose an appropriate date for the baseline data, based on an assessment of its theory of change. Analyses can include data from a period before the start of the HEARTH activity. The baseline year choice and the rationale for that choice must be included in each activity's MEL plan.

INDICATOR TITLE: Change in presence/absence of target species(s) across target area over a set time interval

LIMITATIONS:

For a single species, this metric only provides information on whether a species is present in the area. It is not informative about the dynamics of that population, nor can it be used to indicate health of that species.

For multiple species, this metric can be used to calculate a similarity index of species diversity between sites. As the observations gathered here do not include the number of unique individuals per species, they cannot be used to calculate diversity indices for species richness.

Presence/absence data can be confounded by "false zeros" which indicate non-detection events for species that may be present but not observed. Ideally, interpreting presence/absence data should be treated as detection/non-detection data. Chance of detection will depend on the sampling scheme and biology and ecology of the target species. As such, presence/absence data are prone to miss rare or hard to detect species. To adjust for this bias, conducting replicate surveys at sampling locations and/or using multiple observers can help. In addition, sampling probability models can be used to guide design of sampling intervals. Tools like PowerSensor![80] can be used to assess the ability of alternative sampling designs in wildlife sampling to detect changes in presence over time. The tool can be used also to evaluate sampling designs with varying numbers of sampling points and sampling durations for populations with different initial occupancies, detection probabilities, and occupancy changes (relevant for HEARTH indicator for change in species abundance).

To understand whether habitats are improved for species, projects should track the abundance of a target species that would be expected to utilize the area for specific purposes (e.g., mating, breeding, nursery, or hunting) and behaviors that are observed. However, presence/absence data can at the minimum indicate whether species that were previously present (or not present) have changed. This can provide information on overall habitat utility and quality. It cannot indicate any measures of species health or risk unless the project is certain they have sampled all potential spatial areas where the species may occur (to avoid ascertainment bias). Therefore, presence/absence should be not used to discern trends of species health nor habitat quality.

Poor metadata collection (e.g., spatial, temporal, habitat data) can also limit the utility of presence/absence data.

UNIT:	DISAGGREGATE BY:

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[80] Tropical Ecology Assessment and Monitoring Network. (n.d.). How Much Change Can You Detect in Your Occupancy-Based Monitoring Project? PowerSensor! Retrieved from https://jaap.shinyapps.io/powerSensor.

INDICATOR TITLE: Change in presence/absence of target species(s) across target area over a set time interval	
Number of species detected per unit area per unit of time	Target species: Number of observations indicating presence/absence of different target species or functional groups should be recorded separately (if multiple target species are under observation). Temporal units: Each HEARTH activity should determine the appropriate temporal sampling intervals for this indicator. Temporal sampling should be based on feasibility and ecological relevance for the target species. Spatial units: Each HEARTH activity should determine the appropriate level of geographic aggregation for this indicator. Additional disaggregation may be appropriate in specific cases, for example, by locality, ecosystem type, or if different approaches were implemented at different sites. The level of spatial aggregation for these data must be clearly noted in the activity's MEL plan.
FREQUENCY: TBD – based on relevant sampling intervals for target species and landscape	DATA SOURCE: Implementing partners will collect presence/absence data through observations. These can be done using a variety of approaches from visual transects to camera trapping to environmental DNA and other types of physical traps and trackers (e.g., radio collars, Passive Integrated Transponder tags, etc.).
REPORTING NOTES	
Each HEARTH activity should assess whether a target is appropriate for this indicator.	

INDICATOR TITLE: Change in abundance of target species(s) across target area over a set time interval

DEFINITIONS:

"Abundance" - Total number of individuals in a taxon or taxa in a defined area, a population, or a community. Abundance is typically expressed as relative abundance which refers to the total number of individuals of one taxon compared with the total number of individuals of all other taxa in a defined area, volume, or community.[81]

"Target species" - This can be a single or group of species depending on the evaluation questions and the ecology of the area. The target species should be agreed upon and defined. Choice of target species should be made based on the evaluation question and any available baseline or inventory data.

"Target area" - This will depend on the HEARTH activity and project area; however, the target area should be defined with clear spatial bounds and ideally be ecologically relevant to the evaluation question. For the indicator on areas important for wildlife movement, these areas must be properly bounded based on biologically relevant areas for the species in question. For example, assessment of species range and likely areas for different types of usage can be used to identify areas for monitoring.

"Set time interval" - This is the temporal sampling interval for making observations. The interval and duration will depend on the HEARTH activity and its timeline, target species, and available resources.

DATA COLLECTION:

Data should be collected through observations and recorded with specific spatial and temporal data including latitude and longitude of observation and time of observation. Details on habitat type should also be recorded. Proper species identification is required, and care should be taken for species that are cryptic in nature. If the indicator is intended to measure abundance over areas important for species movement, care should be taken to observe frequency of movement as well.

There are many ways to calculate indices to compare relative abundance of species over different areas. Projects should choose which index they intend to use and keep consistent over the project MEL plan. The following three approaches are suggested:

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[81] Millennium Ecosystem Assessment. (2005). Millennium assessment. Color Maps and Figures. Retrieved from http://www.millenniumassessment.org/documents/document.767.aspx.pdf

INDICATOR TITLE: Change in abundance of target species(s) across target area over a set time interval

1) Shannon-Wiener Index (H') - this is one of the most commonly used indexes for ecological studies of diversity. H' is calculated as:

$$H' = -\sum \left[\left(\frac{n_i}{N} \right) \times \ln \left(\frac{n_i}{N} \right) \right]$$

Where n_i = number of individuals or amount (e.g., biomass) of each species (the ith species) and N = total number of individuals (or amount) for the site, and ln = the natural log of the number.

Advantages of using H' is that is relatively easy to calculate on a site-by-site basis and can be fairly sensitive to actual site differences. However, H' can also be similar between sites even if the sites are very different in terms of community composition (see below for species abundance distributions).

2) Simpson's Index (λ) - λ is a measure of dominance and gives the probability that any two individuals drawn at random from an infinitely large community belong to different species. 1- λ can be used to measure species diversity. λ can be calculated as:

$$\lambda = \sum \frac{n_i(n_i - 1)}{N(N-1)}$$

Where n_i = number of individuals or amount of each species (i.e., the number of individuals of the ith species) and N = total number of individuals for the site. For this index, 0 indicates high species diversity and 1 indicates low species diversity.

Simpson's Index is less sensitive to species richness and can be weighted towards the most abundant species. It is less sensitive to site level differences.

3) Species abundance distributions - Comparing species abundance across different communities (e.g., between project sites and non-project sites, and/or over time) can be difficult because communities are often comprised of different species whose abundance characteristics will differ widely. To deal with this complexity, species abundance curves can be used. A species abundance curve plots the number of species against observed abundance to determine patterns across communities. Species abundance curves usually indicate some kind of "skew" whether that is towards many species observed in lower abundance or a few species observed with higher abundance. Determining what is "more" or "less" abundant will depend on the area in question and assumptions being made about how that community is assembled and functions. To account for these skews, different types of mathematical models can be used to transform the data depending on

assumptions about how that community functions (for more information, see McGill et al. 2007).[82]

Each HEARTH activity must choose an appropriate date for the baseline data, based on an assessment of its theory of change. Analyses can include data from a period before the start of the HEARTH activity. The baseline year choice and the rationale for that choice must be included in each activity's MEL plan.

LIMITATIONS:

Sampling for species abundance requires more intensive sampling and replicates to ensure completeness of the species inventory. Like presence/absence data, abundance counts can be confounded by "false zeros" which indicate non-detection events for species that may be present but not observed. Chance of detection will depend on the sampling scheme and biology and ecology of the target species. As such, measuring species abundance should employ replicate surveys at sampling locations and/or using multiple observers to account for this type of ascertainment bias. In addition, sampling probability models can be used to guide design of sampling intervals.

Species abundance will also be influenced by a species distribution (known as the 'positive distribution-abundance relationship') where widespread species tend also to occur at high abundances through their range and more range-restricted species will be rarer and potentially harder to detect. To account for this distribution-abundance influence, analyses of species abundance should aim to disaggregate data based on species type (e.g., habitat generalists vs. specialists, dispersal-limited vs. highly dispersive).

To understand whether habitats are improved for species, projects can track the abundance of a target species that would be expected to utilize the area for specific purposes (e.g., mating, breeding, nursery, or hunting) and behaviors that are observed. However, to do that, abundance data should also be complemented by behavioral data and potentially age/size data.

Poor metadata collection (e.g., spatial, temporal, habitat data) can also limit the utility of presence/absence data.

UNIT:	DISAGGREGATE BY:

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[82] McGill, B. J., Etienne, R. S., Gray, J. S., Alonso, D., Anderson, M. J., Benecha, H. K., Dornelas, M., Enquist, B. J., Green, J. L., He, F., Hurlbert, A. H., Magurran, A. E., Marquet, P. A., Maurer, B. A., Ostling, A., Soykan, C. U., Ugland, K. I., and White, E. P. (2007). Species abundance distributions: Moving beyond single prediction theories to integration within an ecological framework. Ecology Letters, 10(10), 995–1015. https://doi.org/10.1111/j.1461-0248.2007.01094.x

INDICATOR TITLE: Change in abundance of target species(s) across target area over a set time interval	
Number of individuals of a species detected per unit area per unit of time	Target species: Number of observations indicating abundance of different target species or functional groups should be recorded separately (if multiple target species are under observation). Temporal units: Each HEARTH activity should determine the appropriate temporal sampling intervals for this indicator. Temporal sampling should be based on feasibility and ecological relevance for the target species. Spatial units: Each HEARTH activity should determine the appropriate level of geographic aggregation for this indicator. Additional disaggregation may be appropriate in specific cases, for example, by locality, ecosystem type, or if different approaches were implemented at different sites. The level of spatial aggregation for these data must be clearly noted in the activity's MEL plan.
FREQUENCY: TBD – based on relevant sampling intervals for target species and landscape	DATA SOURCE: Implementing partners will collect abundance data through observations. These can be done using a variety of approaches from visual transects to physical and camera trapping.
REPORTING NOTES	
Each HEARTH activity should assess whether a target is appropriate for this indicator.	

INDICATOR TITLE: Change in total area of one or more classes of vegetation, e.g., forest class, across the defined spatial unit(s)

DEFINITION:

This indicator should use global data on forest extent and loss from the University of Maryland GLAD laboratory's Global Forest Change dataset,[83] as additionally provided by the World Resources Institute's GFW program.[84]

Forest loss data can be downloaded directly from the University of Maryland GLAD website[85] using the "Download data" link for analysis and display in a geographic information system (GIS). Alternatively, the GFW web interface allows users to specify specific areas of interest (e.g., HEARTH sites) and calculate the area of forest cover loss at different times without use of a GIS. For example, if a farm is a beneficiary in a HEARTH activity, the boundaries of that farm can be uploaded to GFW to calculate how many hectares of forests were lost each year (since 2001). Data on forest extent and loss can then be downloaded from GFW as a spreadsheet.

Notably, users need to be aware that GFW only reports on forest loss, which can be the result of a variety of factors, including deforestation but also natural processes such as fire, disease, and storm damage. Therefore, users should not equate forest loss data as reported by the GLAD Forest Change dataset to deforestation unless these data have been ground-truthed. Over a HEARTH's landscape, and in the absence of additional information (e.g., a forest fire affecting HEARTH intervention sites but not the comparison sites), it may be assumed that natural factors driving forest loss are uniformly distributed. Therefore, the working hypothesis about the effectiveness of the HEARTH approach in conserving forests is that trends in forest cover loss within HEARTH sites will differ from those seen outside them.

In addition, both GLAD and GFW provide data on global forest extent in the year 2000 as a baseline for the forest loss datasets, also available from the above web sites. These datasets define forest as vegetation taller than 5m in height, and these data are provided as a percentage of forest cover the range 0–100.

When calculating forest extent and loss, GFW allows users to define a threshold percentage tree cover that marks a geographical unit as forest or non-forest. That is, each pixel in a map will be classified as forest only if it contains tree cover for at least that specified threshold percentage. HEARTHs are recommended to use a default threshold of 30%, which is the default in the GFW

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[83] Hansen, M. C., Potapov, P. T., Moore, R., Hancher, M., and Turubanova, S. A. (n.d.). Global Forest Change. Google Crisis Map. Retrieved from http://earthenginepartners.appspot.com/google.com/science-2013-global-forest.

[84] Vizzuality. (n.d.). Forest Monitoring, land use and deforestation trends. Global Forest Watch. Retrieved from https://www.globalforestwatch.org./.

[85] Hansen, M. C., Potapov, P. T., Moore, R., Hancher, M., and Turubanova, S. A. (n.d.). Global Forest Change. Google Crisis Map. Retrieved from http://earthenginepartners.appspot.com/google.com/science-2013-global-forest.

INDICATOR TITLE: Change in total area of one or more classes of vegetation, e.g., forest class, across the defined spatial unit(s)

website. That is, unless the user specifies a different percentage under the "Displaying Tree cover loss with X % canopy density" entry in GFW, the results will be based on a default 30% threshold.

Each HEARTH should consider whether the specific attributes of the intervention or the ecosystem(s) included in its area of influence warrant using a different threshold percentage. If this is the case, the new threshold and the rationale behind the different value should be clearly reported in the activity's MEL plan.

Forest loss data can be converted to a percentage lost by year as follows. To calculate the percentage forest loss in $Year_n$:

$$\% \ loss \ in \ Year_n = \frac{\left(Forest \ extent \ in \ Year_{n-1} - Forest \ extent \ in \ Year_n\right) x \ 100}{Forest \ extent \ in \ Year_{n-1}}$$

Yearly forest loss percentages cannot be added but can be averaged throughout a specific period.

DATA COLLECTION:

All raw data for this indicator come from the Global Forest Watch forest loss database or the University of Maryland's Global Forest Change Data.

GFW includes step by step instructions for accessing its data.[86]

The University of Maryland's Global Forest Change[87] provides instructions for downloading the data as well as descriptions of each layer. If using these data, tree cover for the year 2000 is available in the *treecover2000* layer. The *lossyear* layer includes the cells that changed from a forest to non-forest state in a specific year. Producing layers showing forest and non-forest areas per year requires basic map algebra using raster layers of the HEARTH activity sites.

Each HEARTH activity must choose an appropriate date for the baseline forest cover data, based on an assessment of its theory of change. Analyses can include data from a period before the start of the HEARTH activity. It is likely that global databases will remain producing forest loss data for

[86] Tree cover loss. Global Forest Watch Open Data Portal. (n.d.). Retrieved from https://data.globalforestwatch.org/documents/tree-cover-loss/explore.

[87] Hansen, M. C., Potapov, P. T., Moore, R., Hancher, M., and Turubanova, S. A. (n.d.). Global Forest Change. Google Crisis Map. Retrieved from http://earthenginepartners.appspot.com/google.com/science-2013-global-forest.

many more years, and therefore the impacts of HEARTH investments could potentially be analyzed for a period following the end of the activity.

The baseline year choice and the rationale for that choice must be included in each activity's MEL plan.

LIMITATIONS:

As explained above, forest cover loss data includes both natural and anthropogenic influences, meaning that raw forest loss data by themselves should not be interpreted as measuring deforestation.

Forest cover data by themselves are a poor proxy for biodiversity. There are documented instances of "empty forests" where forest canopy remains, but the ecosystem is species poor, for example as a result of overhunting. Therefore, in the absence of additional information (e.g., biological surveys), forest cover extent or loss data alone should not be used to make inferences about the status of biodiversity or ecosystem function.

Data limitations for this indicator also include those associated with the input spatial data. The use of global databases generally trades off some accuracy and/or sensitivity for coverage. Individual HEARTHs may consider ground-truthing forest cover loss data for a sample of their sites to assess the accuracy of the GLAD GFW data for their specific landscapes. Raw data from GLAD GFW should be included in the MEL plan of each activity using this indicator. Any modifications to the data should be described in detail in the activity's MEL plan. Data limitations of the forest loss data from GLAD and GFW.[88]

Besides other factors mentioned elsewhere in this sheet, data limitations for this indicator also include those associated with the source data on forest loss. GFW warns that "the overall prevalence of false positives (commission errors) in these data at 13%, and the prevalence of false negatives (omission errors) at 12%, though the accuracy varies by biome and thus may be higher or lower in any particular location. The model often misses disturbances in smallholder landscapes, resulting in lower accuracy of the data in sub-Saharan Africa, where this type of disturbance is more common. The authors are 75 percent confident that the loss occurred within the stated year, and 97 percent confident that it occurred within a year before or after. Users of the data can smooth out such uncertainty by examining the average over multiple years."

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[88] Vizzuality. (n.d.). Interactive World Forest Map and Tree Cover Change Data: GFW. Global Forest Watch. Retrieved from https://www.globalforestwatch.org/map/?modalMeta=tree_cover_loss.

INDICATOR TITLE: Change in total area of one or more classes of vegetation, e.g., forest class, across the defined spatial unit(s)

Additional information about the potential limitations of these data can be found in the Usage Notes section in the University of Maryland's Global Forest Change Data Download website.[89]

UNIT:	DISAGGREGATE BY:
Forest extent in the global datasets is defined for 30 by 30-meter units and is measured as a percentage of those units that show forest cover. For the GFW web interface, forest area is provided in hectares. The minimum value is zero (indicating that there are no pixels that include canopy cover at the specified percentage threshold). The maximum value is the total area of analysis (e.g., the total area of a specific farm or protected area), indicating that the totality of that specific spatial unit is covered by forests. Forest loss areas are cumulative through time. For example, results from 2011 through 2020 can be added to report a total forest cover loss figure for that period.	Each HEARTH activity should determine the appropriate level of geographic aggregation for this indicator. If using the GFW web interface, it will be time consuming to upload individual sites (e.g., farm boundaries). Aggregation may be appropriate and should be defined in each activity's MEL plan. For example, sites may be aggregated by locality, ecosystem type, or if different approaches were implemented at different sites. The level of spatial aggregation for these data must be clearly noted in the activity's MEL plan.
FREQUENCY: Annual	DATA SOURCE: Forest loss data can be obtained from Global Forest Watch[90] or the University of Maryland's Global Forest Change dataset.[91]

REPORTING NOTES
HEARTH activities should report areas as decimals with two decimal places.

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[89] Global Forest Change 2000–2020data download. Global Forest Change. (n.d.). Retrieved from https://storage.googleapis.com/earthenginepartners-hansen/GFC-2020-v1.8/download.html.

[90] Vizzuality. (n.d.). Forest Monitoring, land use and deforestation trends. Global Forest Watch. Retrieved from https://www.globalforestwatch.org/.

[91] Tree cover loss. Global Forest Watch Open Data Portal. (n.d.). Retrieved from https://data.globalforestwatch.org/documents/tree-cover-loss/explore.

INDICATOR TITLE: Change in total area of one or more classes of vegetation, e.g., forest class, across the defined spatial unit(s)

RATIONALE FOR TARGETS

Each HEARTH activity should assess whether a target is appropriate for this indicator. It may be difficult to set a quantifiable target for this indicator given the multiplicity of factors that modulate forest cover loss and the fact that forest cover loss can result from natural processes. Instead, activities may choose to determine forest loss trends within and outside the HEARTH areas of influence. That is, the theory of change for an activity may indicate that overall forest loss should decelerate within HEARTH sites when compared to similar sites outside the activity's area of influence. In this case, there should not be a target for forest cover loss, but the expectation is to measure divergent trends in the two groups of sites.

INDICATOR TITLE: Change in Land Capability Classification (LCC)

DEFINITIONS:

The LCC is a land evaluation ranking that groups soils based on their potential for agriculture and other uses. LCC is used to help determine if land is suitable for certain uses as well as assess risks for degradation.[92] LCC classifies land on a scale of 1-8 to determine the best use for land, with additional sub-class codes that indicate which soil indicators are limiting factors. LandPKS uses the following definitions for determining LCC:

Class:
1. Slight limitations that restrict use
2. Moderate limitations that reduce the choice of plants or use conservations practices
3. Severe limitations that reduce the choice of plants, required conservations practices, or both
4. Very severe limitations that reduce the choice of plant or require very careful management, or both
5. Little or no hazard of erosion but have other limitations that are impractical to remove; limit use mainly to pasture, rangeland, forestland, or wildlife habitat
6. Severe limitations, unsuited for cultivation; limit use mainly to pasture, rangeland, forestland, or wildlife habitat
7. Very severe limitations, unsuited for cultivation; limit use to mainly rangeland, forestland, or wildlife habitat
8. Limitations that preclude use for commercial plant production; limit use to mainly recreation, wildlife habitat, water supply, infrastructure, or esthetic purposes

Sub-class:
- e: Erosion risk: limitations created from soil movement by wind or water
- s-a: Soil water storage capacity: limitations caused by availability of water for plants
- s-d: Soil depth: limitations caused by plant rooting depth
- s-k: Salinity: Limitations caused by risk from salinity
- s-l: Lime requirement: limitations caused by soil pH
- s-r: Surface stoniness: limitations caused by soil covered with stones and boulder
- s-t: Surface soil texture: limitations caused by soil texture near the surface (impacts to soil cultivation and seedling establishment).
- w-d: Water table depth: Limitations created by occurrence of shallow water table
- w-f: Flooding during the growing season: Limitations created by surface accumulation of water (overflow from rivers or streams, run-on from upslope areas, or topographic depressions)

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[92] LandPKS Knowledge Hub. What is Land Capability Classifcation? Retrieved from https://landpotential.org/knowledge/what-is-land-capability-classification/

INDICATOR TITLE: Change in Land Capability Classification (LCC)

DATA COLLECTION:

LCC data is collected in the LandPKS platform. Data collectors should complete the LandInfo,[93] Vegetation and LandCover,[94] and SoilHealth[95] modules in LandPKS, each with training videos available. After the soil texture, slope, and soil limitations sections are entered, the LCC can be found on the report screen. A user guide for project and impact evaluators is also available online with more details.[96]

Generally, entering more data will improve the accuracy of classification. LandPKS also allows users to adjust their LCC based on criteria that are or are not important for their use. For example, if the soil is limited by flooding during the growing season, but farmers are planning on growing rice, the flooding (w-f) indicator can be turned off, and the classification will be recalibrated without this subclass. This function can also be used to run scenarios about the potential of the soil if the user were to mitigate against particular soil risk factors.[97]

LIMITATIONS:

Unlike other LCC systems, LandPKS does not consider climate in its LCC classes due to the variability in climate requirements between different crops and cultivars. Note that this indicator is most useful for HEARTHs that include an objective related to sustainable agriculture and improvement of land for agriculture.

UNIT:	DISAGGREGATE BY:
LCC class 1 through 8, and sub-class	Farm size

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[93] Kerchof, C. (2021, January 27). Training videos: LandInfo. LandPKS. Retrieved n.d., from https://landpotential.org/knowledge/landinfo-training/.

[94] Kerchof, C. (2021, April 27). Training videos: Vegetation. LandPKS. Retrieved from https://landpotential.org/knowledge/vegetation-landcover-video-training/.

[95] Kerchof, C. (2021, April 27). Training videos: Soil Health. LandPKS. Retrieved from https://landpotential.org/knowledge/intro-to-the-landpks-soilhealth-module/.

[96] Barnese, D. (2020, December 8). User guide for project and impact evaluators. LandPKS. Retrieved from https://landpotential.org/knowledge/project-and-impact-evaluators-user-guide/.

[97] LandPKS Knowledge Hub. What is Land Capability Classifcation? Retrieved from https://landpotential.org/knowledge/what-is-land-capability-classification/

INDICATOR TITLE: Change in Land Capability Classification (LCC)
FREQUENCY: TBD – based on relevant sampling intervals	**DATA SOURCE:** HEARTH activities or farm managers will collect LCC data through LandPKS.
REPORTING NOTES
Each HEARTH activity should assess whether a target is appropriate for this indicator.

INDICATOR TITLE: Turbidity of natural aquatic environments (surface, freshwater sources) near agricultural activity sites

DEFINITION:

"Natural aquatic environments" refers to surface freshwater sources such as lakes, rivers, and streams whose turbidity and/or pH could be affected by soil erosion from agricultural activity sites.

"Turbidity" is a measure of the clarity of a liquid, i.e., how easily light transmits through the liquid. More turbid water is less clear; less turbid water is clearer.

"Near agricultural activity sites" will depend on the local context. Soil is most likely to be transported from agricultural sites via wind or water runoff to natural aquatic environments.

DATA COLLECTION:

To assess whether natural aquatic environments might be polluted with soil erosion, one simple, inexpensive, and readily available tool is the turbidity tube (also known as a transparency tube).[98, 99]

Practitioners can fill a turbidity tube with water samples and make direct observations of water clarity.

LIMITATIONS:

Regarding the validity of turbidity as a soil erosion indicator, it is important to note that events other than soil erosion might also cause water to become turbid, e.g., heavy stream flow or eutrophication. Practitioners should use sampling procedures that help identify potential links between soil erosion and observed changes in turbidity. For example, practitioners can collect samples from a stream near a farm both upstream and downstream of the farm to help isolate the source of particulates in the water; practitioners can monitor weather conditions during the water sampling periods and note whether either or both of the two main causes of agricultural soil erosion–wind and precipitation at the farm site(s)–might be correlated with turbidity measurements.

UNIT:	DISAGGREGATE BY:
	Each water sample collected should have a unique sample ID number. Samples tested for turbidity and/or pH should be

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[98] Transparency/turbidity tubes. Performance Results Plus, Inc. (n.d.). Retrieved from https://prph2o.com/transparency-turbidity-tubes/.

[99] Avanator. (n.d.). Turbidity tube. VWR. Retrieved from https://us.vwr.com/store/product/8891171/turbidity-tube.

INDICATOR TITLE: Turbidity of natural aquatic environments (surface, freshwater sources) near agricultural activity sites	
Number of centimeters of water in the tube	disaggregated by sample ID, the date the samples were collected and tested, and the locations where the samples were collected.
FREQUENCY: TBD per USAID guidance.	DATA SOURCE: Implementing partners collect natural water samples and test for turbidity.

REPORTING NOTES
Sample ID numbers, collection and test dates, sampling locations, results, and other relevant information can be stored in a spreadsheet.

RATIONALE FOR TARGETS
Some countries regulate turbidity in drinking water as a contaminant; in general, it is recommended to filter and disinfect surface freshwater sources prior to drinking. For example, the United States Environmental Protection Agency (US EPA) National Primary Drinking Water Regulations require filtration and disinfection of all public water systems that use surface freshwater sources.[100] Targets for turbidity will vary with local environmental conditions and public health regulations. For environmental protection, practitioners working on agricultural activities should strive at least to maintain baseline conditions and not contribute to soil erosion that increases turbidity. If soil erosion from agricultural activities affects public drinking water sources, practitioners should promote filtration and disinfection and comply with local regulations.

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[100] Environmental Protection Agency. (n.d.). National Primary Drinking Water Regulations. EPA. Retrieved from https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations#three.

INDICATOR TITLE: pH of natural aquatic environments (surface, freshwater sources) near agricultural activity sites

DEFINITION:

"Natural aquatic environments" refers to surface freshwater sources such as lakes, rivers, and streams whose turbidity and/or pH could be affected by soil erosion from agricultural activity sites.

"pH" is a measure of how acidic or basic water is. pH is measured on a scale from 0 to 14, with 7 being neutral. Acidic water has a pH less than 7; basic water has a pH greater than 7.

"Near agricultural activity sites" will depend on the local context. Soil is most likely to be transported from agricultural sites via wind or water runoff to natural aquatic environments.

DATA COLLECTION:

Testing the pH of water samples is simple and inexpensive; pH test strips and pH meters are widely used and readily available. Test strips are recommended because they do not require calibration. They often are sold in kits with other strips that indicate other water quality parameters.[101]

A pH meter may be more accurate than a pH test strip.[102]

But many pH meters require calibration with solution standards; without proper calibration, the meters' readings are questionable.

UNIT:	DISAGGREGATE BY:
Scale from 0 to 14	Each water sample collected should have a unique sample ID number. Samples tested for turbidity and/or pH should be disaggregated by sample ID, the date the samples were collected and tested, and the locations where the samples were collected.
FREQUENCY: TBD per USAID guidance.	**DATA SOURCE:**

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[101] Varify. (n.d.). Complete drinking water test kit. Complete Drinking Water Test Kit. Retrieved from https://varifytest.com/collections/drinking-water-tests/products/complete-drinking-water-test-kit.

[102] Sharma, T., and Singh, A. P. (2013). Laboratory practices: Useful to the new research scholars, technicians, lab caretaker of school/college/institutional laboratories. PH Testers. Retrieved from https://www.amazon.com/Lab-pH-Meters/b?ie=UTF8&node=39327101.

INDICATOR TITLE: pH of natural aquatic environments (surface, freshwater sources) near agricultural activity sites	
	Implementing partners collect natural water samples and test for pH.

REPORTING NOTES

Sample ID numbers, collection and test dates, sampling locations, results, and other relevant information can be stored in a spreadsheet.

RATIONALE FOR TARGETS

Targets for the pH of a natural aquatic system will vary with local environmental conditions. The US EPA does not regulate the pH of water, but the agency recommends that public drinking water supplies should have a pH between 6.5 and 8.5. [103] More acidic water may be more likely to be contaminated with pollutants, and more basic water may damage appliances and water pipes. Practitioners working on agricultural activities should strive at least to maintain baseline conditions and not contribute to soil erosion that alters the pH of nearby natural waters.

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[103] Environmental Protection Agency. (n.d.). National Primary Drinking Water Regulations. EPA. Retrieved from https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations#three.

INDICATOR TITLE: Presence / absence of *E. coli* bacteria in natural waters (surface, freshwater sources) near agricultural activity sites

DEFINITION:

"Natural waters" refers to surface freshwater sources such as lakes, rivers, and streams that could be contaminated by pathogenic microorganisms traveling from agricultural activity sites.

"*Escherichia coli (E. coli)*" is a type of coliform bacteria.

"Near agricultural activity sites" will depend on the local context. Microorganisms are most likely to travel from agricultural sites to natural waters by being carried on the wind or in water runoff.

DATA COLLECTION:

To assess whether natural waters might be polluted with pathogenic microorganisms, practitioners should test for *E. coli*, a reliable indicator of recent fecal contamination. There are simple, "off-the-shelf" *E. coli* test kits available that come with instructions for conducting the tests in a home or office setting (these tests will require incubation for several hours at a constant warm temperature and a fluorescent light to detect results), e.g.

- LaMotte total coliform and E. coli bacteria test kit[104]
- Simplex Health coliform bacteria water test with E. coli detection[105]

LIMITATIONS:

Presence/absence tests for *E. coli* only determine whether water is contaminated; they do not measure the amount of bacteria in contaminated samples. If implementing partners wish to quantify the amount of *E. coli* in natural waters, the best option probably will be to consult with professional water quality analysts, e.g., at a university or commercial lab.

UNIT:	DISAGGREGATE BY:
Number of test results with presence/absence of E. coli	Each water sample collected should have a unique sample ID number. Samples should be disaggregated by sample ID, the date the samples were collected and tested, and the locations where the samples were collected. Other important disaggregates are:

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[104] Forestry-Suppliers.com. (n.d.). LaMotte® total coliform and E. Coli bacteria test kit. Forestry Suppliers, Inc. https://www.forestry-suppliers.com/product_pages/products.php?mi=33252and;itemnum=77411and;redir=Y.

[105] Coliform bacteria water test with e. coli detection (1 test). SimplexHealth. (2021, October 8). https://www.simplexhealth.co.uk/product/simplexhealth-water-bacteria-test-with-e-coli-detection/.

INDICATOR TITLE: Presence / absence of *E. coli* bacteria in natural waters (surface, freshwater sources) near agricultural activity sites	
	Sample, positive control, negative control: If positive and/or negative control samples are used, results for the natural water samples should be disaggregated from results for the controls
FREQUENCY: TBD per USAID guidance.	DATA SOURCE: Implementing partners collect natural water samples and test for presence/absence of *E. coli.*

REPORTING NOTES
Sample ID numbers, collection and test dates, sampling locations, results, and other relevant information can be stored in a spreadsheet.

RATIONALE FOR TARGETS
Both the US EPA[106] and the WHO[107] recommend that drinking water should not contain any *E. coli*. It is considered unsafe to drink water that is contaminated with *E. coli.*

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[106] Environmental Protection Agency. (n.d.). Revised Total Coliform Rule and Total Coliform Rule. Retrieved from https://www.epa.gov/dwreginfo/revised-total-coliform-rule-and-total-coliform-rule.

[107] Guidelines for drinking-water quality, second edition, addendum to volume 1: Recommendations. (1999). Chemistry International -- Newsmagazine for IUPAC, 21(2). https://doi.org/10.1515/ci.1999.21.2.49a.

INDICATOR TITLE: Change in concentration of nitrites and nitrates in natural aquatic environments (surface, freshwater sources) near agricultural activity sites

DEFINITIONS:

Nitrite and nitrate are constituents and/or byproducts of inorganic commercial fertilizers and animal waste used as fertilizer, and they are commonly found in natural aquatic environments near agricultural activity sites.

- Nitrite (chemical formula NO_2^-) is a negatively charged molecule consisting of one nitrogen atom and two oxygen atoms.
- Nitrate (chemical formula NO_3^-) is a negatively charged molecule consisting of one nitrogen atom and three oxygen atoms.

"Natural aquatic environments" refers to surface freshwater sources such as lakes, rivers, and streams whose concentrations of nitrite and nitrate could be affected by fertilizer runoff from agricultural activity sites.

"Near agricultural activity sites" will depend on the local context. Fertilizer that contains or is chemically converted into nitrites and nitrates will most likely be transported from agricultural sites via water runoff to natural aquatic environments.

DATA COLLECTION:

There are many simple, inexpensive, and readily available commercial kits that include test strips of indicator paper for measuring levels of nitrite and nitrate. They often are sold with other strips that indicate other water quality parameters.[108,109]

UNIT:	DISAGGREGATE BY:
Parts per million (ppm)	Each water sample collected should have a unique sample ID number. Samples tested for nitrite and nitrate should be disaggregated by sample ID, the date the samples were collected and tested, and the locations where the samples were collected.
FREQUENCY: TBD per USAID guidance.	DATA SOURCE:

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[108] Complete drinking water test kit. Varify. (n.d.). Retrieved from https://varifytest.com/collections/drinking-water-tests/products/complete-drinking-water-test-kit.

[109] 16 in 1 drinking water test kit strips, 100 CNT. Home Water Quality Test for Water. Med Lab Diagnostics. (n.d.). Retrieved from https://www.medlabdiagnosticssupplies.com/products/16-in-1-drinking-water-test-kit-strips-200-cnt-home-water-quality-test-for-water.

	INDICATOR TITLE: Change in concentration of nitrites and nitrates in natural aquatic environments (surface, freshwater sources) near agricultural activity sites	
		Implementing partners collect water samples and test for nitrite and nitrate.

REPORTING NOTES
Sample ID numbers, collection and test dates, sampling locations, results, and other relevant information can be stored in a spreadsheet.

RATIONALE FOR TARGETS
The amount of nitrite and nitrate in natural aquatic systems will vary with local environmental conditions. Practitioners working on agricultural activities should strive at least to maintain baseline conditions and not contribute to fertilizer runoff that increases concentrations of nitrite and nitrate.
If fertilizer runoff from agricultural activities affects public drinking water sources, practitioners should aim to not exceed local health regulations or WHO guidelines for nitrite (3 mg/L) and nitrate (50 mg/L). [110]

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[110] Nitrate and nitrite in drinking-water. (n.d.). Retrieved from https://www.who.int/water_sanitation_health/dwq/chemicals/nitrate-nitrite-background-jan17.pdf.

INDICATOR TITLE: Greenhouse gas (GhG) emissions, estimated in metric tons of CO2 equivalent, reduced, sequestered, or avoided through sustainable landscapes activities supported by USG assistance[111]

DEFINITION:

Sustainable landscapes programming slows, halts, or reverses greenhouse gas emissions from land use, including forests and agricultural ecosystems.

This indicator reports the estimated quantity of GhG emissions, in metric tons of CO2-equivalent, reduced, sequestered, or avoided supported in full or in part by USG assistance, as compared to a baseline level of GhG emissions. The baseline is the "business-as-usual" reference for GhG emissions that would have occurred during the reporting period if there had been no USG intervention.

This indicator applies to estimated emissions reduced, sequestered, or avoided, for the specified reporting period. This can include both emissions reductions from activities implemented during the reporting period as well as activities which were implemented during a previous reporting period but are still achieving ongoing reductions in GhG emissions. Implementers are encouraged to include these continuing results by estimating tons of CO2e avoided during the current reporting period. Regarding land use-related emissions reductions or increased sequestration, if a USG supported project continues to conserve the same hectares of land as in a previous reporting period, those hectares should be included in the calculations for the current reporting period to determine the emissions reductions of the project.

DATA COLLECTION:

This indicator is a calculated estimate, and often not the result of direct emissions measurements. This indicator applies to estimated GhG emissions reductions from carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and other global warming pollutants. Relevant sectors for projects that may report on this indicator include, but are not limited to, climate change, natural resource management, agriculture, biodiversity, energy, industry, urban, and transport.

The 100-year Global Warming Potential of gases from the Intergovernmental Panel on Climate Change 4th Assessment Report or later should be used for calculations.

Land-Use Programs (including Sustainable Landscapes):

USAID has developed the AFOLU Carbon Calculator using standard methodologies and some default data. All Sustainable Landscapes programs (focused or indirect) must reference and adhere

[111] USAID. (2020). 2020 GCC Standard Indicator Handbook: Definition Sheets. Climate Links. Retrieved from https://www.climatelinks.org/sites/default/files/asset/document/2020_USAID_GCC-Indicator-Handbook-August-2020-Update.pdf.

INDICATOR TITLE: Greenhouse gas (GhG) emissions, estimated in metric tons of CO2 equivalent, reduced, sequestered, or avoided through sustainable landscapes activities supported by USG assistance[111]

to the methods and tools in the USAID AFOLU Carbon Calculator (http:/www.afolucarbon.org) if applicable, unless a more rigorous calculation is available.

UNIT:	DISAGGREGATE BY:
Metric tons of CO_2 equivalent (tCO_2e)	N/A

FREQUENCY:	DATA SOURCE:
Annually. However, reporting by implementing partners may be required on a more frequent basis.	Data will be collected and reported by implementing partners with knowledge of their specific activities and programs.

REPORTING NOTES
All USAID Operating Units should document tools, methods, and data sources used for this indicator in the PPR Sustainable Landscapes Key Issue Narrative.

INDICATOR TITLE: Number of hectares under improved management expected to reduce greenhouse gas emissions as a result of USG assistance[112]

DEFINITION:

Sustainable landscapes programming slows, halts, or reverses greenhouse gas emissions from land use, including forests and agricultural ecosystems.

Emissions of GHGs, such as carbon dioxide (CO_2) and methane (CH_4), can be reduced, avoided, or sequestered as a result of improved management practices, including protection, restoration, and management.

For hectares included under this indicator, the improved management approaches applied must be reasonably expected to result in emission reductions.

'Improved management' includes protection, restoration, and management activities that reduce emissions while promoting enhanced management of natural resources for one or more objectives, such as mitigating climate change, conserving biodiversity, maintaining ecosystem services, strengthening sustainable use of natural resources, and/or promoting community participation. An area is considered to be under improved management practices when, at least partially as a result of USG support, additional areas have been conserved or restored, or additional emissions reductions are expected be achieved due to changes in management planning, implementation of management plans or policies, or application of data to management decisions and enforcement actions.

Improved management should be reported for activities where the USG-supported activity can be plausibly linked to the approaches applied. Implementing partners should clearly articulate the milestones used to gauge success and provide a short narrative describing the milestones reached in the reporting period. The conversion to hectares of some management actions can be challenging but should be based on the theory of change behind how the management action is expected to lead to emissions reductions. Operating Units should document tools, methods, and data sources used for this indicator in the PPR Sustainable Landscapes Narrative.

Hectares reported may include sustained improvements in previously reported hectares and/or new, additional hectares. The same hectares should only be reported once per year per implementing mechanism.

Results for this indicator should be classified under two sets of disaggregates:

1) The type of intervention: Protection, Restoration, or Management; and
2) The intervention land type: Forest or Non-Forest.

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[112] USAID. (2020). 2020 GCC Standard Indicator Handbook: Definition Sheets. Climate Links. Retrieved from https://www.climatelinks.org/sites/default/files/asset/document/2020_USAID_GCC-Indicator-Handbook-August-2020-Update.pdf.

INDICATOR TITLE: Number of hectares under improved management expected to reduce greenhouse gas emissions as a result of USG assistance[112]

'Protection' includes improved management activities that prevent the loss of native ecosystems. Examples of protection include: reducing conversion of forests to agricultural lands; preventing or mitigating forest fires; halting or slowing illegal mining or logging; preventing the loss of biodiversity and native ecosystems; and supporting the enforcement of designated protected areas.

'Restoration' includes improved management activities that expand the spatial extent of native cover types, including forest and non-forest ecosystems, to areas from where they had previously been lost or degraded as a result of human activity. Examples of restoration include: planting native trees in degraded forested areas; peatland restoration; and rehabilitating mangroves or watersheds for improved ecosystem services.

'Management' includes improved management activities that avoid or reduce GhG emissions or enhance carbon sinks on working or managed lands through improved management practices. Examples of management include: planting fruit, woodfuel, and/or timber trees for economic development; alternate wetting and drying of rice; improved agroforestry and silvopastoral systems; nutrient management; and improved grazing practices.

'Forest' lands can be defined broadly for the purpose of this indicator. Operating Units may choose to refer to the definition of forests used by the local government (e.g., the country Forest Reference Emission Level) or partner organizations (e.g., Food and Agriculture Organization (FAO)). Examples of landscapes included under this disaggregate are: forest in national parks, nature reserves and other protected areas; forest stands on agricultural lands (e.g., windbreaks and shelterbelts of trees); mangrove forests; peat swamp forests; and plantation forests (e.g., timber, pulp, rubber).

'Non-forest' lands include areas with little or no tree cover. Examples of landscapes included under this disaggregate are: rice paddies; pastures with few or no trees; agricultural lands (e.g., oil palm, fruit, coffee, cacao plantations); and agroforestry systems.

DATA COLLECTION: Implementing Partners should collect geospatial data associated with the hectares under improved management. These data should be collected at the relevant scales of implementation or impact of the activities or sub-activities (e.g., national, provincial, municipal, household, or plot). These datasets should further be tagged and calculated for each applicable disaggregate: protection, restoration, and management.	
UNIT:	DISAGGREGATE BY:

INDICATOR TITLE: Number of hectares under improved management expected to reduce greenhouse gas emissions as a result of USG assistance[112]	
Number of hectares	Type of intervention: Protection, Restoration, or Management Intervention land type: Forest or Non-Forest
FREQUENCY: Annually. However, reporting by implementing partners may be required on a more frequent basis.	DATA SOURCE: Data will be collected and reported by implementing partners with knowledge of their specific activities and programs. Implementing partners will collect geospatial data or other documentation to estimate the number of hectares under improved management based on the expected impact of the management improvements that have been applied.
REPORTING NOTES	
If an area with expected emission reductions under improved management is also a biologically significant area for biodiversity (indicator EG10.2-2) or shows improved biophysical conditions (indicator EG10.2-1), then the corresponding hectares can be reported under each applicable indicator in the same year.	

Annex 1. Guidance For Using Global Forest Watch Data

Data collected, stored, and analyzed in support of USAID activities should comply with the guidance in ADS Chapter 579 (USAID, 2021a). Spatial data must also comply with the guidance included in "Geographic Data Collection and Submission Standards. An Additional Help for ADS 579" (USAID, 2021b). The latter covers important points about managing data risk, geographic data collection standards, and geographic data asset submission standards. All HEARTH implementing partners collecting and analyzing data (including spatial data) must be familiar with the contents of these Agency documents and implement actions to ensure that data collection and submission comply with their guidance.

Estimating Forest Extent

The GLAD dataset allows for a definition of forest cover as an estimated percentage of tree canopy closure for all vegetation taller than 5 meters and is encoded as a percentage per output grid cell, in the range 0 – 100. That is, each cell is attributed with a value between 0 (no canopy cover of vegetation taller than 5 meters) and 100 (complete cover of vegetation taller than 5 meters). Users can select   thresholds appropriate for specific definitions of forest cover. The suggested default for HEARTH MERL is 30%, meaning that cells with a value greater than 30 are considered forested. In GFW, users can define the threshold percentage in the web interface and can select a threshold between 0 and 75 in the tabular data; in GLAD, the threshold selection needs to be implemented through map algebra.

In the GLAD dataset, layers labeled *treecover2000* (plus a convention for specific 10 x 10-degree granules) contain tree cover in the year 2000. Layers labeled *lossyear* (plus a convention for specific 10 x 10-degree granules)[113] contain forest loss during the period 2000 – X,[114] defined as a stand-replacement disturbance, or a change from a forest to non-forest state; it is encoded as either 0 (no loss) or else a value in the range 1–X, representing loss detected primarily in a year ranging from 2001 to X.[115]

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[113] For example, forest extent in the year 2000 for southern Madagascar is in the layer treecover2000_20S_040E.tif and forest loss per year is in the layer lossyear_20S_040E.tif.

[114] At the time of writing the data ranged from 1 to 20.

[115] For example, a cell of value 18 represents an area where forest loss was detected in 2018.