Food and Agriculture
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SDG INDICATOR 2.4.1

PROPORTION OF AGRICULTURAL AREA
UNDER PRODUCTIVE AND SUSTAINABLE AGRICULTURE

Sub-indicator methodological sheets

18 October 2017

Contents

Land Productivity

Dimension: Economic
Theme: Land Productivity
Sub-indicator: Farm output value per farm agricultural area

Aim and relevance

What is the reason we need to focus on this theme? What is the relevance for decision-making?

Land productivity is a measure of agricultural outputs (volume valued in constant prices) obtained on a given area of land. Maintaining or improving the output over time relative to the area of land used is an important aspect in sustainability for a range of reasons. At farm level, in the land productivity reflects the technology and production process, and quantity and quality of environmental inputs (e.g. soil and water), among other factors. In a broader sense, increases in the level of land productivity enable higher production without utilizing increasingly scarce land resources, commonly linked to deforestation and associated losses of ecosystem services and biodiversity.

What concept needs to be measured?

Expressing the theme in terms of what exactly we try to capture

Measures of land productivity are aimed at providing information on the area of land required to produce agricultural output valued in constant prices. It is a measure of the production relationship between land and output in physical terms and as for any productivity measure, should be independent of changes in the prices of land and changes in the prices of output.

Definition of the sub-indicator

Define the selected sub-indicator, including relevant formula as appropriate and explain choice.

Farm output (valued in constant prices) / Farm Agricultural Area

How should this be measured (Data source and methods):

Different sustainability indicators require different data collection methods. Four main methods have been identified that cover the different dimensions of sustainability: farm survey; household surveys; landscape-level measurements (including remote sensing; GIS, or other geography-based measurements), or administrative surveys. The section should describe the merits of different measurement approaches, with particular note of the potential to use farm surveys.

Information on farm agricultural area and outputs should be standard information available from farm surveys thus providing a good basis for assessment at farm level.

<u>Farm output:</u> The volume of agricultural output at farm level generally takes into account production of multiple outputs, e.g. crop types and crop and livestock combinations, etc. Since the volume of agricultural outputs is not measured in commensurate units (e.g. not all outputs are measured in tonnes, and tonnes of different output represent different products), it is necessary to establish an appropriate means of aggregation, in this case using a monetary unit. A simple way to enable

aggregation is to reflect the multiple outputs produced by a single farm in terms of values (i.e. quantity multiplied by prices).

Farm agricultural area: Farm area is defined as the area used for agriculture within the farm. Thus, ideally, following the interim land use classification of the System of Environmental-Economic Accounting (SEEA), and consistent with the application of this classification for the World Agricultural Census 2020. It includes:

- Land under temporary crops
- Land under temporary meadows and pastures
- Land with temporary fallow
- Land under permanent crops
- Land under permanent meadows and pastures
- Agricultural land under protective cover

The farm agricultural area should exclude areas of the farm that have been set aside for conservation and the maintenance of ecosystems and biodiversity. The agricultural area of the holding could comprise of land owned, rented and other type of land tenure. Nomadic livestock and common land are out of scope as well other agricultural activities not associated to land.

The key variables for estimating land productivity are as follows:

- .Variables:
  - Farm output (valued in constant prices)
  - Average farm gate prices of the commodities
  - Farm Agricultural Area
- Data items:
  - Quantities of all agricultural products and by-products produced by the farm
  - Farm gate prices of all products and by-products produced
  - Farm agricultural area in hectare
- Unit of Measurement (UoM):
  UoM of the data items: Enlist physical unit of measurements for quantity of production for crops (i.e. tonnes, KGs, bushels, etc.), and livestock (i.e. number of animals by types, species, breeds and by-products with specific appropriate units) and respective prices to convert it into monetary units.
  UoM of the sub-indicator: Currency per hectare
- Reference period:
  12 months
- Estimations domains:
  - Types of activity
  - Agro-ecological zones

What would be the criteria to use to assess sustainability for this theme:

Indicate thresholds used in the literature or propose thresholds and give justification

The criteria proposed is to assess land productivity performance of a given farm against a threshold derived from the estimated frontier of productivity of the sampled farms. The threshold is defined as one third of the 90th percentile.

The assessment should be done by type of activity and agro-ecological zones. Meaning the productivity performance of the farm will be compared to a reference value for the respective activity type and/or agro-ecological zone.

For type of activities, the reference is ISIC rev-4 of which the country should select the main categories relevant and important to them. For most of the countries the relevant categories refers to these group. Mainly:

- 011 - Growing of non-perennial crops
- 012 - Growing of perennial crops
- 014 - Animal production
- 015 - Mixed farming

The relevant types of animal production should be taken into account according to country livestock activities e.g. ruminants, non-ruminants, milk etc.

Depending on country size and environmental specificities, the productivity assessment also should take into account the different agro-ecological zones like arid, semi-arid, humid etc.

The relevant domains (i.e. combinations of activities and agro-ecological zones) will be country specific and the analysis by domain will depend on the sample size and design of the farm survey.

Link with other SDG indicators:

Indicate whether this indicator can relate fully or partially to other SDG indicators.

This indicator links directly to SDG-2.3.1 concerning land productivity in small and medium scale agriculture.

Notes:

Provide any notes that you consider relevant in relation to this sub-indicator.

Review of metrics used in the literature:

There are many ways to assess the quantity of output and land input to arrive at productivity estimates. Some examples are given below;

- Farm output volume (valued in constant prices) / farm agricultural area
- Farm value added (valued in constant prices) / farm agricultural area
- Gross value of agricultural production / farm agricultural area
- Net farm income / farm agricultural area
- Volume of output / Planted Area

For this sub-indicator we are recommending the land productivity formula: Farm output volume (valued in constant prices)/ farm agricultural area (in hectares).

Rationale and caveats:

As majority of the agricultural holdings produce several output using many inputs, outputs and inputs generally needs to be converted into monetary units for aggregation into a common measure and comparison across productivities of different commodities.

As productivity measures are always volume based either expressed in physical quantities, or in constant value terms, implying that values be adjusted for price change. This requires time series for outputs and inputs volumes, prices and price indices. Obtaining the correct price or price indices adds significantly to the complexity of productivity measurement, most of which is related to matching the correct price (or index) to the product or input. Over the years, the research has suggested using different price indices for deflating outputs and inputs, each with different properties and each yielding different results.

However, in the sustainability assessment, the analysis focuses on the comparison across farms for the given year; in this sense, the usage of current vs constant prices is less relevant, although the constant prices could provide a more stable relative price across commodities.

This sub-indicator refers to the total agricultural output of the holding consequently, the denominator measures the total agricultural area of the farm comprising area devoted to both crops and livestock.

For more information:

- *http://gsars.org/wp-content/uploads/2017/02/TR-17.02.2017-Productivity-and-Efficiency-Measurement-in-Agriculture.pdf*
- https://www.oecd.org/std/productivity-stats/2352458.pdf
- https://unstats.un.org/unsd/cr/registry/regcs.asp?Cl=27&Lg=1&Co=01

Farm Profitability

Dimension: Economic
Theme: Farm Profitability
Sub-indicator: Net Farm Income

Aim and relevance

What is the reason we need to focus on this theme? What is the relevance for decision-making?

An important part of sustainability in agriculture is the economic viability of the farm, driven to a large extent by its profitability. Profitability here is measured using Net Income that the farmer is able to earn from farming operations.

Availability and use of information on farm economic performance, measured using profitability, will support better decision making both at micro and macro-economic level. Since performance measures drive behavior, better information on performance can alter behavior and decision-making by government and producers both in large-scale commercial farming, medium and small-scale subsistence agriculture.

What concept needs to be measured?

Expressing the theme in terms of what exactly we try to capture

To capture and assess, whether the level of income earned by the farm is reasonable while taking into account factors of production and assets employed. The focus of this sub-indicator is on income from farming operations as distinct from the total income of the farming household which may be sourced from activities in other areas, for example, employment in local businesses by other family members, tourism activity, etc. While these other sources of income are important in the context of assessing the sustainability of living in rural areas, they are not of direct relevance in the assessment of the sustainability of agriculture.

Net Farm Income measures: 1) return to unpaid operator and family labour; 2) return to operator's management and risk and 3) return to investment and owner of equity[1].

Definition of the sub-indicator

Define the selected sub-indicator, including relevant formula as appropriate and explain the choice.

Formula:

[1] http://wr.colostate.edu/ABM/abmincomestatement.pdf

Total Net Farm income	Total farm cash receipts including direct program payments ***(plus)*** Income in kind ***(minus)*** Total operating expenses after rebates (including costs of labour) ***(minus)*** Depreciation ***(plus)*** Value of inventory change

Discussion:

One of the key considerations in selecting a sub-indicator for this theme is to define precisely the activities that generate farm income. These should align with the activities included in the measurement of the Land Productivity sub-indicator.

The following definitions and notes are relevant for this sub-indicator[2];

The main data source should be farm income accounts (likely collected via a farm survey) which provide an annual measure of income returned to the owners of agricultural businesses from the production of agricultural commodities. Two points should be noted:

1. Farm income accounts only relate to the farm business. They do not include any income that farm operators or their families may receive from other sources (wages and salaries, investment income, etc.)
2. Farm income accounts pertain only to the production and marketing of agricultural commodities. Revenue or expenses related to the sale or purchase of farm capital (real estate, machinery and equipment) are not included.

Other key definitional issues are:

- Net farm income refers to the return (both monetary and non-monetary) to farm operators for their labor, management and capital, after all production expenses have been paid (that is, gross farm income minus production expenses). It includes net income from farm production, the value of commodities consumed on the farm, depreciation, and inventory changes.
- Gross farm income refers to the monetary and non-monetary income received by farm. Its main components include cash receipts from the sale of farm products, direct program payments to producers, other farm income (such as income from custom work), value of food and fuel

[2] Substantial part of the methodology have been adopted from Canada Statistics: http://www.statcan.gc.ca/pub/21-010-x/21-010-x2014001-eng.pdf

produced and consumed on the same farm, and change in value of year-end inventories of crops and livestock[3].

- Farm cash receipts include revenues from the sale of agricultural commodities in local currency units that include sales of crops, livestock and its by-products.
- Direct program payments to producers included in farm cash receipts represent the amounts paid under various government and private programs to individuals involved in agricultural production. The payments related to current agricultural production include subsidies to encourage production or to compensate producers for low market returns, payments to stabilize incomes and payments to compensate producers for crop or livestock losses caused by extreme climatic conditions, disease or other reasons and insurance payments.
- Income-in-kind measures the value of the agricultural goods produced on farms and consumed by farm operator families. It is included to measure total farm production.
- Operating expenses represent business costs incurred by farm businesses for goods and services used in the production process. Expenses include both purchase and self-produced items that are: property taxes, custom work, seeds, rent, fertiliser and lime, chemicals, machinery and building repairs, irrigation, fuel for heating and machines, wages, interest and business share of insurance premiums.
- Depreciation charges account for the economic depreciation or for the loss in fair market value of the capital assets of the farm business. Calculated on farm buildings, farm machinery, and the farm business share of autos, trucks and the farm home, depreciation is generally considered to be the result of aging, wear and tear, and obsolescence. It represents a decrease in the potential economic benefits that can be generated by the capital asset.
- Value of inventory change (VIC) measures the currency value of the physical change in producer-owned inventories. This concept is used to value total agricultural economic production. To calculate VIC, the change in producer-owned inventories (between the end and the beginning of a calendar year) is first derived and then multiplied by the average annual crop prices or value per animal. This calculation is different from the financial or accounting book value approach, which values the beginning and ending stocks, and then derives the change.
- The VIC over all the major commodities can vary widely (depending on the size of the change of inventories and prices). The VIC can be either positive (when inventories are larger at the end of the year compared to the beginning levels) or negative (when year- end inventories are smaller than the levels at the beginning of the year). If the inventory levels are the same at the beginning and end of the year, VIC will be zero despite price changes.

How should this be measured (data sources and methods):

Different sustainability indicators require different data collection methods. Four main methods have been identified that cover the different dimensions of sustainability: farm survey; household surveys; landscape-level measurements (including remote sensing; GIS, or other geography-based measurements), or administrative surveys. The section should describe the merits of different measurement approaches, with particular note of the potential to use farm surveys.

Estimating profitability at a farm level will generally require compilation of basic farm financial records, i.e. daily, weekly, monthly or seasonal transactions in an organized way. In general, large commercial

3 Rental value of farm dwellings is not considered as part of farm income.

farms maintain detailed financial records however, in case of medium farms and small subsistence agriculture, record keeping is seldom practiced and in most of the countries it doesn't exist at all.

Where the detailed data ideally required are not available at farm level especially in case of small holders and household sector, then:

a. Estimates will be developed based on farmer declaration of outputs and inputs quantity (and appropriate prices) and/or sales and purchases.
b. Depreciation, variation of stocks and taxes could be neglected..

- Variables:
  - Farm Cash Receipts
  - Income in kind
  - Direct program payments
  - Operating Expenses
  - Depreciation
  - Value of Inventory change
- Data:
  - Output (crops and livestock products and by-products marketed or self-consumed) quantity and prices
  - Inputs quantity and prices (
  - Other farm incomes generating activities (renting machines and direct program payments)
  - Operating Expenses
- Unit of Measurement (UoM):
  - Currency units
- Reference Period:
  - 12 months

What would be the criteria to use to assess sustainability for this theme:

Indicate thresholds used in the literature or propose thresholds and give justification

Proposed:

This sub-indicator implicitly reflects an understanding that the appropriate threshold for this theme is whether, for an individual farm, the net farm income is positive or negative.

The proposed threshold is set at zero – i.e. net farm income greater than zero is considered sustainable while zero or negative net farm income is considered unsustainable. This threshold can be applied irrespective of the mix of production, the location of the farm or size of operation.

Link with other SDG indicators:

Indicate whether this indicator can relate fully or partially to other SDG indicators.

SDG-2.3.2 on agricultural productivity

Notes:

Provide any notes that you consider relevant in relation to this sub-indicator.

Productivity indicators constitute an essential piece of information for the ag Data collection challenges:

i. Access to farm financial records / income statements in case of large and medium private commercial farms (protected by confidentiality laws).
ii. Non-availability of detailed financial records for small and subsistence farms and the capacity of farmers to record or recall relevant information and understand the requirements.
iii. Non-availability of records for farms on common lands.
iv. Collection and estimation of farm gate and market prices by region for different type of products.

Financial Resilience

Dimension: Economic
Theme: Financial Resilience
Sub-indicator: Access to financial services

Aim and relevance

What is the reason we need to focus on this theme? What is the relevance for decision-making?

Resilience refers to the properties of a system that allow it to deal with shocks and stresses, to persist and to continue to function well (in the sense of providing stability, predictable rules, security and other benefits to its members). Resilience encompass absorptive, anticipatory and adaptive capacities (Bahadur et al., 2015)[4].

Better understanding of the factors and processes that contribute to farm resilience results in shifting farming systems from equilibrium- based command-and-control management approaches towards sustainable food production systems. For a farm to continue during the period of expected growth and in phases of turbulent change, the farmer has to implement strategies to leverage its current strengths on one hand and build adaptability and transformability on the other in the face of scarce resources (Ika et al., 2008)[5].

However, before resilience can be assessed, it is crucial to specify what system state is being considered (resilience of what) and what perturbations are of interest (resilience to what) (Ika et al., 2008)[6]. The goal is for a farm to be sustainable and to persist that is to maintain its identity in the face of both internal change as well as external shocks and disturbances (Cumming et al. 2005[3], Loring 2007[7]).

Focusing on the ability of a farm to maintain its identity as a cohesive unit through space and time implies that its functions must be maintained, but not necessarily its components. The farm is expected to change its activities over time, e.g., shift from dairy production to pig fattening, stop animal husbandry, grow different crops, or convert to organic farming. Such a change in components or a reconfiguration of resources is a system innovation that entails a degree of reorganization, but not a loss of identity.

When studying farm resilience, the external and internal drivers of change must be clearly stated i.e. the kind(s) of change that the system is to be resilient to, as well as the time scale considered. There are wide range of stressors and drivers from the ecological, economic and social domain that a farm

[4] Bahadur, A.V., Peters, K., Wilkinson, E., Pichon, F., Gray, K. and Tanner, T. (2015) The 3As: Tracking resilience across BRACED. Working Paper. London: ODI

[5] Ika Darnhofer, Henrik Moller and John Fairweather (2008) Farm resilience for sustainable food production: A conceptual framework. Working Paper.

must be able to tackle. Farm resilience also needs to cover several spatial scales, i.e. from the ecological processes at the field-level to the social processes at the farm level (e.g. farm family cycle) and at the local and regional level (e.g. knowledge networks, social and cultural capital) (Ika et al., 2008)[8].
What concept needs to be measured? *Expressing the theme in terms of what exactly we try to capture* The concept to be measured is the capacity of the farm to prevent, resist, adapt and recover from internal and/or external shocks i.e. how resilient is the farm? However, to apply resilience at farm level, the concept needs to be operationalized, so that it is empirically measurable but the abstract, multi-dimensional nature of the concept of resilience makes it difficult to do so (Cumming et al. 2005)[9]. Several frameworks have been developed to capture the dynamic and multi-dimensional aspects of resilience. In the context of indicator 2.4.1, it is not feasible to provide a multi-dimensional assessment of resilience. Given this, the sub-indicator, “Access to Financial Services (Credit and/or Insurance)” is proposed as a proxy to capture some aspects of resilience. Access to financial services is important as it enables the vulnerable and disadvantaged strata of the society (characterized by fewer resources and lack access to social safety nets) especially those involved in and dependent on agricultural sector to become more resilient to market and climate shocks (Wilkinson and Peters, 2015)[10].The presence and access to suite of financial services help people plan ahead, adapt to changes, and absorb shocks by mitigating and managing risks. But these services are not always universal in terms of availability, accessibility and affordability particularly for the most vulnerable in the society. Provision of financial services (credit and insurance) is therefore a key policy area for building resilience (Zwendu, 2014)[11].
Definition of the sub-indicator *Define the selected sub-indicator, including relevant formula as appropriate and explain the choice.* Farmer access to financial services (i.e. credit and/or insurance) to prevent, resist, adapt and recover from shocks.
How should this be measured (Data source and methods): *Different sustainability indicators require different data collection methods. Four main methods have been identified that cover the different dimensions of sustainability: farm survey; household surveys; landscape-level measurements (including remote sensing; GIS, or other geography-based measurements), or administrative surveys. The section should describe the merits of different measurement approaches, with particular note of the potential to use farm surveys.*

[9] Cumming et al. (2005) An Exploratory Framework for the Empirical Measurement of Resilience. 8: 975–987.
[10] Wilkinson, E. and Peters, K. (2015) *Climate extremes and resilient poverty reduction: Development designed with uncertainty in mind*. London: ODI.
[11] Zwendu, G.A. (2014) Financial inclusion, regulation and inclusive growth in Ethiopia. Working Paper 408. London: ODI

The data on farmer declaration about the access to credit and/or insurance can be collected using farm survey and/or community surveys.

Access is defined as when a given service is available and the holder has enough means to obtain the service (required documents, collateral, positive credit history, etc.)

The type of survey questions that are relevant in assessing access to finance are the following:

<u>Loans and Financing:-</u>

Q1: In 20XX or the last agricultural year, did this agricultural holding obtain any loans (both formal and informal)?
* Include cash loans and in-kind loans (e.g., seeds provided by another farmer and repaid with a share of the harvest, seeds, etc.) only for agriculture related investments.

- Yes
- No, I have access but I didn't avail it
- No, I didn't have access

<u>Insurance:-</u>

Q2: Was the Agricultural holding covered by Insurance in 20XX or in the last agricultural year?

- Yes
- No, I have access but I didn't avail it
- No, I didn't have access

<u>Data sources:</u>

These include:

- Farm based surveys with geo-referenced information
- Additional modules in existing agricultural surveys
- Community Survey

What would be the criteria to use to assess sustainability for this theme:

Indicate criteria used in the literature or propose criteria and give justification

Proposed sustainability criteria:

Farms with positive access to at least one of the financial services i.e. with answers "Yes" and "No (I have access but I didn't avail it)" are considered sustainable otherwise the answers "No (I didn't have access)" for both credit and insurance are unsustainable.

Link with other SDG indicators:

Indicate whether this indicator can relate fully or partially to other SDG indicators.

N/A

Notes:

Provide any notes that you consider relevant in relation to this sub-indicator.

N/A

Soil health

Dimension: Environmental
Theme: Soil health
Sub-indicator: Soil health

Aim and relevance

What is the reason we need to focus on this theme? What is the relevance for decision-making?

Soil health refers to "the continued capacity of the soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity, promote the quality of air and water environments, and maintain plant, animal and human health" (FAO and ITPS, 2015). With more than 95% of food being directly or indirectly produced from soil, healthy soil forms the foundation of productive and sustainable agriculture and is a key theme under Sub-indicator 2.4.1.

By implication of its definition, healthy soil ensures a habitat and growth medium with an adequate supply and availability of water and nutrients to plants, microbes and soil fauna. Soil health is therefore established by ensuring the balanced interaction of the physical, chemical and biological properties of soil that collectively determine a soil's productivity.

A key soil component that contributes to this balanced interaction in the various soil properties is soil organic matter (SOM) which supports various soil functions related to plant growth, soil biodiversity, soil water, land degradation, and greenhouse gas dynamics (which links to climate change). Soil organic matter is measured by the content in soli organic carbon (SOC). Monitoring SOC is probably the most integrative way to assess trends in soil health. Unfortunately, measuring and reporting on SOC is complex and expensive.

Many of the processes affecting soil health over the past century have been driven by agricultural practices (ITPS 2015). Unsustainable cultivation of soils has been causing changes in vegetation cover, rooting depth and organic matter turnover, as well as soil biodiversity. As a result, the availability of plant litter and residues are often reduced, diminishing biological activity (organic matter decomposition, transformation and stabilization) and subsequently nutrient availability.

FAO and the ITPS (2015) have identified 10 main threats to soil functions: soil erosion; soil organic carbon losses; nutrient imbalance; acidification; contamination; waterlogging; compaction; soil sealing; salinization and loss of soil biodiversity. The following four threats have been selected to assess the level of sustainability of agriculture in relation with soil health: erosion; nutrient imbalance; waterlogging; salinization. They combine the characteristics of being representative of the impact of agricultural practices on soil health, and of being relatively easily to assess through simple surveys.

What concept needs to be measured?

Expressing the theme in terms of what exactly we try to capture

This indicator should help measuring the extent to which agricultural practices result in or degrading soil health.

Definition of the sub-indicator

Define the selected sub-indicator, including relevant formula as appropriate and explain choice.

$$\boldsymbol{Soil\ Health} = \min_{\boldsymbol{n}:\mathbf{1-4}}(\boldsymbol{SHn})$$

where n = number corresponding to a given threat to soil health:

n=1: soil erosion

n=2: nutrient imbalance

n=3: waterlogging

n=4: salinization

SHn = -1 if the problem is observed on half of the farm area or more

0 if the problem does not exist or exists only on a small part of the farm area

How should this be measured (Data source and methods):

Different sustainability indicators require different data collection methods. Four main methods have been identified that cover the different dimensions of sustainability: farm survey; household surveys; landscape-level measurements (including remote sensing; GIS, or other geography-based measurements), or administrative surveys. The section should describe the merits of different measurement approaches, with particular note of the potential to use farm surveys.

FAO's LADA Programme has developed a set of guidelines to assess soil health, status and trends at global, national and farm levels (http://www.fao.org/nr/lada/). These three scales are linked to each other and allow for a good assessment of the situation at all levels.

Farm questionnaires can offer a relatively robust way or assessing soil health with respect to the above four threats. The type of survey questions that are relevant in assessing soil health according to these four dimensions is as follows:

<u>Soil erosion:-</u>

Q1: Over the last 5 years, did you notice loss of soil by washing or wind blowing from your farm

- Yes, the problem affects half of my farm or more → SH=-1
- Yes, but less than half of my farm is affected → SH=0
- No, I am not aware of such problem → SH=0
- The problem existed but the situation has improved → SH=1

<u>Nutrient balance:-</u>

Q2: Over the last 5 years, did you notice a reduction in the fertility of your soil (production is reducing, and/or you have to abandon part of your land because it is not any more productive)

- Yes, the problem affects half of my farm or more → SH=-1
- Yes, but less than half of my farm is affected → SH=0
- No, I am not aware of such problem → SH=0
- The problem existed but the situation has improved → SH=1

<u>Waterlogging:</u> Q2: Over the last 5 years, did you notice excessive accumulation of water on part of your holding that affects production (production is reducing, and/or you have to abandon part of your land because it is not any more productive) • Yes, the problem affects half of my farm or more → SH=-1 • Yes, but less than half of my farm is affected → SH=0 • No, I am not aware of such problem → SH=0 • The problem existed but the situation has improved → SH=1 <u>Salinization:</u> Q2: Over the last 5 years, did you notice accumulation of salt on the surface of your soil which affects its productivity (production is reducing, and/or you have to abandon part of your land because it is not any more productive) • Yes, the problem affects half of my farm or more → SH=-1 • Yes, but less than half of my farm is affected → SH=0 • No, I am not aware of such problem → SH=0 • The problem existed but the situation has improved → SH=1 <u>Data sources:</u> Farm based surveys with geo-referenced information
What would be the criteria to use to assess sustainability for this theme: *Indicate thresholds used in the literature or propose thresholds and give justification* See above. If SH is < 0, then the farm is unsustainable from the viewpoint of soil health. If SH = 0, this indicates that there is no degradation of soil health, and therefore the farm is sustainable from the point of view of soil health.
Link with other SDG indicators: *Indicate whether this indicator can relate fully or partially to other SDG indicators.* This indicator is linked to SDG 15.3.1 but focuses on local level assessment, while 15.3.1 is mostly computed through remote sensing data processing.
Notes: *Provide any notes that you consider relevant in relation to this sub-indicator.* ***Soil organic carbon measurement*** Soil organic carbon is the most important indicators of soil health. Below are some technical discussions on the way it could be assessed. Soil organic carbon is measured through sampling and analysis by national soil laboratories. In the framework of the Global Soil Partnership, members of the International Network of Soil Information Institutions (INSII) are committed to prepare a map of national soil organic carbon stocks based on standard laboratory analyses, and by spatially inter– and extrapolating sample data on the basis of soil types and environmental factors. In order to calculate SOC stocks, the measurement of bulk density and stone content of the soil samples is essential. Common methods used include wet and dry oxidation, while dry combustion for SOC measurement may be recommended rather that the more commonly used and cheaper Walkley and Black method, because the latter requires correction factors to compensate for incomplete oxidation. Dry combustion has high analytical costs, however, and

requires extensive sample preparation and destruction. The application of this analytical method in reference laboratories has been regarded necessary to build large spectral libraries and develop accurate calibration models (FAO, 2017).

It is practically extremely difficult to set up a system of measurement of soil organic carbon as part of a farm survey. Ideally, this should be assessed by taking several samples of soil in each farm and measure soil organic carbon in laboratories. Such measurements would be extremely expensive if they were to be made in sufficient quantity on each farm in a farm survey. However, there is large potential in the use of innovative methods that can rapidly and inexpensively characterize SOC, such as visible and near-infrared (Vis-NIR) and mid-infrared (MIR) reflectance spectroscopy which have produced good results for the prediction of SOC content (FAO, 2017). Such methods need regular calibration with wet and dry chemistry, but may be very useful in generating more regular assessments of SOC to determine changes in SOC stocks which can be cross-referenced with more intermittent sampling for wet or dry chemistry analyses.

Various modelling approaches such as memory-based learning combined with stratified analyses are promising means to optimize calibration and unlocking the potential of spectroscopic techniques to accurately and quickly determine SOC at larger scales (FAO, 2017). This includes the use of space-borne and air-borne remote sensing techniques which enable assessments over large areas, but are limited in terms of sampling depth and need surrogate indices for SOC determination (FAO, 2017).

Thresholds:

1. Where the IPCC-Tier 2 default approach is used:
   a. Reference soil carbon stocks will be determined and documented for all major soil types, stratified by climate regions.
   b. Stock change factors and emission factors will be determined and documented for all land uses/management systems, and where needed, any additional sub-types.
2. An assessment of SOC stocks within each homogeneous land cover unit of the defined disaggregation scheme will be made for the baseline.
3. An average SOC stock will be generated for each identified stratum for the baseline period. The 95% confidence interval around the mean will also be reported.
4. During the reporting period, the monitored SOC will be compared with the average baseline SOC for the same minimum unit of land by calculation the relative percentage change.
5. The most appropriate method to assess whether change results in a significant decrease in SOC (degradation) or an increase or no change in SOC (no degradation) will be applied. Where estimated overall uncertainties are relatively low, a statistical approach is the most robust way to estimate whether change is significant. However, in most cases, uncertainty is likely to be high and a thus statistical assessment is not recommended. As an alternative, assessment of both the direction of change and magnitude of the relative percentage change in SOC stocks, relative to some defined threshold, is suggested.
6. Increases in SOC stocks may not always be representative of a positive change. Potential false positives and explainable anomalies should be defined, justified and maintained in the original dataset.

Thresholds for soil erosion by water are provided by Morgan (2000), which identified the following erosion severity classes:

Soil erosion table

The table below offers a description of the different erosion severity classes as described by Morgan (2000).

Table 1. Erosion severity classes (Morgan, 2000).

Erosion class	Verbal assessment	Erosion rate (t/ha)	Visual assessment
1	Very slight	<2	No evidence of compaction or crusting of the soil. No wash marks or scour features. No splash pedestals or exposed roots or channels.
2	Slight	2–5	Some crusting of soil surface. Localised wash but no or minor scouring. Rills (channels $<1\,m^2$ in cross-sectional area and <30 cm deep) every 50–100 m. Small splash pedestals where stones or exposed roots protect underlying soil.
3	Moderate	5–10	Wash marks. Discontinuous rills spaced every 20–50 m. Splash pedestals and exposed roots mark level of former surface. Slight risk of pollution problems downstream.
4	High	10–50	Connected and continuous network of rills every 5–10 m or gullies ($>1\,m^2$ in cross-sectional area and >30 cm deep) spaced every 50–100 m. Washing out of seeds and young plants. Reseeding may be required. Danger of pollution and sedimentation problems downstream.
5	Severe	50–100	Continuous network of rills every 2–5 m or gullies every 20 m. Access to site becomes difficult. Revegetation work impaired and remedial measures required. Damage to roads by erosion and sedimentation. Siltation of water bodies.
6	Very severe	100–500	Continuous network of channels with gullies every 5–10 m. Surrounding soil heavily crusted. Integrity of the pipeline threatened by exposure. Severe siltation, pollution and eutrophication problems.
7	Catastrophic	>500	Extensive network of rills and gullies; large gullies ($>10\,m^2$ in cross-sectional area) every 20 m. Most of original surface washed away exposing pipeline. Severe damage from erosion and sedimentation on-site and downstream.

Water health

Water quality

Dimension: Environmental
Theme: Water health
Sub-indicator: Water quality
Aim and relevance *What is the reason we need to focus on this theme? What is the relevance for decision-making?* Agriculture can affect water health by altering the quality of water bodies (rivers, lakes and aquifers) through excessive use and inadequate management of chemicals like fertilisers and pesticides, thus harming the ecosystem and affecting all other water-related services. Intensive livestock production can also lead to excessive concentrations of ammonia leaching in the water bodies (rivers and aquifers). In arid regions, the leaching of salt in irrigated fields may lead to excessive concentrations of salts in rivers. Sustainable agriculture therefore implies that that levels of chemicals and salts in water remain within acceptable boundaries.
What concept needs to be measured? *Expressing the theme in terms of what exactly we try to capture* The extent to which agriculture contributes to a reduction in water quality and related ecosystem services. Ideally, the impact of farming practices on water quality should be assessed by measuring the quality of water that seeps from the farm into groundwater or that feeds river reaches. Measuring water quality would capture all possible causes of agricultural pollution. In order to ensure cost-effectiveness, the focus has been put on the single most important sources of water pollution from agriculture, i.e. nitrogen pollution.
Definition of the sub-indicator *Define the selected sub-indicator, including relevant formula as appropriate and explain the choice.* Agricultural area of the farms that contribute to nitrogen pollution. Nitrogen pollution is expressed as the concentration of nitrates in groundwater and rivers (expressed in mg NO_3/l for groundwater and mg N/l for rivers) above a given threshold. A farm will be considered: ***Unsustainable*** (with respect to water quality) if nitrogen concentration in neighbouring rivers and aquifers is above agreed threshold AND farm makes use of nitrogen fertiliser. ***Sustainable*** (with respect to water quality) if nitrogen concentration in neighbouring rivers and aquifers is below agreed threshold OR farm makes low use of nitrogen fertiliser.
How should the sub-indicator be measured (Data source and methods): Water flows through the landscape, and all water users and land users in a given river basin or aquifer are connected through the water cycle. Activities in one part of a basin affect users in other parts, and only combined effects of all water and land use activities can be associated with a certain level of water health.

It is practically impossible to set up a system of measurement of nitrates pollution through farm surveys. Ideally, this should be assessed by measuring the quality of water that seeps from the farm to the groundwater or feeds river reaches. Such measurements would be extremely expensive if they were to be made on each farm in a farm survey.

This must be reflected in the monitoring protocol. This is why a dual approach is proposed to assess water pollution and the impact of farming activities:

- A first step consists in analysing data at regional level, based on information collected by institutions in charge of water monitoring. A national map showing areas with excessive levels of nitrogen pollution is derived from this information.
- A second step consists in understanding whether a given farm contributes or not to the regional water health problem. Farm questionnaire focusing on nitrogen fertiliser use practices and livestock activities is used to understand to what extent single farms are likely to contribute to the problem.
- The combination of these two steps indicate whether a farm is sustainable from the viewpoint of nitrogen pollution. Only those farms that are located in areas showing excessive level of pollution and are likely to contribute to the problem will be considered unsustainable.

All analyses are based on annual average concentration data from single monitoring stations (groundwater or river monitoring stations). Such monitoring networks are usually maintained by agencies in charge of ambient water quality. Analyses are made in laboratories on the basis of samples collected from these water points.

Note: The above definition assumes that all farms using nitrogen fertiliser contribute to nitrogen pollution when they are located in an area with high level of nitrogen pollution. This is a simplification as it does not consider the rate of fertiliser application, nor does it consider other factors that influence nitrogen pollution. Nitrogen pollution from agriculture is directly related to farming practices, in particular the volume and application modalities of mineral nitrogen fertiliser, and the volume of livestock manure produced. Other factors that influence the possibility of nitrogen pollution include soil types, topography, and the frequency and distribution of rainfall events.

What would be the criteria to use to assess sustainability for this theme:

Indicate thresholds used in the literature or propose thresholds and give justification

The EU standards consider that water bodies are polluted when water in rivers and groundwater reach a nitrate concentration above 50 mg NO_3/l (equivalent to 11.3 mg N/l).

Link with other SDG indicators:

Indicate whether this indicator can relate fully or partially to other SDG indicators.

SDG 6 deals with ‘Water for all’, and includes considerations of access to water and sanitation, the conservation of water-related ecosystems, water use efficiency, water scarcity and water pollution. In particular, the following SDG indicators are related to this sub-indicator:

6.3.1 Percentage of wastewater safely treated, disaggregated by economic activity (Note: this indicator talks about municipal wastewater mainly)
6.3.2 Percentage of receiving water bodies with ambient water quality not presenting risk to the environment or human health

Notes:
The value of 25 mg NO_3/l is used as a threshold of concern that would trigger remedial action. The WHO guidelines for drinking water quality indicate a threshold of 10 mg N/l, very close to the above value used by the EU.

Assessment of the existing sources of data and information
In the first phase, the existing data sources will be screened and assessed in order to identify to what extent the available data is sufficient and adapted to construct the proposed sub-indicator.

Region with water pollution problems are usually places where intensive agriculture or livestock raising is practiced. FAO's SOLAW (2011) provides a map showing the level of crop production intensification across countries. Countries or regions with low productivity are unlikely to experience major nitrate pollution. Instead, regions showing high levels of productivity may be exposed to nitrate pollution problems.

In terms of potential impact of livestock, an additional measurement issue is that the geographical distribution of livestock is highly variable, with places of high concentration surrounded by large areas with minor livestock density. FAO produced a map showing the estimated distribution of livestock (expressed in livestock units) across the world. Areas in the higher concentration classes are more likely than others to be associated with local nitrogen pollution from livestock production, but even in regions with low livestock density, one can observe local areas with high concentration of livestock and possible pollution problems.

Data on water quality are usually collected by institutions related to the Ministry of Environment or Ministry of Health. In some countries, they are collected by River Basin Organisations. Data for surface water (rivers, lakes, etc.) may not always be collected by the same entity as data on groundwater. The density of monitoring sites and frequency of data collection are also extremely variable.

An assessment of the existing sources of data and information will therefore start with a review of existing institutions in charge of ambient water quality. These institutions develop and maintain water-related databases. As a starting point, one can refer to the AQUASTAT country profile[12], maintained by FAO, and which provides a brief overview of the country's agricultural water-related issues, institutions and policies.

Water-related databases typically include the following:
- Water quality data from boreholes
- Water quality data from rivers and lakes
- Associated water flow (rivers) and levels (groundwater)

Institutions in charge of water quality also produce regular assessments, yearbook and statistics on the state of water quality. Maps are produced on the basis of point measurements and models to provide estimates of the geographical distribution of water quality.

In addition, the AQUASTAT country profile[13] provides some information about the availability of water quality data in countries. The AQUASTAT country profile does not provide specific data on

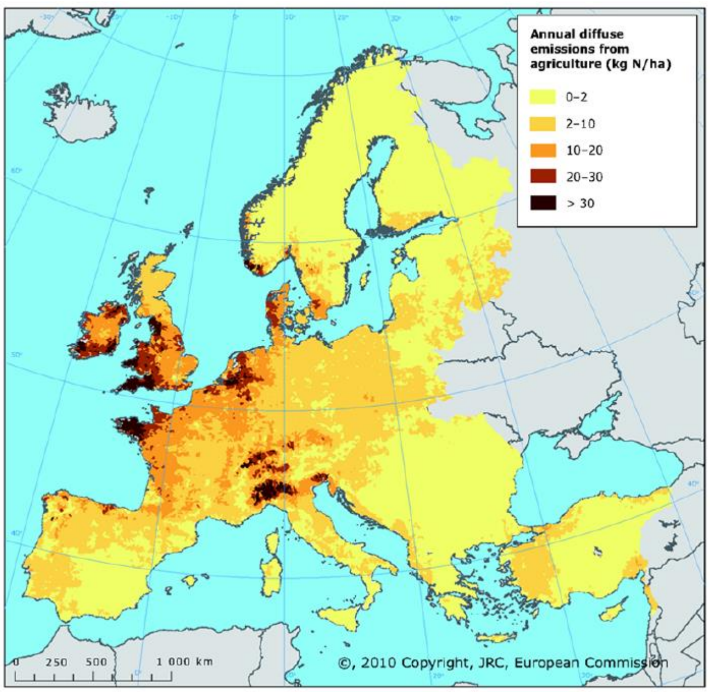
[12] http://www.fao.org/nr/water/aquastat/countries_regions/index.stm.
[13] http://www.fao.org/nr/water/aquastat/main/index.stm

nitrogen pollution but a narrative on environmental issues related to water and agriculture in the country, with reference to existing publications and databases.

The data available with the institution in charge of water quality will determine to what extent and with which level of precision the sub-indicator can be calculated at country level. Ideally, the institution in charge of water quality is able to produce, on regular basis (yearly; every 2, 3 or 5 years), a series of tables and maps showing the situation of water quality in its major river basins and aquifers. These maps should be used as a basis to assess the extent of agricultural area which is located in areas with problems associated with nitrogen pollution.

The map below shows the distribution of nitrogen emission from agriculture into freshwater in Europe, based on point measurements and extrapolation by GIS techniques.

Combining the information from the water quality map with information on the geographical distribution of agricultural area, one can estimate the area of farms that are located in areas where water is polluted.



Map: Annual diffuse agricultural emissions of nitrogen to freshwater (kg N/ha of total land area), (2009). Source: Joint Research Centre, European Commission. http://ec.europa.eu/eurostat/statistics-explained/pdfscache/16825.pdf

The above definition considers that all farms that are located in polluted areas and that use nitrogen fertiliser contribute to nitrogen pollution. An improvement of the methodology would be to devise a probabilistic distribution curve based on information on fertiliser use by farms and apply it to the farms in the areas where nitrogen pollution is observed, establishing a threshold of nitrogen application per area above which the farm can be considered contributing to nitrogen pollution. Such threshold could be established on the basis of nutrient balance models that would assess the total quantity of nitrogen reaching water bodies in a given period.

Water use

Dimension: Environmental
Theme: Water health
Sub-indicator: Water use
Aim and relevance *What is the reason we need to focus on this theme? What is the relevance for decision-making?* Agriculture is by far the main user of freshwater. On average, 70% of all water withdrawal is for agriculture. In many places, the collective withdrawal of water for all sectors (agriculture, cities, industries, etc.) is beyond what can be considered environmentally sustainable: dry rivers without environmental flow, dried up wetlands, overexploitation of groundwater leading to progressive reduction of the water table. Sustainable agriculture therefore implies that that level of use of freshwater for irrigation remains within acceptable boundaries.
What concept needs to be measured? *Expressing the theme in terms of what exactly we try to capture* The extent to which agriculture contributes to unsustainable patterns of groundwater use, i.e. where more water is being abstracted from aquifers than is replenished. Groundwater over-abstraction is not the only problem related to water use, but it is probably the most critical in water scarce regions, and the easiest to capture. Other issues related to water use are the excessive withdrawal of water from rivers, with its impact on freshwater ecosystems, and, to a certain extent, the question of 'wasteful' water use, usually expressed in terms of low water use efficiency in agriculture.
Definition of the sub-indicator *Define the selected sub-indicator, including relevant formula as appropriate and explain the choice.* Agricultural area of the farms that contribute to a groundwater depletion. In order to establish the level of sustainability in relation to water use, the sub-indicator calculates the groundwater balance as follows: ***Groundwater balance = annual groundwater abstraction for agriculture – annual groundwater recharge from rainfall*** When groundwater abstraction is systematically higher than groundwater recharge over several years, the groundwater balance is negative and the pattern of groundwater use is unsustainable.
How should the sub-indicator be measured (Data source and methods): Water flows through the landscape, and all water users and land users in a given river basin or aquifer are connected through the water cycle. Activities in one part of a basin affect users in other parts, and only combined effects of all water and land use activities can be associated with a certain level of water health. This is the case for over-exploitation of water, and for water pollution from agriculture. This must be reflected in the monitoring protocol. This is why a dual approach is proposed to assess water balance and the impact of farming activities:

- A first step consists in analysing data at regional level, based on information collected by institutions in charge of water monitoring. A national map showing areas with water unbalance is derived from this information
- A second step consists in understanding whether a given farm contributes or not to the regional water balance problem. Farm questionnaire is used to understand to what extent single farms are likely to contribute to the problem.
- The combination of these two steps indicate whether a farm is sustainable from the viewpoint of water use. Only those farms that are located in areas showing progressive reduction of water level over several years and are likely to contribute to the problem will be considered unsustainable.

Measures of water use sustainability must capture the balance between supply and demand. Countries experiencing problems with excessive water use are usually well equipped with information at national level. Water authorities maintain maps of river basins and aquifers with a measure of the level of water use. One can safely state that if such information is not available there is no major problem of water use in the country.

Agricultural water use refers to the water that is used for irrigation (and in a few places for aquaculture). Other uses of water in agriculture can be considered marginal.

Some parameters are good proxies for a measure of the water balance. The evolution of water level in wells provides information on the long term evolution of the water balance: a progressive reduction of water level, over several years, indicates an imbalance between water abstraction and recharge.

Note on the time distribution

Groundwater levels in wells vary all the time as a result of recharge and abstraction. Furthermore, groundwater is often considered as a 'buffer' resource, which can be used in the periods of low water availability, and recharged in periods of high rainfall. In many parts of the world, water levels drop during the dry season as a result of pumping, and is recharged during the rainfall season. A trend showing seasonal variations is typical of aquifer behaviour. These cycles are seasonal and therefore do not indicate over-exploitation. It is the long term trend that indicates sustainability problem. In addition, groundwater is often used to compensate for low water availability for agriculture in dry years, with replenishment occurring during wet years. For this reason, assessing the level of sustainability in groundwater use must be done by considering several years. In this case, a period of 5 years is proposed to assess trend in groundwater use sustainability.

Note on water use and the role of agriculture

Water use issues reflect an imbalance between recharge and abstraction of water by all water use sectors (irrigation, cities, industries, mining, etc.). Except in very localized cases, agriculture (irrigation) is usually by far the main user of water, and therefore holds prime responsibility for over-abstraction of water.

What would be the criteria to use to assess sustainability for this sub-indicator?

Indicate thresholds used in the literature or propose thresholds and give justification

The proposed sub-indicator on groundwater balance implies the use of a threshold that is zero. Any reduction of the level of the water table (as measured through water level in wells) is an indication of an imbalance between supply and demand.

Farm questionnaires can offer a relatively robust way or assessing the sustainability of water use. The type of survey questions that are relevant in assessing water health in relation to water ruse is as follows:

Water use sustainability:

Q1: Are you using water for agricultural production (to irrigate your corps)

- Yes → go to Q2
- No, I don't use water for irrigation → Farm is sustainable (with respect to water use)

Q2: Over the last 5 years, did you notice a reduction in the volume of water available for irrigation

- Yes, the level of water in my well(s) is progressively going down → Farm is unsustainable (with respect to water use)
- No, I am not aware of such problem → Farm is sustainable (with respect to water use)

Link with other SDG indicators:

Indicate whether this indicator can relate fully or partially to other SDG indicators.

SDG 6 deals with 'Water for all', and includes considerations of access to water and sanitation, the conservation of water-related ecosystems, water use efficiency, water scarcity and water pollution. In particular, the following SDG indicators are related to this sub-indicator:

6.4.1 Water use efficiency
6.4.2 Water scarcity

Notes:

Provide any notes that you consider relevant in relation to this sub-indicator.

In the literature, many studies propose to use water use efficiency as a measure of sustainability in terms of water use. While this seems to make sense, it has been proven that water use efficiency is not directly connected to the level of sustainability in water use. To the contrary, it is in most water stressed basins that water use efficiency is usually the highest. Water use efficiency, or the more sophisticated concept of water productivity (ratio of production over water withdrawal or use) could, instead, be used as part of the productivity dimension of sustainability in agriculture (see also discussion in SDG indicator 6.4.1).

Assessment of the existing sources of data and information

In the first phase, the existing data sources will be screened and assessed in order to identify to what extent the available data is sufficient and adapted to construct the proposed sub-indicator.

Countries or region where water scarcity, and therefore groundwater imbalance, is a problem, are usually aware of the problem, and have performed studies or assessments of water balance, even if not always detailed. In addition, counties where water plays an important role for agriculture and economic development usually have institutions that address the issues of water management: Ministry of water; Ministry of irrigation; River basin agencies, etc. Instead, countries where water use, allocation and management is not a major issue usually do not collect information on water use.

An assessment of the existing sources of data and information will therefore start with a review of existing institutions in charge of water management. These institutions develop and maintain water-related databases. As a starting point, one can refer to the AQUASTAT country profile[14], maintained by FAO, and which provides a brief overview of the country's agricultural water-related issues, institutions and policies.

Water-related databases typically include the following:
- Map of river basins and aquifers
- River flows records
- Boreholes, their geographical location, water level records, abstraction records

Institutions in charge of water also produce regular assessments, yearbook and statistics on the main elements of the water balance.

Procedure in case of complete absence of data at country level

In case of complete absence of data at country level, developing countries can rely on the AQUASTAT country profile for a preliminary estimate of water use in the country and of sustainability problems associated with water use. The AQUASTAT country profile computes an indicator of 'Total water withdrawal over Actual renewable Water Resources'. This ratio, available only at country level, offers a quick overview of the risk associated with water use.

A water abstraction rate of 20% of total water resources is considered to be the threshold above which water use starts to impact the environment and some competition between users appears). Above 40% of water resources abstracted, competition for water is generalised and environmental impact are expected to be widespread.

FAO has computed a global map of water scarcity based on the above thresholds by major river basin (expressed as low, medium and high)[15]. This map offers the opportunity for a quick check about the status of a country or region. In the absence of any national level data, the global map can be used as reference to identify the areas of the country with potential water use problems. Areas with high scarcity could be considered as unsustainable in terms of water use.

Construction of sub-indicator

The data available with the institution in charge of water will determine to what extent and with which level of precision the sub-indicator can be calculated at country level. Ideally, the institution in charge of water is able to produce, on regular basis (yearly; every 2, 3 or 5 years), a map of the situation of water balance in its major river basins, and in its aquifers. This map should be used as a basis to assess the extent of agricultural area which is located in areas with water balance problems.

Combining the information from the water map with the available information from farm surveys, one can estimate the area of farms that contribute to water balance problems in the country. To do this, it is necessary to know which farms use irrigation, given that only these farms can be considered as contributing to the sustainability problem in relation to water use.

[14] http://www.fao.org/nr/water/aquastat/countries_regions/index.stm.
[15] FAO. 2011. The State of Land and Water resources for food and agriculture.

Biodiversity

Dimension: Environmental
Theme: Biodiversity
Sub-indicator: Heterogeneity of agricultural landscape

Aim and relevance

What is the reason we need to focus on this theme? What is the relevance for decision-making?

Biodiversity is one of the theme related to the dimension environment. In order to assess and monitor this theme, a sub-indicator is proposed, that allow reporting countries to measure over the time the relevant theme. The proposed sub-indicator for biodiversity measures the landscape heterogeneity associated to a farm.

Landscape heterogeneity is considered a determinant of biodiversity (Fahrig et al., 2011) and hence related metrics can be used as indicators of species richness due an increased availability of niches. Such association acts at multiple scales and over time. For agricultural land, intensification has commonly led to a decline in biodiversity measured across many taxa. While agricultural intensification is associated with many practices that can negatively affect species richness (increased fertilisers and pesticides for instance) is rather the combined effects on the heterogeneity in habitat structure (removal of natural habitats and field boundaries, monocultures, land consolidation, simplified crop rotations), in time and space, to cause a decline in biodiversity (Benton et al., 2003). Also intensification of grassland management leads to losses of semi-natural pastures, increase in grazing pressure, denser swards and more frequent mowing thus contributing to reduce habitat heterogeneity in farmland.

The evaluation of landscape heterogeneity is strictly related to the concept of patch, defined by Forman (1995) as a relatively homogeneous area that differs from its surroundings. Patches are the basic unit of the landscape and have a definite shape and spatial configuration.

The assessment of the relative importance of agricultural and natural/semi-natural patches is an issue of particular interest. Natural/semi-natural patches are relatively undisturbed and temporally permanent areas that can hold a substantial proportion of the biodiversity in agricultural landscapes. These habitats have been reported to act as biodiversity reservoirs for plants, insects, birds and mammals (Johnson & Beck 1988; Hinsley & Bellamy 2000; Perfecto & Vandermeer 2002; Duelli & Obrist 2003; Van Buskirk & Willi 2004). As a consequence, heterogeneous landscapes composed of agricultural and non-agricultural patches support a higher biodiversity than simplified, coarse-grained landscapes composed of mainly arable fields and pastures (Banaszak 1992; Weibull *et al*. 2000; Söderström *et al*. 2001; Steffan-Dewenter 2002, 2003; Weibull & Östman 2003; Weibull *et al*. 2003; Schmidt *et al*. 2005).

The figures below (from Landis, 2017) shows two landscapes characterized by distinct heterogeneity in Michigan, USA showing, (A) gradient in agricultural landscape complexity. (B) Expanded view of relatively complex landscape with prominent woodlots, fencerows and wooded riparian areas. (C) Expanded view of simplified landscape on higher productivity soils. Note the rounded field corners and centrally located irrigation risers in many fields indicative of center-pivot irrigation. Imagery from Google.

What concept needs to be measured?

Expressing the theme in terms of what exactly we try to capture

The heterogeneity in a landscape can be distinct into two components, which both, contributes to biodiversity:

- A **compositional heterogeneity** – the number and the abundance of different land cover classes within the landscape
- A **configurational heterogeneity** – how these land cover classes are interspersed

When addressing heterogeneity at farm level, a farmland with high compositional heterogeneity has patches referring to many different land cover types (cover type richness) and/or similar cover of the different patch types (cover type evenness). A farmland with higher configurational heterogeneity has smaller patches and a greater total length of patches edges.

An evaluation of farmland sustainability that combines compositional heterogeneity and configurational landscape heterogeneity is here proposed.

Definition of the sub-indicator

Define the selected sub-indicator, including relevant formula as appropriate and explain the choice.

Farm sustainability for what that concerns the environmental dimension and the biodiversity theme relies on both compositional and configurational heterogeneity.

Concerning compositional heterogeneity the simplest measure is the number of different cover types or cover type richness. However having two landscapes with the same cover type richness the more heterogeneous landscape is the one where cover types are in similar proportions (cover type evenness). A measure of compositional heterogeneity that combines cover type richness and evenness is the Shannon Diversity Index.

$$SHDI = -\sum_{i=1}^{m} (P_i * \ln P_i)$$

where Pi = proportion of the landscape occupied by land cover type (class) i.

A higher value of Shannon's diversity index means greater compositional heterogeneity (Fahrig et al., 2011). Shannon's diversity index is a popular measure of diversity in community ecology, applied here to landscapes. It is somewhat more sensitive to rare patch types respects to other indices such as the Simpson's diversity index.

In order to obtain a numeric value from 0 to 1 the Shannon index can be normalized by dividing it by the maximum Shannon's Diversity Index, this latter obtained by computing the natural logarithm of the total number of land cover classes in the classification system . This is called Shannon Evenness index

$$\mathrm{SHEI} = \frac{-\sum_{i=1}^{m} (P_i * \ln P_i)}{\ln m}$$

where m = number of land cover classes

SHEI = 0 when the landscape contains only 1 patch (i.e., no diversity) and approaches 0 as the distribution of area among the different patch types becomes increasingly uneven (i.e., dominated by 1 type). SHEI = 1 when distribution of area among patch types is perfectly even (i.e., proportional abundances are the same).
Shannon Evenness index is the variable here proposed to assess the compositional heterogeneity.

The number of land cover classes is here defined a priori and refers to a classification compliant with System of Environmental Economic Accounts (SEEA) and FAO ISO Land Cover Classification System (LCCS). The following 8 land-cover types are proposed:

1) Artificial Surfaces: any type of areas with a predominant artificial surface, mainly roads and settlements. Any urban or related feature is included in this class, for example urban parks (parks, parkland, sport facilities). The class also includes industrial areas, waste dump deposit and extraction sites.

Cropland is divided in turn into 2 sub-classes:

2) Herbaceous Crops: composed of a main layer of cultivated herbaceous plants (graminoids or forbs).
3) Woody Crops composed of a main layer of permanent crops (trees and/or shrub crops) and includes all types of orchards and plantations.

4) Grassland: includes any geographic area dominated by natural herbaceous plants (grasslands, prairies, steppes and savannahs) with a cover of 10% or more, irrespective of different human and/or animal activities, such as: grazing, selective fire management etc.

5) Tree Covered Area: includes any geographic area dominated by natural tree plants with a cover of 10% or more. Other types of plants (shrubs and/or herbs) can be present, even with a density higher than trees.

6) Shrubs Covered Area: includes any geographical area dominated by natural shrubs having a cover of 10% or more. Trees can be present in scattered form if their cover is less than 10%. Herbaceous plants can also be present at any density.

7) Bare soil: includes any geographic areas where the cover of natural vegetation is between 2% and 10%. (sparse vegetation) and any geographic area dominated by natural abiotic surfaces (bare soil, sand, rocks, etc.) where the natural vegetation is absent or almost absent, i.e. covers less than 2%.

8) Waterbodies: includes also herbaceous vegetation, aquatic or regularly flooded.

Configurational heterogeneity can be assessed through metrics such as mean field size, edge density, large patch dominance, interspersion ⁄ juxtaposition and mean patch shape variability. Only the spatial patters is taken in consideration, not the actual cover types and configurational heterogeneity increases with increasing complexity of the spatial pattern. Two measures are here calculated:

a) Average size of the agricultural patches (arable land and plus permanent pastures i.e. classes 2, 3 and 4 of the proposed classification) intersecting the observation unit. If the patch partially overlap with the observation unit, the whole patch is accounted. Please consider that a patch of grassland can have a size considerably different from a patch of permanent crop;
b) Length of the natural edges shared between patches. This consider two different situations: the boundary between an agricultural patch and a natural patch, and the linear boundary (hedges or tree lines) between two agricultural patches. Linear elements such as hedges or tree lines are accounted while human made elements such as dry stone walls or trails/paths without visible vegetation are not considered.

Edge density is defined by dividing the length of the natural edges and the total area of the observation units.

ED = E/A

where
E = total length (m) of edges hared between patches classified as belonging to agriculture (including pastures) and natural/semi-natural vegetation.
A = total area of the observation unit (ha, fixed).

Edge density reports edge length on a per unit area basis that facilitates comparison among observation units. It is equal to 0 when there are no edges between agricultural and natural/semi-natural patches.

In order to obtain an index from 0 to 1, a maximum edge density (EDmax) was computed a priori by considering a square grid that includes 100 small fields separated by natural linear elements like hedges or tree lines.

The second component of the configurational heterogeneity is calculated as

ED/EDmax

How should this be measured (Data sources and methods):

Different sustainability indicators require different data collection methods. Four main methods have been identified that cover the different dimensions of sustainability: farm survey; household surveys; landscape-level measurements (including remote sensing; GIS, or other geography-based measurements), or administrative surveys. The section should describe the merits of different measurement approaches, with particular note of the potential to use farm surveys.

The sampling methodology described in this proposal is strictly related to the sub-indicator 'Agricultural heterogeneity'. The possibility to detect the landscape metrics from remote sensing imagery represents a peculiarity of this sub-indicator compared to the other sub-indicators and justifies the use of a slightly different approach. However the methodology can be subjected to changes when the overall farm sampling strategy of indicator 2.4.1 will be defined.

Several initiatives have been carried out to assess landscape structure and heterogeneity associated to a farm with a statistically sound area frame approach (Wascher et al, 2010). The suggested methodology uses a similar approach using the tool Collect Earth for country to measure and report on the theme "biodiversity" over the time.

Collect Earth, a tool that enables data collection through Google Earth is considered an appropriate system for performing fast, accurate and cost-effective assessments due to its friendliness and smooth learning curve. This may allow countries, when trained, to collect and monitor information on biodiversity on regular basis.
Collect Earth allows to design a sampling strategies and then create an on-line form that an operator can enter from screen with the support of available imagery available in Google Earth and other sources. In addition, the operator is supported by ad-hoc scripts that allow to determine multi-temporal analysis of satellite imagery available in the cloud Google Earth Engine. Data can then be exported to Saiku to facilitate analysis and reporting.

Advantages on using Collect Earth for this purpose:

- Robust tool
- Free and open
- Easy to operate and maintain by countries
- Relatively fast to obtain national assessments
- Customizable depending on countries need
- Very High Resolution images suitable for farm-level analysis

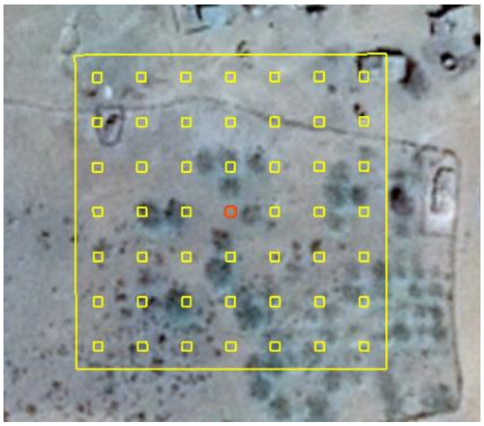
Below, are listed the main steps required for the analysis

1. Design the sampling survey

The proposed methodology will use the coordinates of the selected farms provided by the country. The coordinates will be imported in the system to be used as centroids of the observation units and a square buffer will be generated. We propose for each observation unit a fixed size of 5 ha but further studies are needed and a sensitivity analysis must be conducted to set the optimal fixed size of the observation unit.

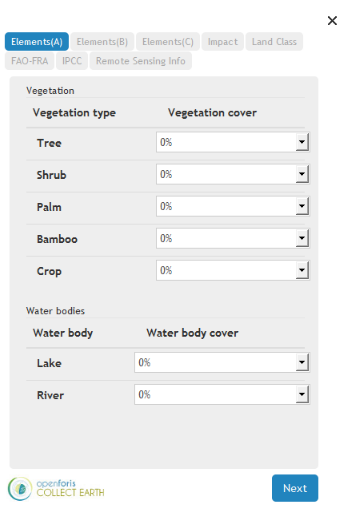
Each observation unit will include a fixed number of dots (49 as standard setting) used to calculate land cover classes and average size of the agricultural patches (only those elements that intersect the dots are accounted). Edge density will be calculated within the whole observation unit and not only on those elements that intersect the dots.

The figure here below shows a typical observation unit in Google Earth



2.<u>Design the form for data entry</u>

The design of the form allows the operator to enter information through a number of tabs from the Google Earth application. Visual dots in each sample point allows the operator to measure occurrence of land types and features. Available tools in Google Earth support the measure features.



This are the minimum information that should be captured within each observation units:

- Number of land cover classes
- Presence of hedges or other linear features delimiting patch boundaries
- Average patch size

3. <u>Aggregate the results and define the sustainable condition</u>

The objective of this analysis is to assess for each observation unit whether the biodiversity, measured through the indicator "agricultural heterogeneity" is below a certain threshold that is considered

"unsustainable". Then, the results will be aggregated at national level (number of observation units with sustainable and unsustainable biodiversity).
What would be the criteria to use to assess sustainability for this theme: *Indicate thresholds used in the literature or propose thresholds and give justification* No large literature exists for this purpose. We propose to classify parameters used to define compositional and configurational heterogeneity into three levels, low, medium and high according their values and then build a matrix to derive a sustainability assessment. Concerning compositional heterogeneity values of Shannon Evenness index below 0.3 (included) are considered low, values of Shannon Evenness index from 0.3 (excluded) and 0.6 (included) are considered medium, and values above 0.6 (excluded) are considered high. Concerning configurational heterogeneity two variables are considered: average agricultural patch size and edge density. In general, smaller average agricultural patch size and greater edge density indicate greater configurational heterogeneity. An average patch size above 5 ha (large patch size) is considered as proxy of low configurational heterogeneity, an average patch size comprised between 2 (excluded) and 5 ha (medium patch size) is considered as proxy of medium configurational heterogeneity and an average patch size below 2 ha (small patch size) is considered as proxy of high configurational heterogeneity. For what that concern edge density, values below 0.01 (included) are considered low, values from 0.01 (excluded) to 0.5 (included) are considered medium and values above 0.5 (excluded) are considered high. Finally a Heterogeneity Identification Matrix can be built:

	Low	Medium	High
Shannon Evenness Index			
Average patch size			
Edge density/ Max edge density			

Minimum requirements to consider an observation unit sustainable from the point of view of the theme 'biodiversity' are that at least 2 of the 3 parameters fall in the medium column. Country-specific threshold ranges for both compositional and configurational heterogeneity can be set, if needed, considering also the "natural" aptitude to the country to biodiversity.
Link with other SDG indicators: *Indicate whether this indicator can relate fully or partially to other SDG indicators.* This indicator is directly related to following other SDG indicators:

- 2.5.1 “Number of plant and animal genetic resources for food and agriculture secured in either medium or long-term conservation facilities” and 2.5.2 “Proportion of local breeds classified as being at risk, not-at-risk or at unknown level of risk of extinction”
There is an important relationship between the maintenance of crop genetic biodiversity and sustainable agriculture and protection of environment. The use of a greater diversity of available crops is a strategy that farmers can apply to develop their own agricultural systems with minimal environmental impacts. Crop varieties that are resistant to pests and diseases can reduce the need for application of harmful pesticides, while more vigorous varieties can better compete with weeds, reducing the need for applying herbicides. Moreover drought resistant plants can help save water through reducing the need for irrigation; deeper rooting varieties can help stabilize soils; and varieties that are more efficient in their use of nutrients require less fertiliser.

- 15.1.1 “Forest area as a proportion of total land area” and 15.1.2 “Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type”.
The occurrence of residual natural and semi-natural vegetation and structures on farmland, if not overly affected by inappropriate management, can provide important reservoirs of biodiversity and corridors and stepping-stones between natural habitat including protected areas. Low-intensity farming systems including pieces of natural and semi-natural vegetation can mimic some of the attributes of more natural systems and can be associated with greater species diversity than other land uses competing with them.

- 15.2.1 “Progress towards sustainable forest Management”
Sustainable forest management in farmland can contribute to sustainable agriculture by moving degraded ecosystem closer to their former state and thereby contributing to the restoration of ecosystem function. There are many advantages of planting trees and manage them in a sustainable way on farmland, i.e carbon sequestration, erosion control, habitat restoration, increased water use (reduced secondary salinity) and also wood production.

- 15.4.1 “Coverage by protected areas of important sites for mountain biodiversity”
Mountains are complex and fragile ecosystems with marked topography, highly differentiated climatic conditions and vertical processes. Their protection is strictly related to the theme of sustainable agriculture.

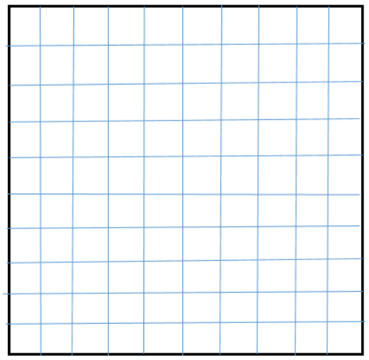
Notes:

Provide any notes that you consider relevant in relation to this sub-indicator.

In order to test the proposed methodology a total of 10 observation units were built through Collect Earth in the following countries: Ecuador, Bangladesh, Ruanda, France and Kirghizstan. Each observation unit has a standard size of 5 ha (50,000 sq. m).
Parameters for compositional and configurational heterogeneity were calculated for each observation unit.

By considering the proposed classification system with 8 land cover classes and sampling design the Shannon's Diversity Index can increases to a maximum of 2.07 in case all land-use types have equal cover in the landscape.

The maximum edge density is computed by considering an observation unit that includes 100 small fields of 0.5 ha separated by natural elements like hedges or tree lines (see figure below).



Here the results obtained for each observation unit.

ECUADOR

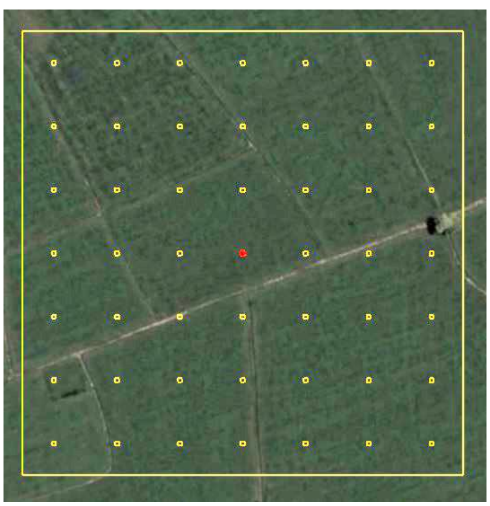
Observation unit number 1:

Lat -1.834105°, Long -80.031839°

SHEI = 0.178

Estimated average agricultural patch size: 1.63 ha

Edge density/Max Edge density = 0



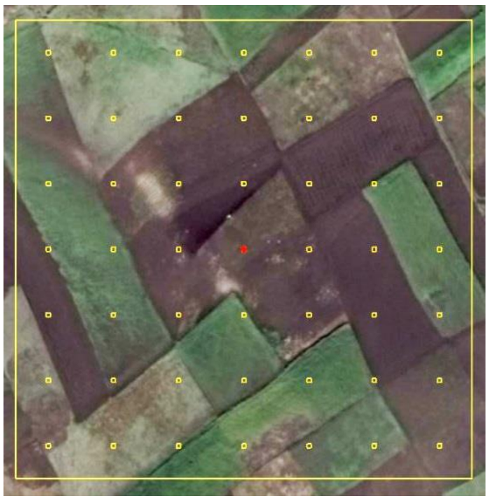
Heterogeneity Identification Matrix:

	Low	Medium	High
Shannon Evenness Index	x		
Average patch size			x
Edge density/ Max edge density	x		

Result: Not sustainable

Observation unit number 2:
Lat -1.783275°, Long -78.696361°

SHEI =0.047
Estimated average agricultural patch size: 0.3 ha
Edge density/Max Edge density = 0



Heterogeneity Identification Matrix:

	Low	Medium	High
Shannon Evenness Index	x		
Average patch size			x
Edge density/ Max edge density	x		

Result: Not sustainable

BANGLADESH
Observation unit number 1:
Lat 22.774713°, Long 91.174599°

SHEI = 0.497
Estimated average agricultural patch size: 0.2 ha
Edge density/Max Edge density = 0.013

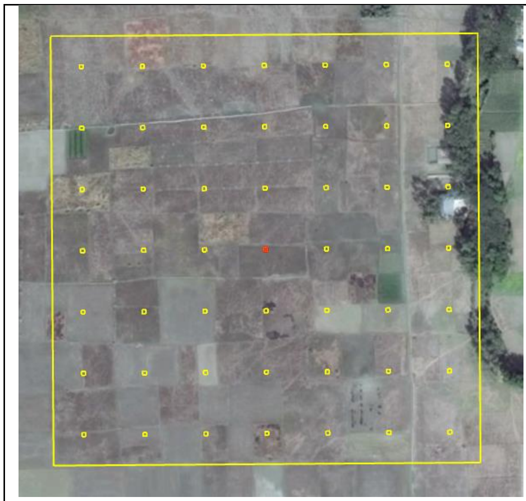
Heterogeneity Identification Matrix:

	Low	Medium	High
Shannon Evenness Index		x	
Average patch size			x
Edge density/ Max edge density		x	

Result: Sustainable

Observation unit number 2:
Lat 22.224991°, Long 91.975249°

SHEI = 0.176
Estimated average agricultural patch size: 0.05 ha
Edge density/Max Edge density = 0.05



Heterogeneity Identification Matrix:

	Low	Medium	High
Shannon Evenness Index	x		
Average patch size			x
Edge density/ Max edge density	x		

Result: Not sustainable

RWANDA

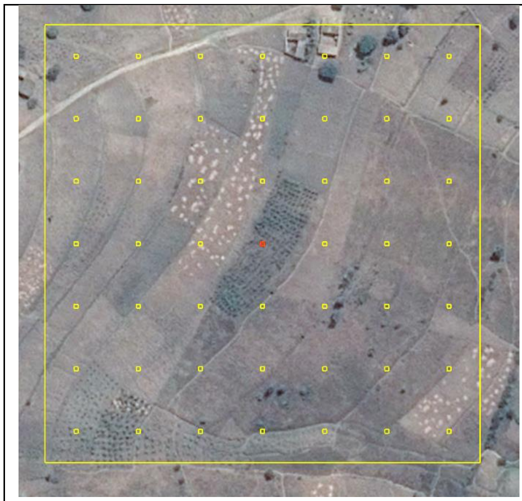
Observation unit number 1:

Lat -2.057391°, Long 29.862338°

SHEI = 0.452

Estimated average agricultural patch size: 0.2 ha

Edge density/Max Edge density = 0.02



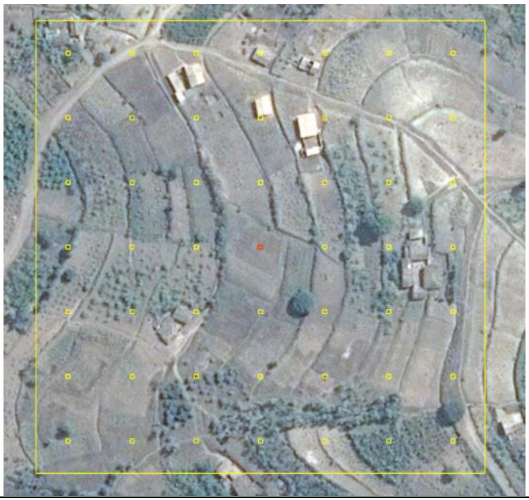
Heterogeneity Identification Matrix:

	Low	Medium	High
Shannon Evenness Index		x	
Average patch size			x
Edge density/ Max edge density		x	

Result: Sustainable

Observation unit number 2:
Lat -2.051209°, Long 29.782615°

SHEI = 0.506
Estimated average agricultural patch size: 0.1 ha
Edge density/Max Edge density = 0.018



Heterogeneity Identification Matrix:

	Low	Medium	High
Shannon Evenness Index		x	
Average patch size			x
Edge density/ Max edge density		x	

Result: Sustainable

FRANCE

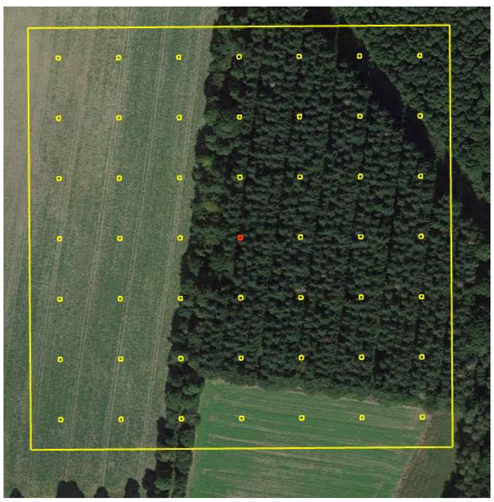
Observation unit number 1:

Lat 48.207127°, Long -2.489669°

SHEI = 0.530

Estimated average agricultural patch size: 3.5 ha

Edge density/Max Edge density = 0.014



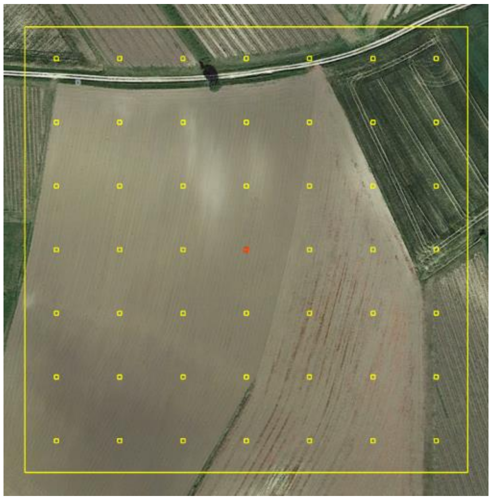
Heterogeneity Identification Matrix:

	Low	Medium	High
Shannon Evenness Index		x	
Average patch size		x	
Edge density/ Max edge density		x	

Result: Sustainable

Observation unit number 2:
Lat 43.991194°, Long 2.021834°

SHEI = 0.047
Estimated average agricultural patch size: 1.8 ha
Edge density/Max Edge density = 0.01



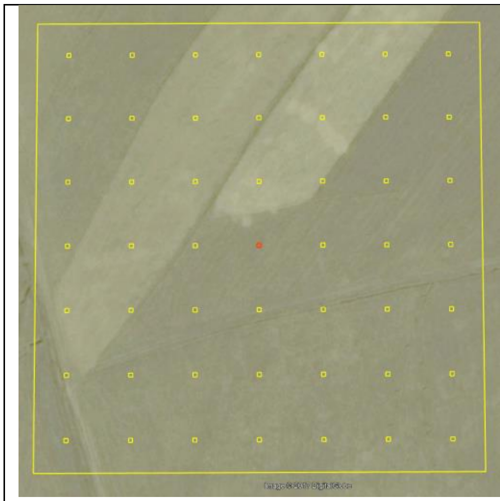
Heterogeneity Identification Matrix:

	Low	Medium	High
Shannon Evenness Index	x		
Average patch size			x
Edge density/ Max edge density	x		

Result: Not sustainable

KYRGYZ REPUBLIC
Observation unit number 1:
Lat 42.027014°, Long 74.845257°

SHEI = 0.047
Estimated average agricultural patch size: 1 ha
Edge density/Max Edge density = 0



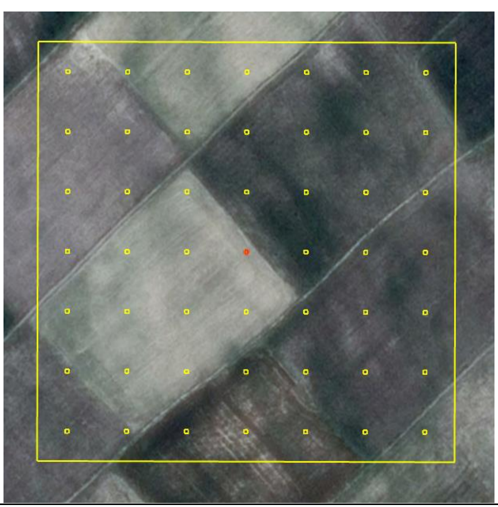
Heterogeneity Identification Matrix:

	Low	Medium	High
Shannon Evenness Index	x		
Average patch size			x
Edge density/ Max edge density	x		

Result: Not sustainable

<u>Observation unit number 2:</u>
Lat 41.892831°, Long 74.499871°

SHEI = 0.110
Estimated average agricultural patch size: 1 ha
Edge density/Max Edge density = 0



Heterogeneity Identification Matrix:

	Low	Medium	High
Shannon Evenness Index	x		
Average patch size			x
Edge density/ Max edge density	x		

Result: Not sustainable

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Decent work

Dimension: Social
Theme: Decent work
Sub-indicator: Wage rate in agriculture

Aim and relevance

What is the reason we need to focus on this theme? What is the relevance for decision-making?

A key motivation for the measurement of decent work is the recognition that traditional employment statistics are insufficient to understand the working conditions of people, especially those working in agriculture. Indeed, in many low income countries there are low unemployment rates (<5%) but in fact many of the population live in poor households and are agricultural workers.

Beyond improving the understanding of this employment situation, measures of decent work also encompass access to social protection, child labour, hazardous working condition and similar aspects to provide a more robust and complete picture of the conditions experienced by agricultural workers.

Monitoring the extent of decent work in agriculture is thus relevant in assessing progress towards sustainable agriculture. Because the concept relates directly to work by individuals, it can be applied at the farm level.

View from an unsustainability perspective, unless work in agriculture is decent, with appropriate working conditions, appropriate working hours and appropriate remuneration, agricultural activity cannot be considered to be sustainable.

What concept needs to be measured?

Expressing the theme in terms of what exactly we try to capture

Decent work is a multiple dimensional phenomenon (see notes below), however, it is not possible to cover all aspects within a single sub-indicator. The sub-indicator **wage rate in agriculture** refers only to the appropriate remuneration aspect of decent work, and focuses on the extent to which the wages paid to farm employees are fair and reasonable. Amongst the different aspects of decent work the level earnings is considered one of the most important and well linked with many others.

This sub-indicator captures only the situation of the employees in the agriculture sector. In some cases, the paid employees could be a small percentage of the total employment in agriculture (paid plus unpaid family workers), however, the agriculture area managed with hired employees could be significant. In concept, the return to family workers may be captured in the economic sub-indicator farm profitability and the social sub-indicator for well-being.

Definition of the sub-indicator

Define the selected sub-indicator, including relevant formula as appropriate and explain the choice.

Wage rate in agriculture: The average daily wage rate (per day of 8 hours) paid by the farm.

How should this be measured (Data sources and methods):

Different sustainability indicators require different data collection methods. Four main methods have been identified that cover the different dimensions of sustainability: farm survey; household surveys; landscape-level measurements (including remote sensing; GIS, or other geography-based measurements), or administrative surveys. The section should describe the merits of different measurement approaches, with particular note of the potential to use farm surveys.

According to the resolution concerning an integrated system of wage statistics (ILO-ICLS, 1973), the concept of wage earning is based on the remuneration in cash or in kind paid to employees for time worked or work done together with the remuneration for time not-worked, *e.g.* annual remuneration, paid leave or holidays, etc.

Formula:

$$Average\ daily\ wage\ rate = \frac{Total\ annual\ expenses\ on\ hired\ labor}{Total\ annual\ hours\ worked\ by\ hired\ labor} * 8\ hours$$

For estimation of the denominator i.e. the hired labour hours should be measured using the number of hours effectively worked. Using the number of hours corrects for the difference between seasonal and non-seasonal workers and the different working regimes (part-time versus full-time). This allows better comparisons across production systems, regions and countries, as the number of workers or of days per worker may not indicate the labour input effectively used on the farm (OECD 2001).

Appropriate adjustments should be carried out to adjust wages in case of rapidly changing prices during the reference year.

Information on labour expenses and hours worked should be available from farm surveys or household survey with agricultural modules. The key variables for estimating this sub-indicator are as follows.

- Variables:
  - Hired labour expenses (cash and kind)
  - Hired labour input (hours worked)
- Data items:
  - Labour payments in cash (total annual value)
  - Labour payments in kind (total annual value)
  - Labour hours worked by external employees (annual)
- Frequency:
  - Reference year of 2.4.1.
- Reference period:
  - 12 months
- Unit of measurement (UoM):
  - Currency per day

What would be the criteria to use to assess sustainability for this theme:

Indicate thresholds used in the literature or propose thresholds and give justification

The farm is considered sustainable against this sub-indicator, if average wage rate of the farm is equal to or higher that the international poverty line (expressed in currency per day).

Link with other SDG indicators: *Indicate whether this indicator can relate fully or partially to other SDG indicators.* There are links here to Target 8.3 that includes the creation of decent jobs. At present the proposed indicator excludes agriculture (SDG 8.3.1 – Proportion of informal employment in non-agriculture employment, by sex)
Notes: *Provide any notes that you consider relevant in relation to this sub-indicator.* ***Review of literature:*** The concept of decent work is a relatively recent development and its application to agriculture is particularly challenging. Broadly, the thematic areas for decent work defined by the ILO are the following. Indicators in each of these areas may be considered. • Labour market participation; • Status in employment (employee, own account; including vulnerable employment); • Labour time (part time/ full time; part/full year; including precarious workers); • Wage employment; • Participation of children in working activities • School to work transition status The measurement of decent work remains an area of active research. A range of research has identified key themes and a recent report for FAO (Oya, 2015) (http://www.fao.org/3/a-i5060e.pdf) provides a comprehensive summary of the application of the concept of decent work to agriculture and a description of the potential for measurement of decent work in agriculture around the world.

Well-being

Dimension: Social
Theme: Well-being
Sub-indicator: Agricultural household income
Aim and relevance *What is the reason we need to focus on this theme? What is the relevance for decision-making?* The sustainability of farming from a social perspective with respect to equity could be assessed from levels of income of agricultural households. It is unacceptable that the engagement in farming doesn't provide for a decent way of living.. One plausible and comprehensive way to assess the well-being is through the level of income or consumption of an agricultural household. In particular, while subsistence farming and related activity is not likely to be an agreed outcome of sustainable development, it is highly likely that the potential for farming and other rural households to maintain levels of income/consumption above designated poverty lines through agricultural activity will be an important pathway towards sustainable development. In this context, it is important to assess overall measures of income and consumption for agricultural households and monitor the proportion who are below a poverty line.
What concept needs to be measured? *Expressing the theme in terms of what exactly we try to capture* This proposed sub-indicator on well-being in the context of sustainable agriculture is the Income per capita of agricultural household. For the purpose of this sub-indicator the broad definition of the agricultural households is adopted: Households that derive some income from independent activity in agriculture (other than income solely in kind that is of a "hobby" nature). This income can arise from the activity of the head of the household or any other member (The Wye Group Handbook 2007). This definition is consistent with the explanation offered by WCA 2020 that refers to the relationship between the agricultural holding and the household with own-account agricultural production activities (either for sale or for own use).
Definition of the sub-indicator *Define the selected sub-indicator, including relevant formula as appropriate and explain choice.* Income per capita of agricultural household per day Note: The sub-indicator is applicable only for the household sector farms.
How should this be measured (Data sources and methods): *Different sustainability indicators require different data collection methods. Four main methods have been identified that cover the different dimensions of sustainability: farm survey; household surveys; landscape-level measurements (including remote sensing; GIS, or other geography-based measurements), or administrative surveys. The section should describe the merits of different measurement approaches, with particular note of the potential to use farm surveys.*

There are two possible approaches to measure the level of wellbeing i.e. an income approach or a consumption expenditure approach. The consumption approach is considered preferable to estimate wellbeing of agricultural households (see notes below). However, Standard Household Income and Expenditure Surveys (HIES) do not include information about agricultural area that is required for 2.4.1. One possible source that can provide the information is LSMS-ISA by World Bank.

In the context of indicator 2.4.1 the income approach is an alternative that could be more practical using as a source agricultural surveys that include both on and off-farm income.

Potential data sources:

1. Farm based survey (e.g. AGRIS)
2. Agricultural module in household survey (e.g. LSMS-ISA)
3. Household survey (e.g. LSMS or others)

Implementation steps:
Step 1: Estimate agricultural household income (both on and off-farm) or consumption over one year.
Step 2: Express the agricultural household income or consumption per capita per day (divided by 365).
Step 3: Compare it with international poverty line (expressed in currency per day)

What would be the criteria to use to assess sustainability for this theme:

Indicate thresholds used in the literature or propose thresholds and give justification

In the context of this sub-indicator, the farm is considered sustainable if the agricultural household associated to the farm show a level of income / consumption per capita per day equal to or higher than the international poverty line (expressed in currency per day).

Link with other SDG indicators:

Indicate whether this indicator can relate fully or partially to other SDG indicators.

SDG 1: Ending poverty, particularly SDGs 1.1.1,,1.2.1 and 1.2.2

Notes:

Provide any notes that you consider relevant in relation to this sub-indicator.

Review of literature:

- For monetary measurement of income we are using the background developed by the World Bank exclusively given its custodianship of SDG indicators 1.1.1, 1.2.1 and 1.2.2 and its experience in poverty related measurements.
- There are many different nonmonetary indicators of poverty internationally recognized methodology e.g. the Multidimensional Poverty Index (MPI).

Discussion:

As per World Bank (2003), when estimating poverty using monetary measures, one may have a choice between using income or consumption as the indicator of well-being. Most analysts argue that, provided the information on consumption obtained from a household survey is detailed enough, consumption will be a better indicator of poverty measurement than income for the following reasons:

- **Consumption is a better outcome indicator than income.** Actual consumption is more closely related to a person's well-being in the sense defined above, that is, of having enough to meet current basic needs. On the other hand, income is only one of the elements that will allow consumption of goods; others include questions of access and availability.
- **Consumption may be better measured than income.** In poor agrarian economies, incomes for rural households may fluctuate during the year, according to the harvest cycle. In urban economies with large informal sectors, income flows also may be erratic. This implies a potential difficulty for households in correctly recalling their income, in which case the information on income derived from the survey may be of low quality. In estimating agrarian income, an additional difficulty in estimating income consists in excluding the inputs purchased for agricultural production from the farmer's revenues. Finally, large shares of income are not monetized if households consume their own production or exchange it for other goods, and it might be difficult to price these. Estimating consumption has its own difficulties, but it may be more reliable if the consumption module in the household survey is well designed.
- **Consumption may better reflect a household's actual standard of living and ability to meet basic needs.** Consumption expenditures reflect not only the goods and services that a household can command based on its current income, but also whether that household can access credit markets or household savings at times when current income is low or even negative, perhaps because of seasonal variation, harvest failure, or other circumstances that cause income to fluctuate widely.

One should not be dogmatic, however, about using consumption data for poverty measurement. The use of income as a poverty measurement may have its own advantages. For example, measuring poverty by income allows for a distinction to be made between sources of income. When such distinctions can be made, income may be more easily compared with data from other sources, such as wages, thereby providing a check on the quality of data in the household survey. Finally, for some surveys consumption or expenditure data might not be collected. When both income and consumption are available, the analyst may want to compute poverty measures with both indicators and compare the results.

Source:

- Coudouel, Aline; Hentschel, Jesko S. and Wodon Quentin T. (2003). Poverty Measurement and Analysis, in World Bank, A Sourcebook for Poverty Reduction Strategies. Available in: http://siteresources.worldbank.org/INTPRS1/Resources/383606-1205334112622/5467_chap1.pdf Accessed in June, 2017.
- The Wye Group Handbook 2007: http://www.fao.org/docrep/015/am085e/am085e.pdf

Access to land

Dimension: Social
Theme: Access to land
Sub-indicator: Secure rights to land tenure

Aim and relevance

What is the reason we need to focus on this theme? What is the relevance for decision-making?

This theme is relevant in the assessment of sustainability since it measures rights over agricultural land. Since agricultural land is a key input for agricultural production, having secure rights over land ensures that the holder control such a key asset and do not risk losing the land they work on.

Evidence shows that many farmers, entrepreneurs and workers are less productive because they have more limited access to and control of economic resources and services. Long-lasting inequalities of economic and financial resources have positioned certain farmers at a disadvantage relative to others in their ability to participate in, contribute to and benefit from broader processes of development.

As such, adequate distribution of economic resources help ensure equitable economic growth, contributes to economic efficiency and has a positive impact on key development outcomes, including poverty reduction, food security and the welfare of households.

This indicator reflect that land is a key economic resource inextricably linked to the access to, use of and control over other economic and productive resources. It is acknowledged that the holder's land ownership and control can be linked to important gains in welfare, productivity, equality and empowerment. Finally, it is recalled that equality in land ownership and control is a human right, recognized for instance by the International Covenant on Civil and Political Rights (ICCPR).

What concept needs to be measured?

Expressing the theme in terms of what exactly we try to capture

This indicator aims at providing information on the incidence of ownership or secure rights over the agricultural land used by the farmer.

Definition of the sub-indicator

Define the selected sub-indicator, including relevant formula as appropriate and explain choice.

The indicator is an incidence measure. It measures how prevalent ownership or secure rights over agricultural land.

$$\frac{\text{Agricultural land characterized by ownership or secure rights}}{\text{Total agricultural land}}$$

How should this be measured (Data sources and methods):

Different sustainability indicators require different data collection methods. Four main methods have been identified that cover the different dimensions of sustainability: farm survey; household surveys; landscape-level measurements (including remote sensing; GIS, or other geography-based *measurements), or administrative surveys. The section should describe the merits of different measurement approaches, with particular note of the potential to use farm surveys.*

The possible sources for this sub indicator are Farms Surveys, Agricultural Census, and Household Surveys that includes questions on agricultural activities.

Respondent selection: who to interview?

Household surveys frequently collect individual-level data from proxy respondents. This approach is problematic for measuring ownership/rights over agricultural land (and assets in general) due to the introduction of non-random measurement errors.

It is strongly recommended that National Statistical Offices (NSOs) collect self-reported data.

Generally speaking, the number of adult household members to be interviewed depends on the objectives of the survey and the resources available. In case of SDG 2.4.1, it is enough to obtain information associated with the holding.

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The following questions are proposed for the calculation of the sub indicator .Two approaches are considered: 1) A minimum set of questions about the ownership of agricultural land collected at the individual farm holder; 2) Module on the ownership of agricultural land collected at the parcel level, that could also be collected at holding level, with adequate customization.

1. **A minimum set of questions on ownership of agricultural land is collected at the individual farm holder level**

A minimum set of five questions is proposed. This approach is recommended if:

1) The survey vehicle can collect only a minimum set of questions on the ownership of agricultural land
2) The inclusion of a roster of parcels goes beyond the scope of the survey
3) The questions refer to the farm holder. The preferred respondent is the holder.

Questions	function
Q1. Do you own any agricultural land, either alone or jointly with someone else? 1 – Yes 2 – No (end of questions)	This questions refers to whether the respondent, not the respondent's household, owns any agricultural land. It measures reported ownership, which captures the respondent's self-perception of his/her ownership status, irrespective of whether the respondent has formal ownership with title deeds, customary tenure or long-term rights over the land.
Q2. Is there an ownership document for <u>any</u> of the agricultural land you own? (for enumerators: multi response question; allow for more than one type of document to be listed)	This question identifies whether there is an ownership document for any of the agricultural land the respondent reports owning and the type of documentation.

1 - A title deed 2 - Certificate of customary tenure 3 - Certificate of occupancy 4 – A will / certificate of hereditary acquisition 5 - A purchase agreement 6 - A certificate of perpetual / long term lease 7 - Other (specify: _________) 8 - No document (skip to Q4) 98 - Don't known (skip to Q4) 99 – refuses to respond (skip to Q4)	Documented ownership refers to the existence of any document an individual can use to claim ownership rights in law over the land. The list of options is indicative and countries are encouraged to adopt country-specific list. However, it is of utmost importance that the list includes only country relevant documents that are enforceable before the law (i.e. formal documents allowing legal or legal like ownership).
Q3. Is your name is listed as an owner on any of the ownership documents? 1 - Yes (alone or jointly with someone else) 2 - No 98 - Don't know 99 - Refuses to respond	This question measures the respondent's documented ownership status. Because individual names can be listed as witnesses on an ownership document, it is important to ask if the respondent is listed "as an owner" on the document. It is recommend that the measure of documented ownership *not* be conditional on the respondent producing the document for the enumerator to confirm.
Q4. Do you have the right to sell any of the agricultural land you own, either alone or jointly with someone else? 1 - Yes (alone or jointly with someone else) 2 – No 98 - Don't know 99 - Refuses to respond	This question obtains information on whether the respondent believes that he/she has the right to sell any of the agricultural land s/he reports owning. When a respondent has the right to sell the land, it means that he or she has the right to permanently transfer the land to another person or entity for cash or in kind benefits.
Q5. Do you have the right to bequeath any of the agricultural land you own, either alone or jointly with someone else? 1 - Yes (alone or jointly with someone else) 2 - No 98 - Don't know 99 - Refuses to respond	This question obtains information on whether the respondent believes that he/she has the right to bequeath any of the agricultural land he/she reports owning. When a respondent has the right to bequeath the land, it means that he/she has the right to give the land by oral or written will to another person(s) upon the death of the respondent.

2. Module on the ownership of agricultural land collected at the parcel level

Countries may opt instead to collect information on the ownership of agricultural land at the parcel level for the calculation of the sub indicator for two reasons. First, the country may implement a nationally-representative survey that already collects a roster of parcels (e.g. farm surveys or household survey with farm information like LSMS-ISA) to which the questions on ownership can be appended. Second, the country wants to go beyond the data items strictly needed for the computation of the indicator and collect a broader set of information in order to carry out a comprehensive analysis of women's and men's ownership, rights and control of agricultural land. Collecting such information, including on the characteristics of agricultural land, could be done at the parcel or agricultural holding level.

When a module on the ownership of agricultural land is appended to an existing survey, the total number and sequence of questions in the module will depend on the general objectives and structure of the survey. For calculation of sub indicator, the following protocols should be followed:

i) Data should be self-reported, therefore the farm holder or a selected adult respondent should be interviewed.

ii) If the main survey already captures a roster of parcels belonging to the household in the household questionnaire, the respondent selected to complete the module on agricultural land ownership should be asked if she/he owns any agricultural land. If yes, the respondent should report according to the roster of parcels generated at the household level that belongs to the holding. The remaining questions in the module will only be asked for the agricultural parcels owned by the holder.

iii) If the main survey does not capture a roster of parcels at the household level and one selected adult household member will be administered the module on agricultural land ownership, a respondent roster of parcels can be created in the individual questionnaire by asking the respondent to list all of the parcels that s/he owns.

Parcel-level module on the ownership of agricultural land based on household parcel roster/list

Q1. Do you own any agricultural land, either alone or jointly with someone else?

1 – Yes
2 – No (end of module)

	Q2	Q3	Q4	Q5	Q6
Parcel ID	**Please tell me/list which agricultural parcels you own** *ENUMERATOR: LIST PARCEL ID CODES FROM THE HOUSEHOLD QUESTIONNAIRE THAT ARE* ***OWNED*** *INDIVIDUALLY OR JOINTLY BY RESPONDENT*	**Is there an ownership document for this [PARCEL]?** **(tick all that applies)** 1 - A title deed 2 - Certificate of customary tenure 3 - Certificate of occupancy 4 – A will / certificate of hereditary acquisition 5 - A purchase agreement	**Is your name is listed as owner on the ownership document for this [PARCEL]?** 1 - Yes (alone or jointly with someone else) 2 - No 98 - Don't know	**Do you have the right to sell this [PARCEL], either alone or jointly with someone else?** 1 - Yes (alone or jointly with someone else) 2 – No	**Do you have the right to bequeath this [PARCEL], either alone or jointly with someone else?** 1 - Yes (alone or jointly with someone else)

		6 - A certificate of perpetual / long term lease 7 - Other (spec: ________) 8 - No document (skip to Q5) 98 - Don't known (skip to Q5) 99 – refuses to respond (skip to Q5)			99 - Refuses to respond	98 - Don't know 99 - Refuses to respond	2 – No 98 - Don't know 99 - Refuses to respond
1		|__|	|__|	|__|	|__|	|__|	|__|
2		|__|	|__|	|__|	|__|	|__|	|__|
…		|__|	|__|	|__|	|__|	|__|	|__|
N		|__|	|__|	|__|	|__|	|__|	|__|

Background Data

If the source is a household survey, computation of the sub indicator requires information on agricultural activities of the holder, and especially, the agricultural area of the holding.

Computation of the indicator

At the operational level, the indicator relies on three collected data items:

1. The farm holder being identified as an owner on an ownership document that allows protecting the individual's rights on the land
2. The farm holder having the right to sell the land, either exclusively or with someone else
3. The farm holder having the right to bequeath the land, either exclusively or with someone else

The following operationalization is therefore recommended:

- the sub indicator should be measured through the *holders with documented ownership of agricultural land **or** the right to sell **or** bequeath agricultural land*

What would be the criteria to use to assess sustainability for this theme:

Indicate thresholds used in the literature or propose thresholds and give justification

The holdings in which the holder has a positive answer for at least one of the question listed above (i.e. ownership document, right to sell or right to bequeath the land) is considered as sustainable regarding ownership or secure rights over the land.

Link with other SDG indicators:

- SDG 1.4.2 has agricultural population as a unit of observation while this sub-indicator is focused on the holding as unit of observation.
- In comparison to SDG 5.a.1 and 5.a.2 that include gender perspective while analyzing the rights to land, the proposed sub-indicator is limited to right to lands regardless of gender.

Notes:

The operationalization of the sub indicator benefited from SDG 5.a.1 indicator definitions, and as a consequence from the methodological work on asset ownership carried out by the Evidence and Data for Gender Equality (EDGE) initiative, whose key focus is the development of methodological guidelines on measuring asset ownership from a gender perspective.

Building on the work of the Inter-agency and Expert Group on Gender Statistics (IAEG-GS), the EDGE initiative is jointly executed by the United Nations Statistics Division and the United Nations Entity for Gender Equality and the Empowerment of Women (UN Women) in collaboration with National Statistical Offices, the Asian Development Bank, the Food and Agriculture Organization of the United Nations, the Organization for Economic Co-operation and Development (OECD) and the World Bank.

The methodology summarized in this technical note reflects the recommendations expressed in the draft UN Methodological Guidelines on the Production of Statistics on Asset Ownership from a Gender Perspective presented to the 48th Session of the UN Statistical Commission[16].

The proposed methodology was tested in 7 countries (Georgia, Maldives, Mexico, Mongolia, Philippines, Uganda, and South Africa) and benefited from inputs from partners, technical agencies and NSOs.

[16] Source: "UN Methodological Guidelines on the Production of Statistics on Asset Ownership from a Gender Perspective" Draft Guidelines submitted at the UN Statistical Commission in March 2017.