Capacity strengthening in climate change vulnerability and adaptation strategy assessments

Exercise 2
Vulnerability Indicators

In collaboration with:

Exercise 2: Selection of vulnerability indicators to assist in developing adaptation strategies to climate change and natural disasters

Objective: The objective of this exercise is to select and assemble a group of indicators, or when necessary, aggregated indices, to assist in climate change/natural disasters vulnerability assessments and the identification of adaptation strategies.

As a first step, the working group must decide which **geographical area** (region, country, municipality, or community) will be used for this exercise. The area may be **real or hypothetical**.

The purpose of the exercise is to develop, in either table or graphic format, vulnerability indicators/indices at different scales. These indicators should represent the vulnerability of different groups, sectors or regions in order to assist the decision-making process in identifying appropriate adaptation options at different levels. The indicators will be used not only in the vulnerability analysis but also to explore mitigation/adaptation options to face current and future climate impacts.

To keep in mind throughout the exercise:
The current practice in vulnerability assessments is to begin by defining the framework for the analysis. Once the framework has been chosen, one may select a series of indicators for a given theme/domain (e.g. livelihoods, natural resource management) and problem (e.g. natural disasters, climate variability). The indicators can be gathered into a numeric or spatial database based on the information available and the scale of analysis needed (e.g. municipalities, villages or communities for livelihoods; or hydrographic basins, territories, ecosystems for natural resource management). The different layers or data can also be aggregated into a single index, using either simple or elaborate techniques.

To provide information from vulnerability assessments that is relevant to the decision-making process, it is necessary to go beyond simply using indicators or aggregation techniques. One should take the following into consideration when undertaking an assessment:

- The different indicators, indices or a combination of the two that could be used in an assessment, depending on: which field of study is chosen; the nature of the analysis; the spatial and temporal scales of the studied system; and the levels and contexts of the decision-making process for which one seeks to provide information. The needs and perspectives of the stakeholders should also be considered.

- The different methods for selection, aggregation, and assessment must be transparent and understandable. This will ensure that the results of the assessment are used and that they can be verified by experts and stakeholders and validated in the field. Furthermore, it will ensure that information derived from the indicators is turned into concrete action.

- Vulnerability is a dynamic process. To assess it, one must possess a good knowledge of the current situation, the evolution and trends of the problems faced by the vulnerable, and the resources and choices that may be available to stakeholders in the future, including vulnerable groups themselves. Vulnerability assessments and indicators are not ends in themselves, but have

to support the decision-making process for the selection, exploration and monitoring of the best adaptation strategies and measures.

- The level of vulnerability is a function of the risks/hazards faced by vulnerable groups, their exposure to these risks as well as their adaptive capacity and the adaptation options available to them.

The steps and tools outlined in this exercise are **illustrative** only. They are not a "cooking book". Working groups are free to be creative and innovative in their work as long as it remains pragmatic, intelligible and transparent.

Time management is crucial as groups need to ensure that they will have enough time to finish the exercise as well as to prepare a synthesis report that will be presented in plenary.

Step 1 – Choose a methodological framework to guide the selection of indicators according to the system, domain or theme under consideration
The point of departure for any assessment is to first select an appropriate methodological framework able to bridge the development process and its components to the associated vulnerability and its impacts.

As a group, select a methodological framework to guide the indicator selection process. Keep in mind that indicator selection will be a function of the system (socio-ecological, socio-economic, sectoral, etc) and the problem (natural disasters, climate change, desertification, etc) assessed and the themes (livelihoods, food security, heath, etc), geographical scale (local, regional, national or global), and the decision-making level (country, regional, community) of that theme.

⇒ *Example: a group may decide to study the vulnerability of the Sahelian region to natural disasters and climate variability (drought), paying particular attention to the community level and the associated adaptation options available.*

At this stage, it is important that the group have a good overview of the problem/situation that it will be assessing in order to choose the right methodological framework for analyzing the vulnerability of the resources, stakeholders, sectors and regions to that problem/situation.

Step 2 – Indicator identification and selection, and compilation of required data
Identify, select and compile the indicators needed to assess the chosen problem based on the available geographical or numerical data (or a combination of the two), expert opinions and the hypotheses and assumptions made in the selected methodological framework.

⇒ *The table below outlines a number of possible indicators that could be used to assess vulnerability to, and identify adaptation strategies for, natural disasters and climate variability, using the diagnostic-prognosis-response framework.*

Examples of Indicators

Risk/Vulnerability		***Options/Responses***	
Bio-physical	*Social*	*Bio-physical*	*Social*
· *Frequency of natural disasters* · *Risk of flooding* · *Risk of landslides* · *Risk of drought* · *Location of agricultural lands* · *Extent of agricultural lands at risk* · *Extent of urban areas at risk*	· *Number of poor* · *Level of access to basic services* · *Population at risk* · *Infrastructure at risk* · *Loss per disaster* · *Risk of disasters/ population affected* · *Risk of disasters/ GDP affected*	· *Land-use systems* · *Agricultural diversification* · *Production systems* · *Crop adaptation* · *Ecosystem rehabilitation*	· *Insurance against climate risks* · *Building codes* · *Early warning systems* · *Prevention standards* · *Projects of relocation*

Different types of indicators exist for each situation and set of stakeholder needs. The methods for identifying, selecting and developing vulnerability indicators have been presented in Modules 2 & 3 (case study #1) of the training material.

Step 3 – Standardizing indicators

Initially, indicators may be expressed in qualitative (e.g. binary yes/no answers) or quantitative terms. If all the indicators used in the study do not use the same units, their values must be standardized. The standardization process will transform the indicator data into one scale and will ensure that all indicators' values are in the same direction (i.e. high values correspond to high levels of vulnerability and so on).

In general, standardization can be done using simple arithmetic. The easiest way to do this is to transform all of the raw data into relative values on one scale (either a percentage scale were 0 is the lowest value and 100 is the highest; or a 5-point scale). Occasionally, it may be necessary to inverse the values for some indicators (e.g. in the case were a vulnerability of 0 may represent the highest level of vulnerability) so that all indicators progress according to the same direction (from lowest to highest vulnerability). One may also chose to define certain values as thresholds, which will represent limits or significant values with regards to different objectives for development, vulnerability reduction or implementation of adaptation measures (also see Exercise 3 on Multi-criteria analysis for a greater discussion on how to standardize scores).

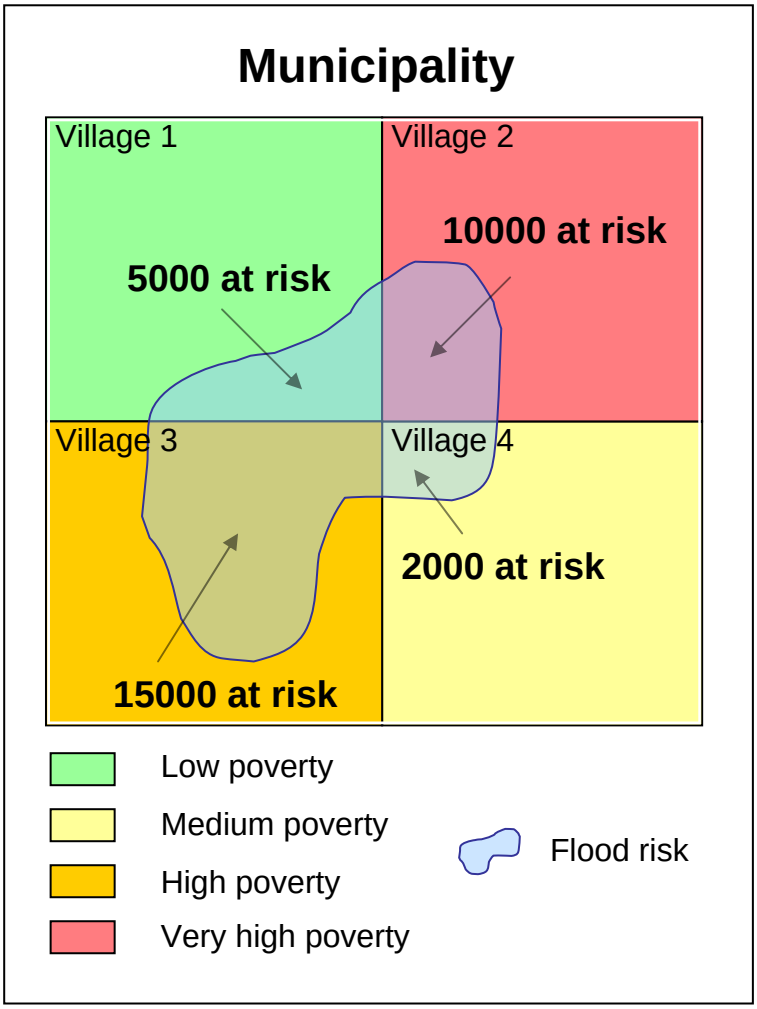
⇒ *Example: one may classify poverty data for a municipality representing 50 000 inhabitants spread in 4 villages, which are all at risk of flooding, as follows (also see graphic below):*

- *Green Zone: Class 1 – low level of poverty (60 - 100% of needs are met);*
- *Yellow Zone: Class 2 – medium level of poverty (40 - 60% of needs are met);*
- *Orange Zone: Class 3 - high level of poverty (20 - 40% of needs are met); &*
- *Red Zone: Class 4 – very high level of poverty (less than 20% of needs are met).*

*In each village the number of poor people at risk of flooding is known (see numbers in the figure below). In village 1, 5,000 inhabitants belonging to poverty class 1 or 10% of the total population (5,000/50,000*100) are exposed. In village 2, 10,000 inhabitants belonging to poverty class 4 or 20% of the total population (10,000/50,000*100) are exposed. In village 3, 15,000 inhabitants belonging to poverty class 3 or 30% of the total population (15,000/50,000*100) are exposed and in village 4, 2,000 inhabitants belonging to poverty class 2 or 4% of the total population (2,000/50,000*100) are exposed.*

If we use the numbers of the various poverty classes as weights, with 1 representing the lowest level of poverty and 4 the highest, we can also calculate the weighted risk of each village. Thus, village 1 has a weighted risk of 10% (10% x 1), village 2, 80% (20% x 4), village 3, 90% (30% x 3), and village 4, 8% (4% x 2). With these weighted risks we can see that even though the population at risk in village 3 is at a lower poverty level (class 3), the village suffers from a greater risk overall than village 2 (90% vs. 80%) because more people are exposed.

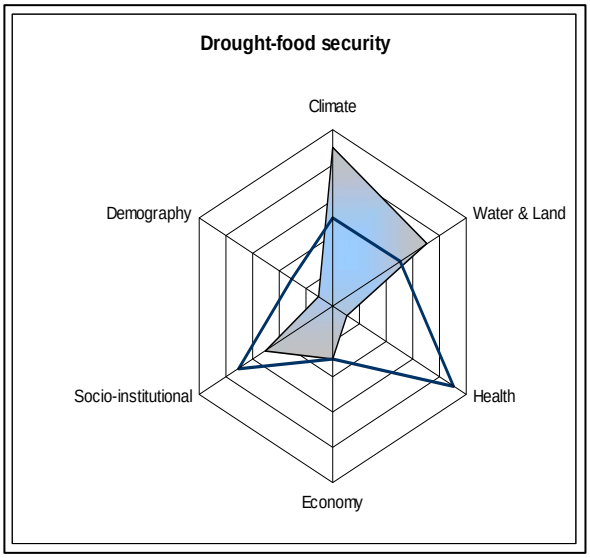
The total weighted risk of all 4 villages is 188 (10+80+90+8). The highest possible weighted risk for all villages is 400 (class 4 x 100% of population). To convert to a 100 point scale we divide the observed weight risk/total risk level (i.e. 188/400 x100%) which yields 47%.



Conclusion: There are a number of ways to combine indicators using the simple statistic tools described here.

Step 4 – Development of vulnerability profiles to visualize and diagnose the structure of the risks and the current vulnerability, using the indicators selected

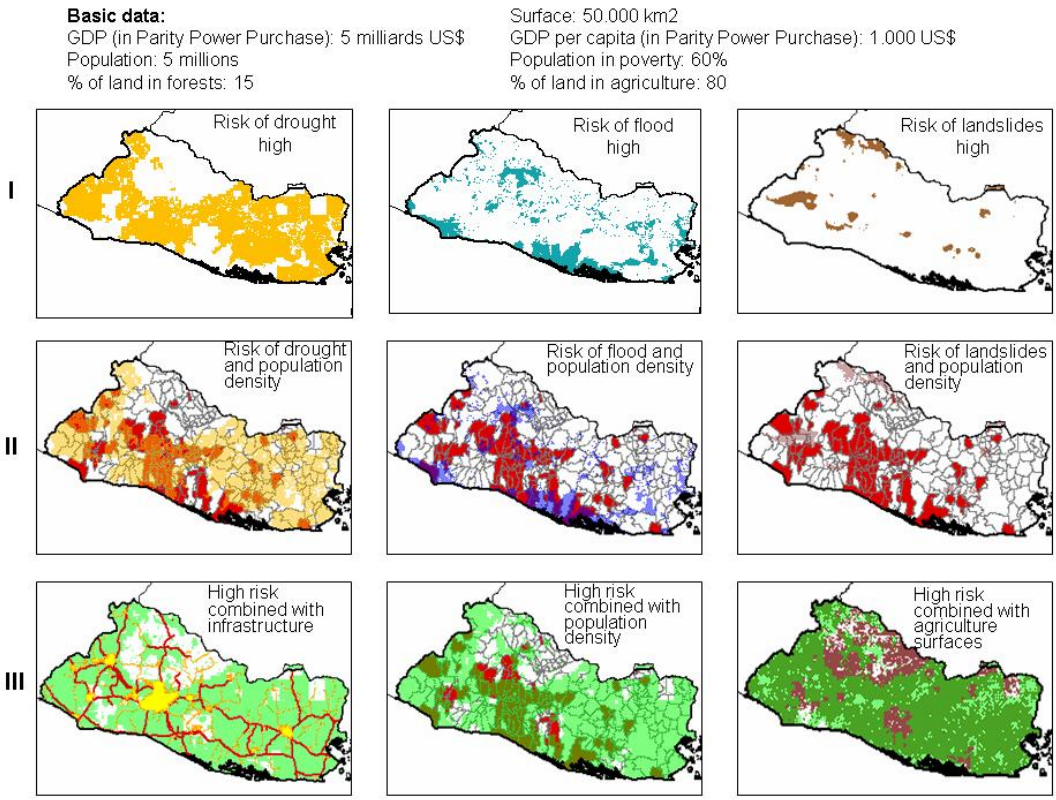
Identify, represent and analyze the different aspects and elements of vulnerability (e.g. relative importance of different factors, current trends, weight of the different risks and vulnerable groups, etc) with the ultimate goal of developing vulnerability profiles (both graphic and narrative). Vulnerability profiles assist in the selection and development of adaptation measures. It also enables one to visualize vulnerability.



⇒ This figure is an example of a vulnerability profile of small landholders' vulnerability to drought-related food security issues. It is a livelihoods-based profile in polygonal format. This type of profile can be made for different stakeholder groups and for different time periods. In the figure, the axes represent the factors that influence the level of vulnerability (climate, water & land, demography, health, socio-institutional, economy, etc). The coloured area represents the level of vulnerability experienced by small landholders. Each factor is represented by an indicator (e.g. the climate indicator is frequency of drought) or an index (e.g. the economic indicator is the Gini co-efficient of GDP).

One can visualize the vulnerability of social groups, sectors, geographical regions or administrative units to different bio-physical and socio-economic factors using simple maps based on spatial indicators. Such visualization can assist in the elaboration of vulnerability profiles. The geographical data and maps in the figure below illustrate the vulnerability of hypothetical communities (at risk of droughts, floods or landslides), the number of people at risk as well as the most vulnerable sectors and economic activities. Vulnerability profiles can provide an indication of which groups, sectors, and regions are the most vulnerable and thus facilitate the process of identifying urgent needs that must be addressed through adaptation options.

Vulnerability profiles can be very useful in the exploration of future trends and developments as well as in the comparison of the vulnerability of different groups or regions.



The methods to develop and use vulnerability profiles are presented in Modules 2 & 3 (Case studies 1-3) of the training material.

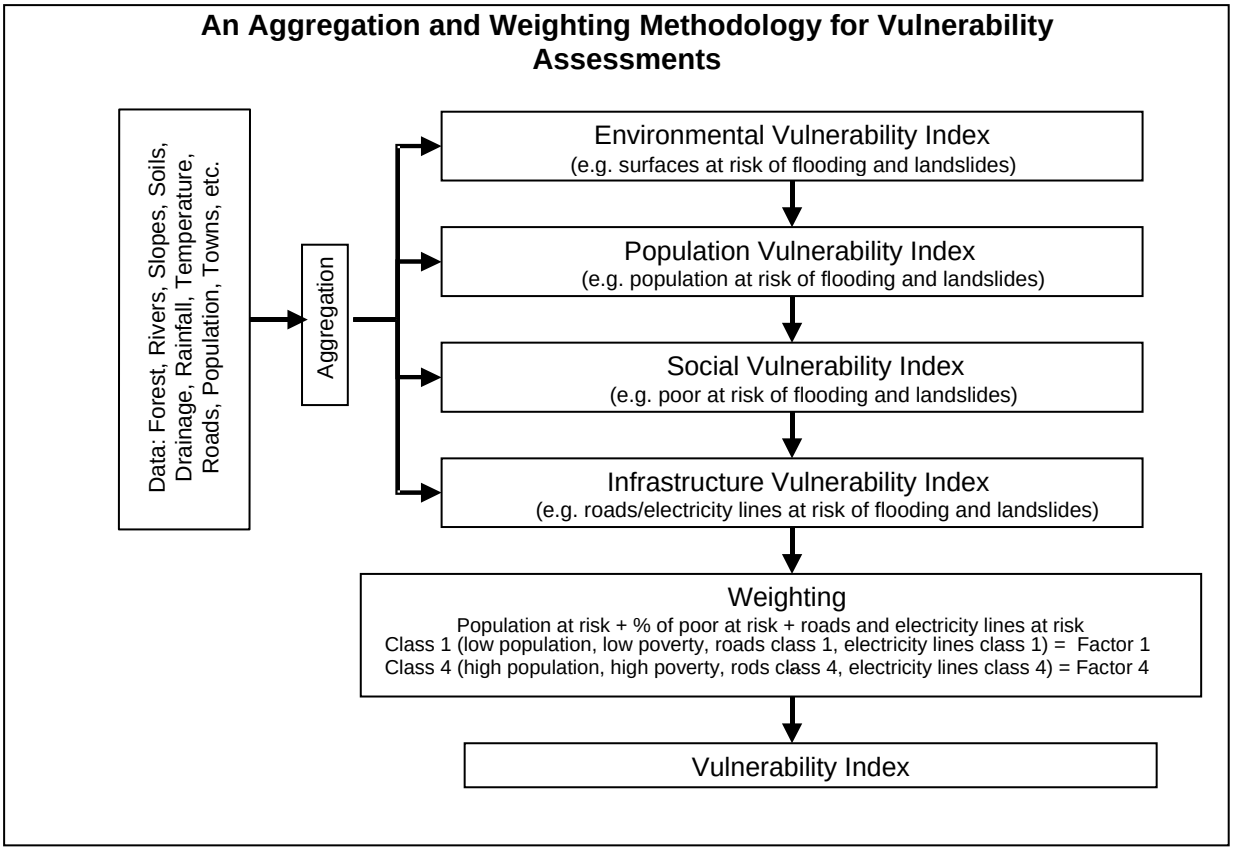
Step 5 – Choose the model, aggregation and weighting methods to develop vulnerability indicators

Model and method choice depends on the framework of analysis and the objectives of the assessment. Simpler methods are more appropriate for rapid assessments of vulnerable groups and regions.

⇒ *The figure below is an example of a simple aggregation and weighting method that can be used to develop vulnerability indicators for different themes (social, infrastructural or environmental vulnerability) and a total vulnerability index. Indicators weights should be chosen by experts, in consultation with stakeholders and users, to ensure that all dimensions, concerns and perceptions are reflected. In the example below, stakeholders and users decided that poverty, poor road conditions and electrical lines at risk where the most important elements in the analysis and thus gave them a higher weight.*

More complicated aggregation models and methods exist that can, for instance, identify cause and effect relationships by examining the relationships between the various indicators. In this case, the vulnerability of communities at risk of floods or landslides can be deduced from a model for quality/location of housing and land-use. GIS (Geographical Information Systems) can also be used to predict and document the results, as is the case with the economic impacts of droughts and floods. In such cases, it is necessary to undertake a statistical analysis to determine which indicators are robust in their ability to predict the likely impacts.

Aggregation and weighing methods and the use of various tools to develop vulnerability indicators and indices are presented in Modules 2 & 3 (Case studies 1-3) of the training material.



Step 6 – Sensitivity analysis and validation of the indicators and their results
As in all exercises where data is transformed into information or where modeling is used to recreate a complex reality, uncertainties exist in the data and aggregation methods used. To ensure the validity of the results, the level of uncertainty must be analyzed. Each indicator, index and weight has a certain degree of uncertainty attached to it. For instance, uncertainty exists due to the collection and availability of data and to the changing nature of natural phenomena over time. Undertaking a sensitivity analysis will allow one to explore the range of uncertainty attached to the results, even for future scenarios and adaptive capacity measures. Furthermore, a sensitivity analysis must also be done to validate the indicators and information used with the stakeholders to ensure that the field reality and differing perspectives and perceptions have been reflected.

The methods and tools to conduct a sensitivity analysis are presented in Modules 2 & 3 (Case studies 1-3) of the training material.

Step 7 – Linking vulnerability assessments to adaptation strategies
Vulnerability indicators are not an end in themselves, but tools to link and support decision-making, and the selection and exploration of adaptation measures, options and strategies. Vulnerability profiles, based on indicators, that target vulnerable socio-economic groups and regions at risk as well as appropriate response options, are the primary link between vulnerability assessments and the adaptation measures

decision-making process. Indicators can be used together with alternative scenarios to examine the trends and predict which underlying processes will affect vulnerability and its effects. Multi-criteria analysis can assist in the selection of adaptation options that will reduce the vulnerability of target groups, based on the needs and priorities of socio-economic groups, productive sectors, environmental goods and services and specific geographic regions.

⇒ *Example: a number of adaptation options exist for urban and rural zones of the municipality described in Step 3. For the urban zones, adaptation/mitigating options include: dredging and channeling rivers, reforestation and rehabilitation of marginal lands, and relocation of populations at high risk. For the rural zones, adaptation/mitigating options include: developing climate-related agricultural insurance programs, changing production and land-use systems through agricultural diversification, terrace development and improving crop variety and agricultural systems.*

Examples of methods and tools to use to go from vulnerability assessments to adaptation strategies are presented in Modules 2 & 3 (case studies 1-3) of the training material.

Step 8 – Monitoring vulnerability and adaptation strategies

A vulnerability and adaptation assessment only becomes valuable when the expected results and impacts are assessed and exploited. Indicators are appropriate tools to monitor changes in the vulnerability of target groups, sectors and regions as a result of implementing adaptation options and measures. It is thus possible to monitor the efficiency of adaptation options and to re-adjust them, as appropriate. The indicators selected for the monitoring process must be sensitive to the anticipated changes whatever they may be.

⇒ *The adaptation options proposed for the urban and rural zones of the municipality (described in step 7) need to be evaluated in light of their ability to reduce vulnerability in the short-term, to prevent vulnerability in the long-term and their compatibility with the political realities of the decision-making process.*

Examples of methods and tools to monitor vulnerability and adaptation are presented in Module 3 (case studies 1-3) of the training material.

Examples of tools useful for this exercise

Scenario development and analysis: Description and analysis of certain key parameters (climatic and other) for the selected horizon time.

Vulnerability indicators: Representation of different vulnerability indicators for different groups.

Livelihood indicators: Analysis of vulnerable groups based on development actions.

Syndromes: Semi-quantitative models for the identification of the links and effects of society-environment relationships.

Vulnerability Profiles: Indicator mapping and analysis for different groups, regions or sectors.

Interactive/participatory GIS: Use of GIS, with the relevant stakeholders, to identify critical links and hotspots.

Multi-criteria analysis: Rank and weight the possible options and responses, using a number of decision-making criteria.

Strategic environmental assessment: Analysis of the state of the environment and the impacts before the identification of options and response measures.

Useful references for this exercise available on-line:

Dow K., 2005, Vulnerability Profile of West Africa, Working Paper, Poverty and Vulnerability Programme, Stockholm Environment Institute (SEI), Stockholm, Sweden.
http://63.166.104.204/sei/seipubs.nsf/Lookup/DBA9C6275C6E9D4EC1256FE1004C6204/$file/West_Africa.pdf
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Winograd M et al., 2000, Vulnerability indicators: A Case study for Honduras, A web-based application, CIAT, Cali, Colombia.
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