Food and Agriculture Organization of the United Nations

GUIDELINES ON DATA ANALYSIS AND REPORTING (SDG Indicator 2.4.1)

2023

©FAO

These guidelines were prepared in support to the farm survey data collection on SDG Indicator 2.4.1 and have been revised in light of the cognitive and field tests conducted in Bangladesh, Kenya and Mexico in 2018 and 2019.

Contents

Acknowledgements

These guidelines have been prepared in support of the methodological concept note of SDG Indicator 2.4.1, particularly the data analysis and reporting on the indicator by Food and Agriculture Organization of the United Nations (FAO) in collaboration with Global Strategy to improve Agricultural and Rural Statistics (GSARS).

The author, Gianluigi Nico would like to thank all those who have contributed to the different aspects of the document especially Arbab Asfandiyar Khan from Statistics division of FAO, Amy Heyman and JeanMarc Faures of Strategic Programme on Sustainable Agriculture of FAO for their continued supervision and suggestions regarding the content, structure and further improvements of the document.

The author would also like to acknowledge all peer reviewers for their valuable inputs and comments that were provided at various stages.

Introduction

The SDG Indicator 2.4.1 has been developed to measure the "proportion of agricultural area under productive and sustainable agriculture". The core objective of SDG Indicator 2.4.1 is to collect information at the agricultural holding level on 11 different themes associated with corresponding 11 subindicators that constitute the framework of SDG 2.4.1 (details in table 1 below). For each subindicator, criteria to assess sustainability levels are developed. The concept of sustainability implies an idea of continuous progress and improvement towards better performances across all themes. In order to capture the concept of continuous progress towards sustainability, a 'traffic light' approach is proposed, in which three sustainability levels are considered for each subindicator. These are:

1. Green: desirable
2. Yellow: acceptable
3. Red: Unsustainable

While a certain level of subjectivity is unavoidable, this approach allows the identification, for each theme, of conditions of critical unsustainability (red), conditions that can be considered "ideal" (green) and, in between, intermediate conditions that are considered 'acceptable' but would need to be scrutinized in terms of possible improvements. This approach also acknowledges the trade-offs existing between sustainability dimensions and themes, and the need to find an acceptable balance between them.

Each subindicator is assessed at the level of the agricultural holding. The sustainability level is then associated with the agricultural land area of the agricultural holding and thus all subindicators for a given agricultural holding refer to the same agriculture land area.

Table 1. List of themes and subindicators

No.	Theme	Subindicator
1	Land productivity	Farm output value per hectare
2	Profitability	Net farm income
3	Resilience	Risk mitigation mechanisms
4	Soil health	Prevalence of soil degradation
5	Water use	Variation in water availability
6	Fertilizer pollution risk	Management of fertilizers
7	Pesticide risk	Management of pesticides
8	Biodiversity	Use of biodiversity-supportive practices
9	Decent employment	Wage rate in agriculture
10	Food security	Food insecurity experience scale (FIES)
11	Land tenure	Secure tenure rights to land

Source: Authors' own elaboration. 2023.

Given the complexity underlying SDG Indicator 2.4.1, this guidance tool aims to explain practical steps towards the calculation of the 11 subindicators that are part of SDG Indicator 2.4.1. In doing so, it addresses the critical steps that are undertaken for the analysis, management and final dissemination of data and statistics on SDG 2.4.1.

This tool specifically provides guidance on analysis and reporting on indicator 2.4.1. Therefore, the guidance tool suggests good practices for enhancing the quality of data and statistics in the context of measuring, monitoring and reporting on indicator 2.4.1.

Who can use this guidance tool?

This tool is for use by data producers and data users alike. It is meant to be a useful tool for government data and statistics authorities, the private sector, civil society, research and other organizations that generate and/or use data and statistics for calculating indicator 2.4.1. This tool is aligned to the approved methodology for indicator 2.4.1 and its content aims at addressing key issues toward a proper calculation of the 11 subindicators that are part of 2.4.1.

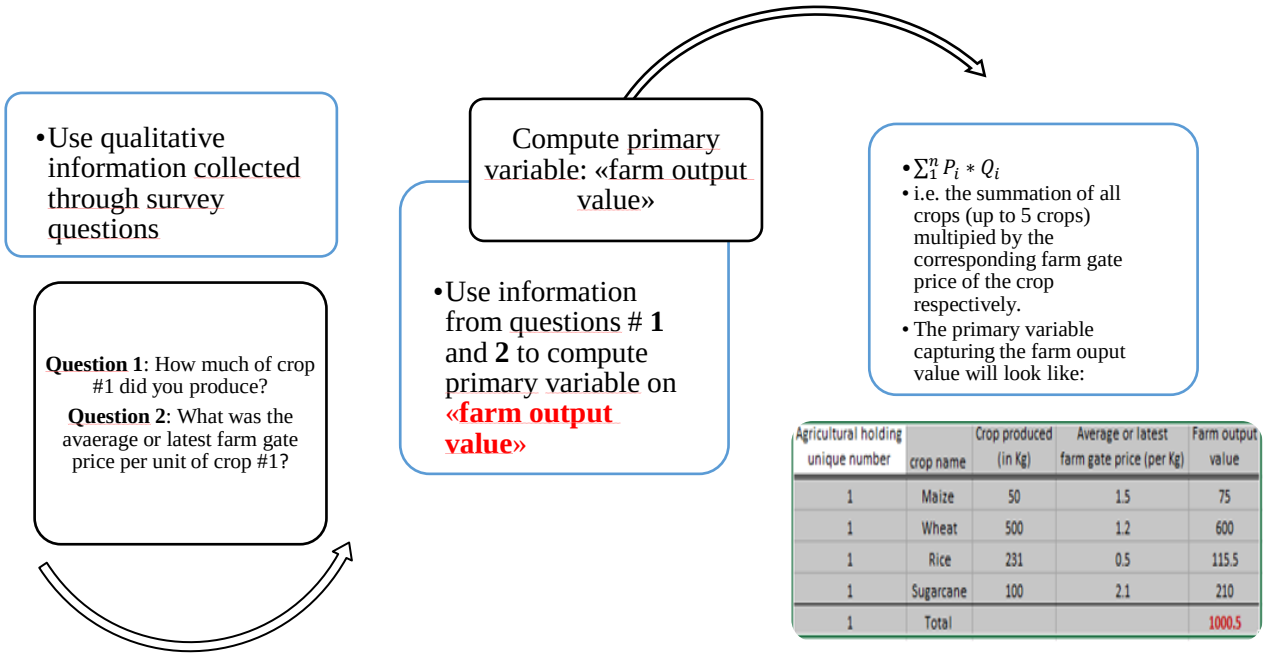
1. From raw data to final indicator

The qualitative information collected through surveys (and further stored on the computer as spreadsheet) must then be transformed in appropriate quantitative primary variables, ultimately used to construct the final subindicators that are part of SDG 2.4.1. While the methodology to construct SDG Indicator 2.4.1 has already been developed and approved, qualitative information collected through surveys has the potential to derive a number of primary variables which, in turn, are used to construct the 11 subindicators associated with SDG Indicator 2.4.1 (see Table 1).

Data analysis need to reflect the original aims and objectives for which data and statistics are being collected. To help structure the analysis, the components of selected subindicators, i.e., variables, must be identified *a priori as informed by the original objectives of the surveys*, to ensure that the qualitative information from the survey is properly transformed into quantitative variables. The computation of variables for constructing and measuring subindicators is better organised according to two steps, as follows:

1. As a first step, a set of scripts and procedures, typically done with statistical software such as *Stata or R*, are applied to the survey data organized in the excel spreadsheet after data collection for obtaining primary variables. Primary variables are vectors of *n* observations, with *n* capturing the total number of agricultural holdings in the sample for which the variable is constructed. The computation of primary variables is typically done by combining the qualitative information collected through questions asked in the survey. For instance, in the context of SDG 2.4.1 we are interested in computing a primary variables that accounts for "farm output value per hectare" (the first subindicator that is associated with the economic dimension of SDG 2.4.1). To this aim, the qualitative information collected from questions asked through the survey must be combined together. Such primary variable is computed by inferring information on a) farm gate *prices and quantities of crop, livestock and other on farm commodities that are produced by the farm (i.e. the farm output value)* and b) *the agricultural area of the holding (as measured in hectares)*. Figure 1 below shows an example on how to compute the primary variable on "farm output value", using information collected through the survey.

Figure 1. From variable formulation to variable computation



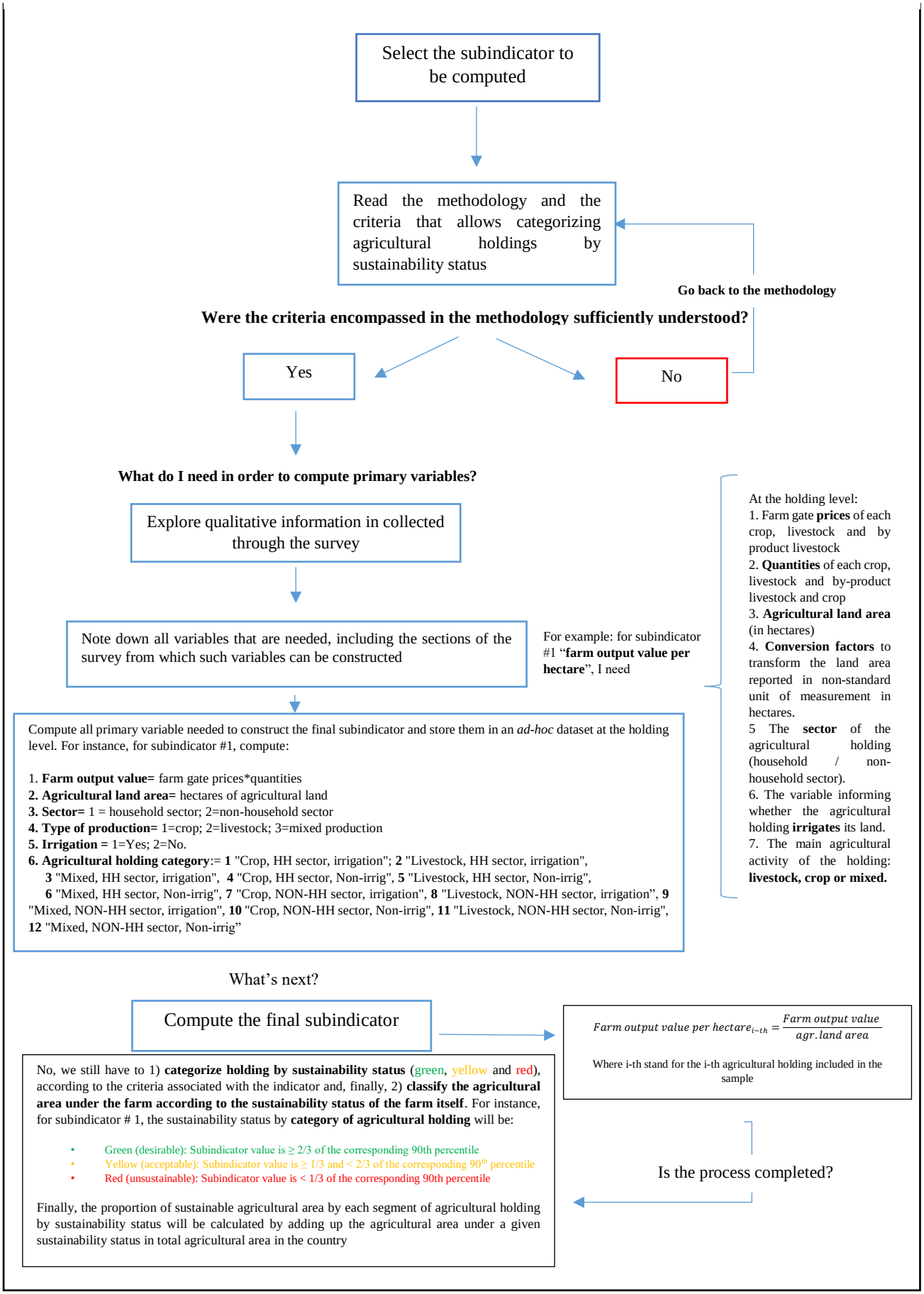
Source: Authors' own elaboration. 2023.

The computation of primary variables must reflect the components associated with each subindicator to monitor.

2. In the second step, SDG 2.4.1 subindicators are computed by combining the primary variables. This is to say that a given subindicator is generally comprised of more than one primary variable, whose combination allows deriving the final subindicator.

The conceptual framework for the computation of primary variable and final subindicators is summarized in the diagram below (figure 2).

Figure 2. Step-by-step procedure to compute primary variables and final subindicators

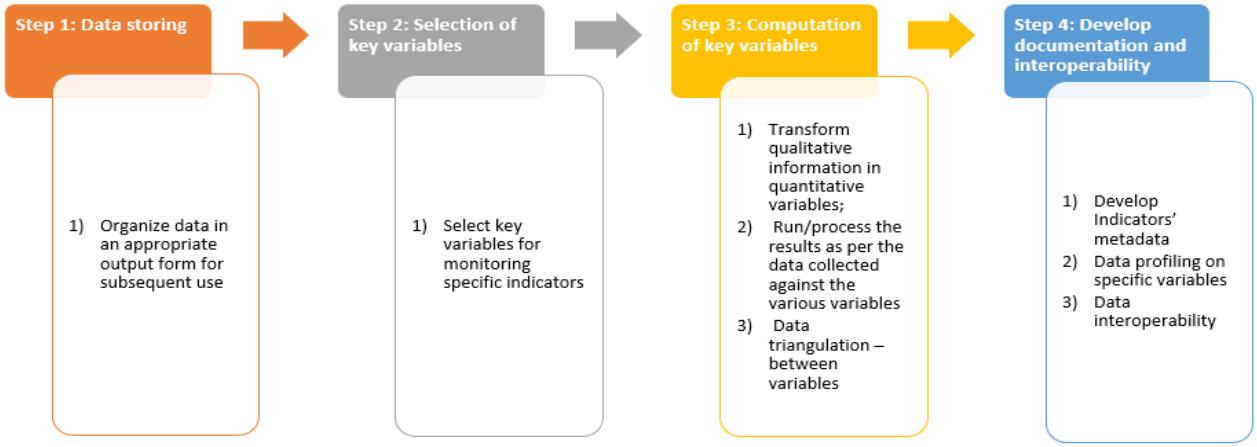


2. From computation of primary variables to assessment of the sustainability level associated with the agricultural land area of the holding

Section I above has attempted to describe the theoretical framework of reference that allows computing primary variables to be further used to construct the final 11 subindicators in the context of SDG 2.4.1. The following subsections aim to explain practical steps that go from the formulation of primary variables to the computation of variables and subindicators, including the way the 11 subindicators must be reported for monitoring purposes. It is important to remind that before embarking in the computation of variables and subindicators, the qualitative information collected from the field through survey instrument is properly organized. The following steps should therefore precede the calculation of variables and corresponding subindicators.

From data storing to data analysis. Once data have been collected from the field, checked, cleaned, harmonized, anonymized and validated, it is then coded and fed into a data system (i.e. SPSS, EPI Data, Microsoft Excel, Stata, R and etc.). These data management and processing systems are also used for analysing and presenting data in ways that can easily be understood. Often, data goes through four steps after it has been collected from the field, as presented in figure 3.

Figure 3. From data storing to data analysis.



Source: Authors' own elaboration. 2023.

Firstly, once field operation activities have been completed, data from the field must be verified, organized, transformed, integrated and extracted in an appropriate output form for subsequent use. Secondly, raw variables and data items to construct the subindicators in the context of SDG 2.4.1 must be selected. In the third step, the key primary variables are computed using raw data from the field, and organized in a specific output form (see step 1 in Figure 3). Finally, appropriate metadata for the selected subindicators must be developed to inform data users about its contents, definitions and limitations.

Steps to follow for computing the 11 subindicators: In general, three steps are envisaged in order to compute the 11 subindicators used to assess the sustainability of the agricultural land area associated with the agricultural holding. These steps are summarized as follows:

1. First, agricultural holding (farms) and their associated agricultural area are classified according to their sustainability status, as per established criteria for each subindicator.
2. Second, once farms and their associated agricultural area have been classified for a given subindicator, the total agricultural area in the country (at the national and/or subnational level) that is associated with a given sustainability status is calculated.

3. Finally, each subindicator is derived by calculating the proportion of agricultural area under a given sustainability status (i.e. desirable, acceptable and unsustainable), in total agricultural area.

The next section will provide details about the calculation of each subindicator of SDG 2.4.1. in detail.

2.1. Farm output value per hectare

Rational behind the subindicator. The subindicator measures the total agricultural area associated with farms whose output value (i.e. those that produce crops and livestock) per hectare fulfil the criteria given below.

Sustainability criteria.

- Green (desirable): holding productivity value is ≥ 2/3 of the corresponding 90th percentile
- Yellow (acceptable): holding productivity value is ≥ 1/3 and < 2/3 of the corresponding 90th percentile
- Red (unsustainable): in all other cases i.e. holding productivity value is < 1/3 of the corresponding 90th percentile

From the formulation to the computation of primary variables. The construction of this subindicators requires a number of primary variables which are derived from the qualitative information collected through the survey. The below matrix describes how the information from the survey (i.e. the raw data) is combined to derive primary variables.

Raw variables	Primary variables					
	Output value crops	Output value livestock	Output value on-farm activities	Total farm output value	Agricultural land area	Category of farm*
Farm gate prices of each crop (up to 5) per unit						
Quantity of each crop(UOM)						
Farm gate prices of each by-product of the crops (up to 5) per unit						
Quantity of each by-product crop (UOM)						
Farm gate prices of each livestock (up to 5) per unit						
Quantity of each livestock						
Farm gate prices of each product and by-product of livestock (up to 5) per unit						
Quantity of each by-product livestock						
Farm gate prices of each on-farm products (up to 5) per unit						
Quantity of each on-farm products						
Area under Temporary crops under green houses or high shelters						
Area under Temporary crops outdoors or under low shelters						
Area under temporary fallow						
Area under temporary meadows and pastures						
Area under Kitchen gardens and backyards						
Area under Permanent crops under green houses or high shelters						
Area under Permanent crops outdoors or under low shelters						
Area under Permanent meadows and pastures						
Conversion factors to hectares						
Sector of the holding (Household and non-household)						
Irrigation (yes/no)						
Main type of production (livestock, crop, mixed)						

*The primary variable "**category of farm**" is used to group farm by 12 potential groups, as follows: 1 "Crop, HH sector, irrigation"; 2 "Livestock, HH sector, irrigated ", 3 "Mixed, HH sector, irrigated ", 4 "Crop, HH sector, Non- irrigated ", 5 "Livestock, HH sector, Non-irrigated", 6 "Mixed, HH sector, Non- irrigated ", 7 "Crop, NON-HH sector, irrigated ", 8 "Livestock, NON-HH sector irrigated, 9 "Mixed, NON-HH sector, irrigated ", 10 "Crop, NON-HH sector, Non- irrigated ", 11 "Livestock, NON-HH sector, Non- irrigated ", 12 "Mixed, NON-HH sector, Non- irrigated"

Source: Authors' own elaboration. 2023.

Content of each primary variables:

This subindicator requires the calculation of 3 main primary variables.

- **Farm output value:** $\sum_{i}^{c} \boldsymbol{p_{i,c}} * \boldsymbol{q_{i,c}}$

  The farm output value is calculated as the summation of the quantity ($\boldsymbol{q_{i,c}}$) of each crop, by-product of crop, livestock, its products and by-product and on-farm commodities of the *i-th* agricultural holding multiplied by the corresponding farm gate prices. The measure is expressed in local currency unit (LCU) and it represents the numerator of the final subindicator. Table 2 below show an example on how to calculate the farm output value using real data from the survey conducted in Bangladesh (2018–2019).

Table 2. Farm output value. Calculation procedure

Agriculture Holding Identification (AHID)	Crop, by-products crop, livestock, products and by-products livestock, on-farm commodities	Quantity	Farm gate prices	Farm output value
001	Aman (rice)	80	750	60 000
001	Boro (rice)	50	650	32 500
001	Maize	35	780	27 300
001	Straw	60	480	28 800
001	Husk	20	400	8 000
			Total farm output value	**156 600**

Source: Pilot study, Bangladesh (2018–2019).

- **Agricultural land area (in hectares).**

This variable measure the agricultural land areas of the farm in hectares of land. It is calculated by adding up the area of the holding under:

- temporary crops outdoors or under low shelters
- temporary crops under green houses or high shelters
- temporary fallow
- temporary meadows and pastures
- kitchen gardens and backyards
- permanent crops outdoors or under low shelters
- permanent crops under green houses or high shelters
- permanent meadows and pastures

The calculation procedure of this primary variable is summarized in table 3 below, further refined by converting the agricultural land area into hectares.

Table 3. Total agricultural area. Calculation procedure.

Agricultural Holding number (AHID)	Land use type	Area	Unit of measurement	Conversion factor to hectares	Land area in hectare
001	Temporary crop outdoors or under low shelters	0.000			
001	Temporary crop under green houses or high shelters	2.000	Acres	0.405	0.809
001	Temporary fallow	0.000			
001	Temporary meadows and pastures				
001	Kitchen gardens and backyards	0.100	Acres	0.405	0.040
001	Permanent crop outdoors or under low shelters	0.000			
001	Permanent crop under green houses or high shelters	0.100	Acres	0.405	0.040
001	Permanent meadows and pastures	0.000			
	Total agricultural area				0.890

Source: Pilot study, Bangladesh (2018–2019).

- **Category of farm.** This variable is constructed in order to group agricultural holding by a) household and non-household sectors, b) main type of production and c) whether or not they irrigate the agricultural area. The calculation procedure of this primary variable is presented in table 4 below.

Table 4 . Category of Farm/Holdings

AHID	Holding sector	Holding activity	Holding irrigation	Category of Holding
001	Household	Crop	Yes	Crop, HH sector, irrigation
009	Household	Crop	Yes	Crop, HH sector, irrigation
013	Household	Mixed	Yes	Mixed, HH sector, irrigation
019	Household	Mixed	Yes	Mixed, HH sector, irrigation
020	Household	Mixed	Yes	Mixed, HH sector, irrigation
021	Household	Livestock	Yes	Livestock, HH sector, irrigation
022	Household	Livestock	Yes	Livestock, HH sector, irrigation
028	Household	Crop	Yes	Crop, HH sector, irrigation
029	Household	Livestock	Yes	Livestock, HH sector, irrigation
030	Household	Livestock	Yes	Livestock, HH sector, irrigation
031	Non-Household	Crop	Yes	Crop, NON-HH sector, irrigation
032	Non-Household	Crop	Yes	Crop, NON-HH sector, irrigation
033	Non-Household	Crop	Yes	Crop, NON-HH sector, irrigation
034	Non-Household	Livestock	Yes	Livestock, NON-HH sector, irrigation
035	Non-Household	Livestock	Yes	Livestock, NON-HH sector, irrigation
101	Non-Household	Mixed	Yes	Mixed, NON-HH sector, irrigation
102	Non-Household	Livestock	Yes	Livestock, NON-HH sector, irrigation
103	Non-Household	Crop	Yes	Crop, NON-HH sector, irrigation
104	Non-Household	Crop	Yes	Crop, NON-HH sector, irrigation
105	Non-Household	Crop	Yes	Crop, NON-HH sector, irrigation
106	Household	Mixed	No	Mixed, HH sector, Non-irrigated
107	Household	Crop	Yes	Crop, HH sector, irrigation
108	Household	Mixed	Yes	Mixed, HH sector, irrigation
109	Household	Crop	No	Crop, HH sector, Non-irrigated
110	Household	Crop	No	Crop, HH sector, Non-irrigated
111	Household	Mixed	No	Mixed, HH sector, Non-irrigated
112	Non-Household	Mixed	No	Mixed, NON-HH sector, Non-irrigated
113	Non-Household	Mixed	Yes	Mixed, NON-HH sector, irrigation

Source: Pilot study, Bangladesh (2018–2019).

Calculation of the subindicator. Once the three primary variables are computed, the calculation of the subindicators is carried out according to the following formula:

$$Farm\ output\ value\ per\ hectare_{i,f} = \frac{Farm\ output\ value\ per\ hectare_{i,f}}{Total\ Agricultural\ land\ area\ (in\ hectares)_{i,f}}$$

Where $Farm\ output\ value\ per\ hectare_{i,f}$ is the total farm value of production of the *i-th* agricultural holding belonging to a given category of farm (with f going from 1 to 12); $Agricultural\ land\ area\ (in\ hectares)_{i,f}$ is the agricultural land area, as expressed in hectare of the *i-th* agricultural holding belonging to a given category of farm (with f going from 1 to 12). 12 farms categories are calculated and presented in table 5 below:

Table 5. Category of farm.

S.No.	Category of farms
1	Crop, HH sector, irrigation
2	Livestock, HH sector, irrigation
3	Mixed, HH sector, irrigation
4	Crop, HH sector, non-irrigation
5	Livestock, HH sector, non-irrigation
6	Mixed, HH sector, non-irrigation
7	Crop, non-HH sector, irrigation
8	Livestock, non-HH sector, irrigation
9	Mixed, non-HH sector, irrigation
10	Crop, non-HH sector, non-irrigation
11	Livestock, non-HH sector, non-irrigation
12	Mixed, non-HH sector, non-irrigation

Source: Authors' own elaboration. 2023.

The rationale behind grouping of agricultural holdings by category of farms reflects the need to estimate different thresholds for productivity by category of farms and then in turn assess the sustainability (the holding belonging to a certain category is to be compared against productivity of the holdings belonging to that category. The 1/3 and 2/3 thresholds are applied to farm output value derived for the 90th percentile by category of farm. In other words, this grouping of agricultural holdings (by category of farm) is done in order to control for the heterogeneity that exists among different categories of farms; thresholds for sustainability are set accordingly.

Characterizing agricultural holding by sustainability status. In general, the sustainability status of agricultural holdings is determined depending on whether (or not) the farm output value per hectare is above, in between or below the thresholds estimated for each category of farm. This is to say that, for each category of farm, the computed farm output value per hectare must be benchmarked against the following threshold for sustainability:

- Green: Above or equal to 2/3 of the corresponding 90th percentile of the farm output value per hectare,
- Yellow: Above or equal to 1/3 of the corresponding 90th percentile of the farm output value per hectare but below 2/3 of the corresponding 90th percentile of the farm output value per hectare.
- Red: Below 1/3 of the corresponding 90th percentile of the farm output value per hectare.

Table 6 below show the sustainability thresholds calculated for the 12 categories of farms in Bangladesh.

Table 6. Sustainability thresholds calculated for each category of farm

HHID	Holding_type	Farm output value per hectare	90th percentile, by holding type	2/3 of 90th percentile	1/3 of 90th percentile
001	Crop, HH sector, irrigation	387,112.94	615,634.00	406,318.44	203,159.22
003	Crop, HH sector, irrigation	1,070,756.13	615,634.00	406,318.44	203,159.22
004	Crop, HH sector, irrigation	854,911.19	615,634.00	406,318.44	203,159.22
005	Crop, HH sector, irrigation	304,817.22	615,634.00	406,318.44	203,159.22
053	Crop, HH sector, irrigation	155,771.80	615,634.00	406,318.44	203,159.22
055	Crop, HH sector, irrigation	420,251.75	615,634.00	406,318.44	203,159.22
162	Crop, HH sector, Non-irrig	215,275.67	354,877.69	234,219.27	117,109.64
166	Crop, HH sector, Non-irrig	213,745.95	354,877.69	234,219.27	117,109.64
169	Crop, HH sector, Non-irrig	145,929.33	354,877.69	234,219.27	117,109.64
194	Crop, HH sector, Non-irrig	195,130.70	354,877.69	234,219.27	117,109.64
200	Crop, HH sector, Non-irrig	144,909.53	354,877.69	234,219.27	117,109.64
205	Crop, HH sector, Non-irrig	229,872.84	354,877.69	234,219.27	117,109.64
031	Crop, NON-HH sector, irrigation	1,079,786.88	1,272,854.25	840,083.81	420,041.90
032	Crop, NON-HH sector, irrigation	342,525.66	1,272,854.25	840,083.81	420,041.90
420	Crop, NON-HH sector, irrigation	1,465,921.63	1,272,854.25	840,083.81	420,041.90
120	Crop, NON-HH sector, Non-irrig	205,033.92	495,190.88	326,825.98	163,412.99
163	Crop, NON-HH sector, Non-irrig	175,708.23	495,190.88	326,825.98	163,412.99
173	Crop, NON-HH sector, Non-irrig	163,041.58	495,190.88	326,825.98	163,412.99
277	Crop, NON-HH sector, Non-irrig	495,190.88	495,190.88	326,825.98	163,412.99
021	Livestock, HH sector, irrigation	518,660.41	2,453,231.50	1,619,132.79	809,566.40
022	Livestock, HH sector, irrigation	757,347.38	2,453,231.50	1,619,132.79	809,566.40
023	Livestock, HH sector, irrigation	1,164,078.88	2,453,231.50	1,619,132.79	809,566.40
024	Livestock, HH sector, irrigation	699,860.69	2,453,231.50	1,619,132.79	809,566.40
027	Livestock, HH sector, irrigation	569,367.75	2,453,231.50	1,619,132.79	809,566.40
029	Livestock, HH sector, irrigation	877,467.00	2,453,231.50	1,619,132.79	809,566.40
030	Livestock, HH sector, irrigation	2,453,231.50	2,453,231.50	1,619,132.79	809,566.40
058	Mixed, HH sector, irrigation	539,924.81	1,010,884.75	667,183.94	333,591.97
059	Mixed, HH sector, irrigation	1,504,570.25	1,010,884.75	667,183.94	333,591.97
060	Mixed, HH sector, irrigation	255,494.27	1,010,884.75	667,183.94	333,591.97
061	Mixed, HH sector, irrigation	686,325.94	1,010,884.75	667,183.94	333,591.97
065	Mixed, HH sector, irrigation	364,434.56	1,010,884.75	667,183.94	333,591.97
076	Mixed, HH sector, irrigation	346,599.97	1,010,884.75	667,183.94	333,591.97
077	Mixed, HH sector, irrigation	344,857.44	1,010,884.75	667,183.94	333,591.97
078	Mixed, HH sector, irrigation	211,876.84	1,010,884.75	667,183.94	333,591.97
314	Mixed, NON-HH sector, irrigation	5,633,914.00	1,289,939.88	851,360.32	425,680.16
350	Mixed, NON-HH sector, irrigation	838,355.75	1,289,939.88	851,360.32	425,680.16
383	Mixed, NON-HH sector, irrigation	1,226,989.38	1,289,939.88	851,360.32	425,680.16
418	Mixed, NON-HH sector, irrigation	471,020.75	1,289,939.88	851,360.32	425,680.16
419	Mixed, NON-HH sector, irrigation	1,289,939.88	1,289,939.88	851,360.32	425,680.16
112	Mixed, NON-HH sector, Non-irrig	407,167.53	6,628,066.50	4,374,523.89	2,187,261.95
155	Mixed, NON-HH sector, Non-irrig	152,010.86	6,628,066.50	4,374,523.89	2,187,261.95
170	Mixed, NON-HH sector, Non-irrig	198,653.17	6,628,066.50	4,374,523.89	2,187,261.95
174	Mixed, NON-HH sector, Non-irrig	419,854.13	6,628,066.50	4,374,523.89	2,187,261.95
209	Mixed, NON-HH sector, Non-irrig	6,628,066.50	6,628,066.50	4,374,523.89	2,187,261.95
210	Mixed, NON-HH sector, Non-irrig	1,860,379.13	6,628,066.50	4,374,523.89	2,187,261.95

Source: Pilot study, Bangladesh (2018–2019).

Reporting

The reporting process of subindicator ''1'' is based on the following steps:

First, the farm output values per hectare (see formula [1] above) is benchmarked against the sustainability thresholds (table 6 above).

Agricultural holdings whose farm output value per hectare is above 2/3 of the 90th percentile of the Farm Output Values Per Hectare of a given category of farm will be classified as "desirable" (e.g. agricultural holding #003). Agricultural holdings whose farm output values per hectare is below 1/3 will be classified as "unsustainable" and, finally, agricultural holdings whose farm output value per hectare is between 2/3 and 1/3 of the 90th percentile of the farm output value will be classified as "acceptable".

Table 7. Farm sustainability.

HHID	Holding type	Farm output value per hectare	90th percentile, by holding type	2/3 of 90th percentile	1/3 of 90th percentile	Sustainability status
001	Crop, HH sector, irrigation	387,112.94	615,634.00	406,318.44	203,159.22	Acceptable
003	Crop, HH sector, irrigation	1,070,756.13	615,634.00	406,318.44	203,159.22	Desirable
004	Crop, HH sector, irrigation	854,911.19	615,634.00	406,318.44	203,159.22	Desirable
005	Crop, HH sector, irrigation	304,817.22	615,634.00	406,318.44	203,159.22	Acceptable
053	Crop, HH sector, irrigation	155,771.80	615,634.00	406,318.44	203,159.22	Non-sustainable
055	Crop, HH sector, irrigation	420,251.75	615,634.00	406,318.44	203,159.22	Desirable
162	Crop, HH sector, Non-irrig	215,275.67	354,877.69	234,219.27	117,109.64	Acceptable
166	Crop, HH sector, Non-irrig	213,745.95	354,877.69	234,219.27	117,109.64	Acceptable
169	Crop, HH sector, Non-irrig	145,929.33	354,877.69	234,219.27	117,109.64	Acceptable
194	Crop, HH sector, Non-irrig	195,130.70	354,877.69	234,219.27	117,109.64	Acceptable
200	Crop, HH sector, Non-irrig	144,909.53	354,877.69	234,219.27	117,109.64	Acceptable
205	Crop, HH sector, Non-irrig	229,872.84	354,877.69	234,219.27	117,109.64	Acceptable
031	Crop, NON-HH sector, irrigation	1,079,786.88	1,272,854.25	840,083.81	420,041.90	Desirable
032	Crop, NON-HH sector, irrigation	342,525.66	1,272,854.25	840,083.81	420,041.90	Non-sustainable
420	Crop, NON-HH sector, irrigation	1,465,921.63	1,272,854.25	840,083.81	420,041.90	Desirable
120	Crop, NON-HH sector, Non-irrig	205,033.92	495,190.88	326,825.98	163,412.99	Acceptable
163	Crop, NON-HH sector, Non-irrig	175,708.23	495,190.88	326,825.98	163,412.99	Acceptable
173	Crop, NON-HH sector, Non-irrig	163,041.58	495,190.88	326,825.98	163,412.99	Non-sustainable
277	Crop, NON-HH sector, Non-irrig	495,190.88	495,190.88	326,825.98	163,412.99	Desirable
021	Livestock, HH sector, irrigation	518,660.41	2,453,231.50	1,619,132.79	809,566.40	Non-sustainable
022	Livestock, HH sector, irrigation	757,347.38	2,453,231.50	1,619,132.79	809,566.40	Non-sustainable
023	Livestock, HH sector, irrigation	1,164,078.88	2,453,231.50	1,619,132.79	809,566.40	Acceptable
024	Livestock, HH sector, irrigation	699,860.69	2,453,231.50	1,619,132.79	809,566.40	Non-sustainable
027	Livestock, HH sector, irrigation	569,367.75	2,453,231.50	1,619,132.79	809,566.40	Non-sustainable
029	Livestock, HH sector, irrigation	877,467.00	2,453,231.50	1,619,132.79	809,566.40	Acceptable
030	Livestock, HH sector, irrigation	2,453,231.50	2,453,231.50	1,619,132.79	809,566.40	Desirable
058	Mixed, HH sector, irrigation	539,924.81	1,010,884.75	667,183.94	333,591.97	Acceptable
059	Mixed, HH sector, irrigation	1,504,570.25	1,010,884.75	667,183.94	333,591.97	Desirable
060	Mixed, HH sector, irrigation	255,494.27	1,010,884.75	667,183.94	333,591.97	Non-sustainable
061	Mixed, HH sector, irrigation	686,325.94	1,010,884.75	667,183.94	333,591.97	Desirable
065	Mixed, HH sector, irrigation	364,434.56	1,010,884.75	667,183.94	333,591.97	Acceptable
076	Mixed, HH sector, irrigation	346,599.97	1,010,884.75	667,183.94	333,591.97	Acceptable
077	Mixed, HH sector, irrigation	344,857.44	1,010,884.75	667,183.94	333,591.97	Acceptable
078	Mixed, HH sector, irrigation	211,876.84	1,010,884.75	667,183.94	333,591.97	Non-sustainable
314	Mixed, NON-HH sector, irrigation	5,633,914.00	1,289,939.88	851,360.32	425,680.16	Desirable
350	Mixed, NON-HH sector, irrigation	838,355.75	1,289,939.88	851,360.32	425,680.16	Acceptable
383	Mixed, NON-HH sector, irrigation	1,226,989.38	1,289,939.88	851,360.32	425,680.16	Desirable
418	Mixed, NON-HH sector, irrigation	471,020.75	1,289,939.88	851,360.32	425,680.16	Acceptable
419	Mixed, NON-HH sector, irrigation	1,289,939.88	1,289,939.88	851,360.32	425,680.16	Desirable
112	Mixed, NON-HH sector, Non-irrig	407,167.53	6,628,066.50	4,374,523.89	2,187,261.95	Non-sustainable
155	Mixed, NON-HH sector, Non-irrig	152,010.86	6,628,066.50	4,374,523.89	2,187,261.95	Non-sustainable
170	Mixed, NON-HH sector, Non-irrig	198,653.17	6,628,066.50	4,374,523.89	2,187,261.95	Non-sustainable
174	Mixed, NON-HH sector, Non-irrig	419,854.13	6,628,066.50	4,374,523.89	2,187,261.95	Non-sustainable
209	Mixed, NON-HH sector, Non-irrig	6,628,066.50	6,628,066.50	4,374,523.89	2,187,261.95	Desirable
210	Mixed, NON-HH sector, Non-irrig	1,860,379.13	6,628,066.50	4,374,523.89	2,187,261.95	Non-sustainable

Source: Pilot study, Bangladesh (2018–2019)

Second, once agricultural holdings have been classified according to their sustainability status, it is important to get the corresponding agricultural area of the holding (see table 8 below).

Table 8. Farm sustainability status

HHID	Agricultural area	Sustainability status (farm output value per hectare)
001	0.90	Acceptable
003	0.20	Desirable
004	0.28	Desirable
005	0.62	Acceptable
053	6.07	Non-sustainable
055	0.81	Desirable
162	0.85	Acceptable
166	1.58	Acceptable
169	1.46	Acceptable
194	0.61	Acceptable
200	1.13	Acceptable
205	0.77	Acceptable
031	23.63	Desirable
032	71.75	Non-sustainable
420	4.03	Desirable
120	0.79	Acceptable
163	1.21	Acceptable
173	6.27	Non-sustainable
277	1.02	Desirable
021	2.25	Non-sustainable
022	0.67	Non-sustainable
023	0.33	Acceptable
024	1.70	Non-sustainable
027	1.12	Non-sustainable
029	0.57	Acceptable
030	0.21	Desirable
058	0.65	Acceptable
059	0.43	Desirable
060	0.96	Non-sustainable
061	0.57	Desirable
065	1.65	Acceptable
076	0.21	Acceptable
077	0.79	Acceptable
078	0.47	Non-sustainable
314	1.78	Desirable
350	0.97	Acceptable
383	0.36	Desirable
418	1.62	Acceptable
419	0.39	Desirable
112	0.81	Non-sustainable
155	2.43	Non-sustainable
170	1.65	Non-sustainable
174	4.45	Non-sustainable
209	1.98	Desirable
210	8.98	Non-sustainable

Source: Pilot study, Bangladesh (2018–2019)

The final step implies adding up and calculating the total agricultural area in the country under a given sustainability status and computing the corresponding proportion (over total agricultural area). The dashboard approach for reporting on this indicator will look like:

Table 9. Reporting the subindicator #1:

Sustainability status (subindicator #1)	Agriculture area in Hectare	Proportion of Agriculture area
Desirable	55.9	11
Acceptable	93.7	18
Unsustainable	360.1	71
Total	**509.8**	100

Source: Pilot study, Bangladesh (2018–2019)

2.2. Net farm income

Rational behind the subindicator. The subindicator measures the proportion of agricultural areas that are economically viable or profitable over time by sustainability status. The sustainability status is classified on the basis as to how often was a given holding profitable in the past three consecutive years.

Sustainability criteria.

- Green (desirable): Profits above zero for past 3 consecutive years
- Yellow (acceptable): Profits above zero for at least 1 of the past 3 consecutive years
- Red (unsustainable): Profits below zero for all of the past 3 consecutive years

From the formulation to the computation of primary variables. In general, information on the profitability of the farm is calculated using detailed information available on the revenues and costs, using the formula;

$$\boldsymbol{NFI = CR + Y_k - OE - Dep + \Delta In} \qquad \textbf{[2]}$$

Where:

- **NFI** = Total Net Farm Income
- **CR** = Total farm cash receipts including direct program payments
- $\boldsymbol{Y_k}$ = Income in kind
- **OE** = Total operating expenses after rebates (including costs of labour)
- **Dep** = Depreciation
- **Δ Inv** = Value of inventory change

The primary variables are combined with the information gathered from the farm survey, as in the matrix below.

Raw Vartiables	Primary Variables									
	Output value from crop	Output value from livestock	Output value from on-farm	Total farm output value	Labour cost	Non-labour cost	Depreciation	Total cost	Value inventory chan	Profitability
Farm gate price of each crop (up to 5) per unit										
Quantity of each crop (in Kg)										
Farm gate price by-product crop (up to 5) per unit										
Quantity of each by-product crop (in Kg)										
Farm gate price of each livestock (up to 5) per unit										
Quantity of each livestock										
Farm gate price of each product and by-product livestock (up to 5) per unit										
Quantity of each product and by-product livestock										
Farm gate price of each on-farm products (up to 5) per unit										
Quantity of each on-farm products										
Labour costs										
Non-labour costs (operating)										
Depreciation										
Inventory change										

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 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.

In case when detailed data are not available at farm level, a 2nd option can be used where estimates will be calculated based on farmer declaration (self-reported answer) of outputs and inputs quantity, farm gate prices and value. In these cases, depreciation, variation of stocks and taxes may be neglected.

Additionally, if the required data items to calculate net farm income are not available at all, a 3rd simplified option is also offered, based on farmer's declaration of the agricultural holding's profitability over the last three calendar years. The calculation provided in this tool is for the 3rd option. Construction of this subindicators may require, therefore only one primary variable which is usually derived from the qualitative information collected through farm survey. The below matrix describes how the information from the survey (i.e. the raw data) is combined to derive primary variable.

Raw variables	**Primary variables** Net farm income
How many time was this agricultural holding profitable over the past 3 years?	

Content of the primary variables. The primary variable informs on whether (or) not the agricultural holding was profitable over the past 3 years.

Characterizing agricultural holdings by sustainability status. In general, the sustainability status of agricultural holdings is determined depending on how many times the agricultural holding was profitable over the past 3 years prior to the date of the interview. Table 10 below show the sustainability status of the holding using real data from Bangladesh pilot study.

Table 10. Sustainability thresholds calculated for each category of farm. Source: farm survey (pilot study), Bangladesh 2018.

HHID	Number of times the holding was profitable	Sustainability status
001	Profitable in two out of the three years	Acceptable
002	Profitable in three out of the three years	Desirable
013	Profitable in one out of the three years	Acceptable
181	Unprofitable for all three years	Unsustainable
186	Unprofitable for all three years	Unsustainable
414	Profitable in three out of the three years	Desirable
416	Unprofitable for all three years	Unsustainable
418	Profitable in three out of the three years	Desirable
419	Profitable in three out of the three years	Desirable

Source: Authors' own elaboration. 2023.

Reporting

The reporting process of subindicator ''2'' is based on the following steps:

First, the number of times the holding was profitable over the past 3 years is benchmarked against the sustainability thresholds (table 10 above).

The final step implies calculating the total agricultural area in the country under a given sustainability status and compute the corresponding proportion (over total agricultural area). The dashboard approach for reporting on this indicator will look like:

Table 11. Reporting on subindicator #2

Sustainability status (subindicator #2)	**Agriculture area in hectare**	**Proportion of agriculture area**
Desirable	237.5	47
Acceptable	250.0	49
Unsustainable	22.3	4
Total	**509.8**	100

Source: Pilot study, Bangladesh (2018–2019).

2.3. Risk mitigation mechanisms

Rational behind the subindicator. This subindicator measures the access to or use of the following risk mitigation mechanisms by the agriculture holding in case of an external shock:

- Access to or availed credit (both formal and informal).
- Access to or availed insurance.
- On farm diversification (share of a single agricultural commodity not greater than 66 percent in the total value of production of the holding).

Sustainability criteria.

- Green (desirable): Access to or availed at least two of the above-listed three mitigation mechanisms.
- Yellow (acceptable): Access to or availed at least one of the above-listed three mitigation mechanisms.
- Red (unsustainable): No access to the above listed three mitigation mechanisms.

From the formulation of primary variables to the computation of primary variables. In general, information on the risk mitigation mechanisms that feed this subindicators requires the computation of 3 primary variables that can be derived from a number of raw variables gathered through the survey. The primary variables are 1) on-farm diversification; 2) access/availed credit and 3) access/availed insurance. The matrix below shows the raw data that are needed in order to compute primary variables for this subindicator.

Raw variables	**Primary variables**						
	Output value	Output value	Output value	Total farm	On farm	Access to/availed	Access to/availed
	Crops	Livestock	On-farm	value of production	diversification	Credit	Insurance
Farm gate prices of each crop (up to 5) per unit	■			■	■		
Quantity of each crop(UOM)	■			■	■		
Farm gate prices of each by-product crop (up to 5) per unit	■			■	■		
Quantity of each by-product crop(UOM)	■			■	■		
Farm gate prices of each livestock (up to 5) per unit		■		■	■		
Quantity of each livestock		■		■	■		
Farm gate prices of each by-product livestock (up to 5) per unit		■		■	■		
Quantity of each by-product livestock		■		■	■		
Farm gate prices of each on-farm products (up to 5) per unit			■	■	■		
Quantity of each on-farm product			■	■	■		
Farm reported to access or availed credit						■	
Farm reported to access or availed insurance							■

Source: Authors' own elaboration. 2023.

Content of the primary variables.

1. **On-farm diversification.** It captures the share of the value of production of one single agricultural commodity over total value of production of the agricultural holding. This variable is calculated according to the below formula:

$$On - farm\ diversification = \frac{Value\ of\ production\ _{i,c}}{Total\ value\ of\ production\ of\ the\ holding_i} \quad [3]$$

Where $Value\ of\ production_{i,c}$ is the value of production of the *c-th* agricultural commodity related to the *i-th* agricultural holding and $Total\ value\ of\ production\ of\ the\ holding_i$ is the total value of production of the *i-th* agricultural holding.

2. **Access to/availed credit.** This variable captures those agricultural holding that availed or has access to credit.
3. **Access to/availed insurance.** This variable captures those agricultural holding that availed or has access to insurance.

Characterizing agricultural holding by sustainability status. In general, the sustainability status of agricultural holdings is determined depending on how many risk mitigation mechanisms have been adopted by the agricultural holding. Table 12 below show the sustainability status of the holding using real data from Bangladesh pilot study (2018–2019).

For instance, the agricultural holding #001 has adopted 2 out of 3 risk mitigation mechanisms (access to/availed credit and insurance), despite it does not diversify its own-farm production: 76 percent of total value of agricultural holding production comes from one single commodity. Nonetheless, the sustainability status of this agricultural holding is "desirable", as per SDG 2.4.1 methodology

Table 12. Sustainability status based on number of risk mitigation mechanisms adopted.

HHID	Share of production for agricultural commodity #1	Share of production for agricultural commodity #2	Share of production for agricultural commodity #3	On-farm diversification	Access to/availed credit	Access to/availed insurance	Total number of Risk mitigation mechanisms adopted	Sub_indicator_3_sust
001	76	24	0	0	1	1	2	Desirable
002	68	32	0	0	1	1	2	Desirable
003	33	33	34	1	0	0	1	Acceptable
004	100	0	0	0	0	0	0	Unsustainable

Source: Pilot study, Bangladesh (2018–2019).

Reporting

The reporting process of subindicator ''3'' is based on the following steps:

First, the number of risk mitigation mechanisms adopted by the agricultural holdings are benchmarked against the sustainability criteria (table 12 above).

The final step implies adding up and calculating the total agricultural area in the country given its sustainability status and computing the corresponding proportion (over total agricultural area). The dashboard approach for reporting on this indicator will look like:

Table 13. Reporting subindicator #3

Sustainability status (subindicator #3)	Agriculture area in hectare	Proportion of agriculture area
Desirable	286.3	56
Acceptable	148.9	29
Unsustainable	74.6	15
Total	**509.8**	100

Source: Pilot study, Bangladesh (2018–2019).

2.4. Prevalence of soil degradation

Rational behind the subindicator. The subindicator measures the sustainability status of agricultural holdings and its associated agricultural areas on the basis of four soil health threats that it may experience over the last three years, the threats are given as follows:

- erosion (loss of topsoil through wind or water)
- reduction in soil fertility
- waterlogging
- salinization
- any other, specify…

Sustainability criteria

- Green (desirable): The combined area affected by any of the four selected threats to soil health is negligible (less than 10 percent of the total agriculture area of the farm).
- Yellow (acceptable): The combined area affected by any of the four selected threats to soil health is between 10 percent and 50 percent of the total agriculture area of the farm.
- Red (unsustainable): The combined area affected by any of the four selected threats to soil health is above 50 percent of the total agriculture area of the farm.

From the formulation of primary variables to the computation of primary variables. In general, information on the prevalence of soil degradation requires the computation of a number of primary variables that can be derived by inferring information from a survey related to: 1) whether or not the agricultural holding was affected by any of the above listed soil degradation threats; 2) the total agricultural area of the holding, as well as the agricultural area of the holding that was affected by these threats; and finally 3) the share of the combined area affected by any of the four selected threats. The matrix below allows identifying all primary variables that are used to construct the final subindicator.

Raw variables	Primary variables								
	Threat #1	Threat #2	Threat #3	Threat #4	Other	Farm affected by any threat	Agricultural area	Agricultural area affected	Share of agricultural area affected by any threat
Erosion									
Reduction in soil fertility									
Waterlogging									
Salinization									
Any other (Specify)									
Area under Temporary crop under green houses or high shelters									
Area under Temporary crop Outdoors or low shelters									
Area under Temporary fallow									
Area under Temporary meadows and pastures									
Area under Kitchen gardens and backyards									
Area under Permanent crop under green houses or high shelters									
Area under Permanent crop Outdoors or low shelters									
Area under Permanent meadows and pastures									
Area affected									
Conversion factors to hectares									

Content of the primary variables.

4. **Threat #1.** A dummy variable taking on value 1 if the area of the agricultural holding was affected by soil erosion (loss of topsoil through wind or water erosion)
5. **Threat #2.** A dummy variable taking on value 1 if the area of the agricultural holding was affected by reduction in soil fertility.
6. **Threat #3.** A dummy variable taking on value 1 if the area of the agricultural holding was affected by waterlogging, including by floods.
7. **Threat #4.** A dummy variable taking on value 1 if the area of the agricultural holding was affected by salinization of irrigated land.
8. **Farm affected by any threat.** A dummy variable taking on value 1 if the area of the agricultural holding was affected by any of the soil degradation threats.
9. **Agricultural area of the holding.** This variable measures the agricultural land areas of the farm in hectares of land. It is calculated by adding up the area of the holding under:
    - temporary crops under green houses or high shelters
    - temporary crops outdoors or under low shelters
    - temporary fallow
    - temporary meadows and pastures
    - kitchen gardens and backyards
    - permanent crops under green houses or high shelters
    - permanent crops outdoors or under low shelters
    - permanent meadows and pastures

10. **Agricultural area affected.** This variable measures the agricultural land areas of the farm which was affected by any of the above-listed soil degradation threats, in hectares of land.

11. **Share of agricultural area affected by any threat=** $\frac{Agricultural\ area\ affected_i}{Agricultural\ area\ of\ the\ holding_i}$ this variable measures the proportion of the total agricultural area of the holding that was affected by soil degradation threats. It represents the key variable to categorize agricultural holding by the corresponding sustainability status.

Characterizing agricultural holding by sustainability status. In general, the sustainability status of agricultural holdings is determined depending on the proportion of the total agricultural area that was affected by any threats. Table 14 below shows the sustainability status of the holding using real data from Bangladesh pilot study (2018–2019).

For instance, the agricultural holding #001 has been affected by 2 out of 4 soil degradation threats, overall affecting 45 percent of the total area. Given the criteria established in the methodology, the sustainability status of this agricultural holding is “acceptable”. In a similar vein, the sustainability status of agricultural holdings #002 and #003 is “desirable”, since they were not affected by any soil degradation threats.

Table 14. *Sustainability status based on proportion of the total area of the holding affected by soil degradation threats.*

HHID	Soil erosion	Reduction in soil fertility	Waterlogging, including by floods	Salinization of irrigated land	Agricultural Area of the holding	Agricultural area affected	Area affected	Prevalence of soil degradation: Sustainability status
001	No	Reduction in soil fertility	Waterlogging	No	0.90	0.40	45	Acceptable
002	No	No	No	No	0.28	-	0	Desirable
003	No	No	No	No	0.20	-	0	Desirable
004	Soil Erosion	Reduction in soil fertility	No	No	0.28	0.20	74	Unsustainable
005	No	Reduction in soil fertility	Waterlogging	No	0.62	0.36	58	Unsustainable
006	Soil Erosion	Reduction in soil fertility	No	No	0.79	0.51	64	Unsustainable
007	Soil Erosion	No	Waterlogging	No	2.15	1.62	75	Unsustainable

Source: Pilot study, Bangladesh (2018–2019).

Reporting

The reporting process of subindicator **''4''** is based on the following steps:

First, the proportion of the total agricultural area of the holding that was affected by any of the above-listed soil degradation threats is benchmarked against the sustainability criteria (table above).

The final step implies calculating the total agricultural area in the country under a given sustainability status and compute the corresponding proportion (over total agricultural area). The dashboard approach for reporting on this indicator will look like:

Table 15. Reporting on SDG 2.4.1, subindicator #4

Sustainability status (subindicator #4)	Agriculture area in hectare	Proportion of agriculture area
Desirable	259.8	51
Acceptable	147.0	29
Unsustainable	103.0	20
Total agricultural area (in hectares)	**509.8**	100

Source: Pilot study, Bangladesh (2018–2019).

2.5. Variation in water availability

Rational behind the subindicator. The subindicator captures the proportion of agricultural areas by sustainability status associated with farms that use water for irrigation:

- Use of water to irrigate crops on at least 10 percent of agricultural area; and
- Reduction in water availability over time; and (or)
- Inefficient functioning of organizations that are in-charge of water allocation

Sustainability criteria.

- Green (desirable): Water availability remains stable over the years, for farms irrigating crops on more than 10 percent of the agriculture area of the farm. Default result for farms irrigating less than 10 percent of their agricultural area
- Yellow (acceptable): uses water to irrigate crops on at least 10 percent of the agriculture area of the farm, does not know whether water availability remains stable over the years, or experiences reduction on water availability over the years, but there is an organisation that effectively allocates water among users.
- Red (unsustainable): in all other cases.

From the formulation of primary variables to the computation of primary variables. In general, information on variation of water availability requires the computation of four main primary variables that can be derived by inferring information from a survey related to: 1) whether or not the agricultural holding irrigated its land; 2) the percentage of the area of the holding where water was used for irrigating crops; 3) whether (or not) water remains stable over years; and, finally 4) if there are organizations that effectively allocate water among users. The list of primary variables is listed in the matrix below.

Raw variables	Primary Variables					
	Use of water for crop irrigation	Total area irrigated	Reduction in water availability	Organizations	Total agricultural area of the holding	% age of total area irrigated
Agricultural holding use water to irrigate crops						
Self-reported percentage of the total area of the holding irrigated						
Observed reduction in water availability						
Organizations dealing with water allocation in the area where this holding is located						
Temporary crop outdoors or under low shelters						
Temporary crop under green houses or high shelters						
Area under Temporary fallow						
Area under Temporary meadows and pastures						
Area under Kitchen gardens and backyards						
Area under Permanent crop outdoors or under low shelters						
Area under Permanent crop under green houses or high shelters						
Area under Permanent meadows and pastures						
Conversion factors to hectares						

Content of the primary variables.

1. **Use of water for crop irrigation.** A dummy variable taking on value 1 if the agricultural holding used water for irrigating crops.
2. **Total area irrigated.** This variable measures the agricultural area of the holding where water was use for irrigating crops.
3. **Reduction in water availability.** A dummy variable taking on value 1 if the agricultural holding observed any reduction in water availability.
4. **Organizations.** A dummy variable taking on value 1 if there are organizations dealing with water allocation in the area where this holding is located.
5. **Agricultural area of the holding.** This variable measures the agricultural land areas of the farm in hectares of land. It is calculated by adding up the area of the holding under:

    - temporary crop under green houses or high shelters
    - temporary crop outdoors or under low shelters
    - temporary fallow
    - temporary meadows and pastures
    - kitchen gardens and backyards
    - permanent crop under green houses or high shelters
    - permanent crop outdoors or under low shelters
    - permanent meadows and pastures

6. **Percentage of total area irrigated =** $\frac{Total\ area\ irrigated_i}{Agricultural\ area\ of\ the\ holding_i}$ **;** this variable measures the proportion of the total agricultural area of the holding where water was used for irrigating crops;

Characterizing agricultural holding by sustainability status. In general, the sustainability status of agricultural holdings is determined as per criteria established in the methodology. Table 16 below shows the sustainability status of the holding using test data from Bangladesh.

For instance, the agricultural holding #001 used water for irrigating crop on almost all agricultural land area (90 percent) but self-reported that water is always available in sufficient quantity, hence resulting into a sustainability status which is “desirable”. By contrast, the sustainability status of the agricultural holding #036 is “Unsustainable ” because: 1) the proportion of the agricultural area where water was used for irrigating crop is much greater than 10 percent and 2) the holding self-reported that water is not always available in sufficient quantity. Finally, because of the presence of organization dealing with water allocation, the sustainability status of the agricultural holding # 002 is “acceptable”.

Table 16. Sustainability status based on variation of water availability.

HHID	Reduction in water availability	Organization dealing with water allocation	Area irrigated	Variation in water availability: Sustainability status
001	No, water is always available in sufficient quantity		89.7	Desirable
002	Yes, water level in my well(s) is progressively going down	Yes, and they are working well	71.4	Acceptable
003	No, water is always available in sufficient quantity		100.0	Desirable
034	No, water is always available in sufficient quantity		74.3	Desirable
035	No, water is always available in sufficient quantity		88.8	Desirable
036	Yes, water level in my well(s) is progressively going down	No, there are none	74.0	Unsustainable
037	I don't know		0.0	Desirable

Source: Pilot study, Bangladesh (2018–2019).

Reporting:

The reporting process of subindicator **''5''** is based on the following steps. Once agricultural holding have been classified according to their sustainability status, the final step implies calculating the total agricultural area in the country under a given sustainability status and compute the corresponding proportion (over total agricultural area). The dashboard approach for reporting on this indicator will look like:

Table 17. Reporting subindicator #5:

Sustainability status (subindicator #5)	**Agriculture area in Hectare**	**Proportion of Agriculture area**
Desirable	443.0	87
Acceptable	11.3	2
Unsustainable	55.5	11
Total	**509.8**	100

Source: Pilot study, Bangladesh (2018–2019).

2.6. Management of fertilizers

Rational behind the subindicator. The subindicator captures agricultural areas by sustainability status, according to the management of fertilizer by farms.

Sustainability criteria.

- Green (desirable): The farm takes specific measures to mitigate environmental risks (at least four from the list above). Default result for farms not using fertilizers.[1]
- Yellow (acceptable): the farm uses fertilizers and takes at least two measures from the above list to mitigate environmental risks
- Red (unsustainable): The farm uses fertilizer and takes less than two of the above specific measures to mitigate environmental risks associated with their use.

From the formulation to the computation of primary variables. In general, information on variation on management of fertilizers requires exploring whether the agricultural holding 1) uses (or do not use) fertilizers and 2) in case of affirmative responses the number of specific measures adopted, if any, in order to mitigate environmental risks. The list of primary variables is listed in the matrix below and combined with the raw variables from the farm survey.

Raw variables	Primary variables									
	Use of fertilizers	#1	#2	#3	#4	#5	#6	#7	#8	Total number of measures
Did this agricultural holding use any synthetic or mineral fertilizer or animal manure/slurry for crops?										
Follow protocols as per extension service or retail outlet recommendations or local regulations, not exceeding recommended dose										
Use organic source of nutrients (including manure or composting residues) alone, or in combination with synthetic or mineral fertilizers										
Use legumes as a cover crop, or component of a multi/crop or pasture system to reduce fertilizer inputs										
Distribute synthetic or mineral fertilizer application over the growing period										
Consider soil type and climate in deciding fertilizer application doses and frequencies										
Use soil sampling at least every 5 years to perform nutrient budget calculations										
Perform site-specific nutrient management or precision farming										
Use buffer strips along water courses.										

Content of the primary variables.

[1] Fertilizers to be considered include mineral and synthetic fertilizers as well as animal manure.

1. **Use of fertilizers.** A dummy variable taking on value 1 if the agricultural holding used fertilizers.
2. **Measures #1.** A dummy variable taking on value 1 if the agricultural holding follows protocols as per extension service or retail outlet recommendations or local regulations, not exceeding recommended dose.
3. **Measures #2.** A dummy variable taking on value 1 if the agricultural holding uses organic source of nutrients (including manure or composting residues) alone, or in combination with synthetic or mineral fertilizers.
4. **Measures #3.** A dummy variable taking on value 1 if the agricultural holding uses legumes as a cover crop, or component of a multi/crop or pasture system to reduce fertilizer inputs.
5. **Measures #4.** A dummy variable taking on value 1 if the agricultural holding distributes synthetic or mineral fertilizer application over the growing period.
6. **Measures #5.** A dummy variable taking on value 1 if the agricultural holding considers soil type and climate in deciding fertilizer application doses and frequencies.
7. **Measures #6.** A dummy variable taking on value 1 if the agricultural holding uses soil sampling at least every 5 years to perform nutrient budget calculations.
8. **Measures #7.** A dummy variable taking on value 1 if the agricultural holding performs site-specific nutrient management or precision farming.
9. **Measures #8.** A dummy variable taking on value 1 if the agricultural holding has buffer strips along water courses.
10. **Total number of measures adopted.** A variable capturing the total number of measures taken by the holding to mitigate environmental-related risks.

Characterizing agricultural holding by sustainability status. In general, the sustainability status of agricultural holdings is determined depending on whether the agricultural holding uses fertilizers and on the total number of measures adopted by the holding to mitigate environmental-related risks.

Table 18 below shows the sustainability status of the holding using test data from Bangladesh pilot study (2018–2019). For instance, the agricultural holding #001 uses fertilizers and adopted only two out of the eight potential measures to mitigate environmental-related risks. As such, the corresponding sustainability status of the agricultural is “acceptable”. The agricultural holding #002, despite using fertilizers, does not adopt any of the 8 potential measures to mitigate environmental-related risks, overall resulting into a sustainability status “Unsustainable”. Finally, the agricultural holding #037 has a sustainability status “desirable” since it does not use fertilizers.

Table 18. Sustainability status based on management of fertilizers.

HHID	Use of synthetic or mineral fertilizer	Measure#1	Measure#2	Measure#3	Measure#4	Measure#5	Measure#6	Measure#7	Measure#8	Total number of measures adopted	Management of fertilizers: Sustainability status
001	Yes	0	1	0	1	0	0	0	0	2	Acceptable
002	Yes	0	0	0	0	0	0	0	0	0	Unsustainable
003	Yes	1	0	0	0	0	0	1	0	2	Acceptable
004	Yes	0	1	1	0	0	0	0	0	2	Acceptable
005	Yes	0	1	1	0	0	0	0	0	2	Acceptable
006	Yes	0	0	1	1	0	0	0	1	3	Acceptable
007	Yes	0	1	0	0	1	0	0	0	2	Acceptable
008	Yes	1	0	1	0	0	0	0	1	3	Acceptable
009	Yes	1	0	1	0	0	0	0	0	2	Acceptable
037	No	0	0	0	0	0	0	0	0	0	Desirable
038	Yes	0	0	0	0	1	0	0	0	1	Unsustainable
039	Yes	1	1	0	0	1	0	1	0	4	Desirable
040	No	0	0	0	0	0	0	0	0	0	Desirable

Source: Pilot study, Bangladesh 2018

Reporting

The reporting process of subindicator **"6"'** is based on the following steps: Once agricultural holdings have been classified according to their sustainability status, the final step implies calculating the total agricultural area in the country under a given sustainability status and computing the corresponding proportion (over total agricultural area). The dashboard approach for reporting on this subindicator will look like:

Table 19. Reporting subindicator #6:

Sustainability status (subindicator #6)	**Agriculture area in hectare**	**Proportion of agriculture area**
Desirable	240.0	47
Acceptable	108.7	21
Unsustainable	161.0	32
Total agricultural area (in hectares)	509.8	100

Source: Pilot study, Bangladesh 2018.

2.7. Management of pesticides

Rational behind the subindicator. The subindicator captures the proportion of agricultural areas by sustainability status, on the basis of information on the use of pesticides on the farms, farmer's awareness of the risks associated to pesticides and the type of measure(s) taken to mitigate those risks.

Sustainability criteria.

- Green (desirable): The farm uses only moderately or slightly hazardous[2] pesticides (WHO Class II or III). In this case, it adheres to all three health-related measures and at least four of the environment-related measures. Default result for farms not using pesticides.
- Yellow (acceptable): The farm uses only moderately or slightly hazardous pesticides (WHO Class II or III) and takes some measures to mitigate environmental and health risks (at least two from each of the lists above)
- Red (unsustainable): The farm uses highly or extremely hazardous pesticides (WHO Class Ia or Ib), illegal pesticides[3], or uses moderately or slightly hazardous pesticides without taking specific measures to mitigate environmental or health risks associated with their use (fewer than two from any of the two lists above).

From the formulation to the computation of primary variables. In general, information on variation on management of fertilizers requires exploring whether the agricultural holding 1) uses (or do not use) pesticides and 2) in case of affirmative responses, the type of pesticide used (moderately or slightly hazardous; highly, extremely hazardous or illegal pesticides), 3) the number of health-specific measures adopted and, finally, 4) the number of environmental-specific measures adopted. The list of primary variables are listed in the matrix below.

Raw variables	Use of pest.	Type of pest.	Health measures																
			1	2	3	T	1	2	3	4	5	6	7	8	9	10	11	12	T.
Did this agricultural holding use any pesticides for crop or livestock production?	■																		
What type of pesticides did this agricultural holding used?		■																	
Adherence to label directions for pesticide use (including use of protection equipment)			■			■													
Maintenance and cleansing of protection equipment after use				■		■													
Safe disposal of waste (cartons, bottles and bags)					■	■													
Adherence to label directions for pesticide application							■												■
Adjustment of planting time								■											■
Application of crop spacing									■										■
Application of crop rotation										■									■
Application of mixed cropping											■								■
Application of inter-cropping												■							■
Perform biological pest control													■						■
Use of bio-pesticides														■					■
Adopting pasture rotation to suppress livestock pest population															■				■
Use one pesticide no more than two times or in mixture in a season to avoid pesticide resistance																■			■
Systematic removal of plant parts attacked by pests																	■		■
Maintenance and cleansing of spray equipment after use																		■	■

[2] WHO Class II or III pesticides as defined by WHO classification (http://www.who.int/ipcs/publications/pesticides_hazard_2009.pdf), or equivalent national classification.

[3] In principle, illegal pesticides refer to any products which do not comply with national regulations on pesticide management, such as un-registered, mislabeled, illegally imported etc. It does not cover "off-label uses," which could be considered as an illegal use action.

Content of the primary variables.

1. **Use of pesticides.** A dummy variable taking on value 1 if the agricultural holding used pesticides.
2. **Type of pesticides.** A variables taking on value 1 if the agricultural holding used moderately or slightly hazardous pesticides and 0 if the agricultural holding used extremely hazardous or illegal pesticides.
3. **Health measures #1.** A dummy variable taking on value 1 if the agricultural holding adheres to label recommendations for pesticide application.
4. **Health measures #2.** A dummy variable taking on value 1 if the agricultural holding perform maintenance and cleansing of protection equipment after use.
5. **Health measures #3.** A dummy variable taking on value 1 if the agricultural holding adheres to safe disposal of waste (cartons, bottles and bags).
6. **Total # of health measure.** A variable capturing the total number of health-related measures adopted by the agricultural holding.
7. **Environmental measure #1.** A dummy variable taking on value 1 if the agricultural holding adheres to label recommendations for pesticide application
8. **Environmental measure** #2 A dummy variable taking on value 1 if the agricultural holding makes adjustments of planting time
9. **Environmental measure** #3 A dummy variable taking on value 1 if the agricultural holding applies crop spacing
10. **Environmental measure** #4 A dummy variable taking on value 1 if the agricultural holding applies crop rotation
11. **Environmental measure** #5 A dummy variable taking on value 1 if the agricultural holding applies mixed cropping
12. **Environmental measure** #6 A dummy variable taking on value 1 if the agricultural holding applies inter-cropping
13. **Environmental measure** #7 A dummy variable taking on value 1 if the agricultural holding performs biological pest control
14. **Environmental measure** #8 A dummy variable taking on value 1 if the agricultural holding uses of biopesticides
15. **Environmental measure** #9 A dummy variable taking on value 1 if the agricultural holding adopts pasture rotation to suppress livestock pest population
16. **Environmental measure** #10 A dummy variable taking on value 1 if the agricultural holding uses one pesticide no more than two times or in mixture in a season to avoid pesticide resistance
17. **Environmental measure** #11 A dummy variable taking on value 1 if the agricultural holding Systematic removes plant parts attacked by pests
18. **Environmental measure** #12 A dummy variable taking on value 1 if the agricultural holding maintains and cleanses spray equipment after use.
19. **Total # of environmental measure.** A variable capturing the total number of environmental-related measures adopted by the agricultural holding

Characterizing agricultural holding by sustainability status. In general, the sustainability status of agricultural holdings is determined depending on whether the agricultural holding uses pesticides, the type of pesticides used and on the total number of measures adopted by the holding to mitigate environmental and heath related risks, as per established criteria (see above). Table 20 below shows the sustainability status of the holding using test data from Bangladesh, which is further commented.

For instance, the agricultural holding #001 uses highly and extremely hazardous pesticides; despite adopting 2 health-related measures and 3 environmental measures is status is “Unsustainable ”, as

per methodology. The agricultural holding #002, moderately or slightly hazardous pesticides, adopts 2 health-related measures and 2 environmental measures, overall resulting into a sustainability status "acceptable". Finally, the agricultural holding #014 has a sustainability status "desirable" since, despite using moderately or slightly hazardous pesticides, adopts 4 environmental measures and 3 health-related measures.

Table 20. Sustainability status based on *management of pesticides*.

HHID	Use of pesticides	Type of pesticides used	Environmental measures	Health measures	Management of pesticides: Sustainability status
001	Yes	Highly, extremely hazardous, illegal	3	2	Unsustainable
002	Yes	Moderately or slightly hazardous	2	2	Acceptable
003	Yes	Highly, extremely hazardous, illegal	0	0	Unsustainable
004	Yes	Moderately or slightly hazardous	1	3	Unsustainable
005	Yes	Highly, extremely hazardous, illegal	2	3	Unsustainable
006	Yes	Highly, extremely hazardous, illegal	2	2	Unsustainable
007	Yes	Highly, extremely hazardous, illegal	3	3	Unsustainable
008	Yes	Highly, extremely hazardous, illegal	3	0	Unsustainable
009	Yes	Moderately or slightly hazardous	2	3	Acceptable
010	Yes	Moderately or slightly hazardous	2	2	Acceptable
011	Yes	Moderately or slightly hazardous	4	2	Acceptable
012	Yes	Moderately or slightly hazardous	3	3	Desirable
013	Yes	Highly, extremely hazardous, illegal	4	2	Unsustainable
014	Yes	Moderately or slightly hazardous	4	3	Desirable

Source: Pilot study, Bangladesh 2018.

Reporting:

The reporting process of subindicator "**7''** is based on the following steps: Once agricultural holding have been classified according to their sustainability status, the final step implies calculating the total agricultural area in the country under a given sustainability status and computing the corresponding proportion (over total agricultural area). The dashboard approach for reporting on this subindicator will look like:

Table 21. Reporting subindicator #7

Sustainability status (subindicator #7)	Agriculture area in hectare	Proportion of agriculture area
Desirable	102.9	20
Acceptable	123.6	24
Unsustainable	283.2	56
Total	509.8	100

Source: Pilot study, Bangladesh 2018.

2.8. Use of agrobiodiversity-supportive practices

Rational behind the subindicator. This subindicator measures the level of adoption of biodiversity-friendly practices by the farm at ecosystem, species and genetic levels. This subindicator addresses both crops and livestock. The practices are broken down as follows:

1. Leaves at least 10 percent of the holding area for natural or diverse vegetation. This can include natural pasture/grassland, maintaining wildflower strips, stone and wood heaps, trees or hedgerows, natural ponds or wetlands.
2. Farm produces agricultural products that are organically certified, or its products are undergoing the certification process (applies only to countries with certification)
3. Farm does not use medically important antimicrobials as growth promoters.
4. At least two of the following contribute to farm production: 1) temporary crops, 2) pasture, 3) permanent crops, 4) trees on farm, 5) livestock or animal products, and 6) aquaculture.
5. Practices crop or crop/pasture rotation involving at least 2 crops or crops and pastures on at least 80 percent of the farm cultivated area (excluding permanent crops and permanent pastures) over a period of 3 years. In case of a 2-crop rotation, the 2 crops have to be from different plant genus, e.g. a grass plus a legume, or a grass plus a tuber etc.
6. Livestock includes locally adapted breeds.

Sustainability criteria.

- Green (desirable): The agricultural holding meets at least [2/5 – for holdings with no organic certification] or [3/6 – for holdings with organic certification] of the above listed criteria.
- Yellow (acceptable): The agricultural holding meets at least [1/5 – for holdings with no organic certification] or at least [1/6 – for holdings with organic certification] of the above listed criteria.
- Red (unsustainable): The agricultural holding meets [0/5 - for holdings with no organic certification] or [0/6 – for holdings with organic certification] of the above listed respective criteria.

From the formulation to the computation of primary variables. Subindicator on the use of biodiversity-supportive practice is one of the most complex and sophisticated among the 11 subindicators of SDG 2.4.1. Its construction requires six main criteria which encompass a number of primary variables derived from the qualitative information collected through the survey. The below matrix describes how the information from the survey (i.e. the raw data) is combined to derive primary variables and then using the six criteria the agricultural holdings are assessed for sustainability status, including the sustainability status of the agricultural area of the holding.

Table 22. Raw and primary variables:

Raw data	Primary variables					
	Criterion #1	Criterion #2	Criterion #3	Criterion #4	Criterion #5	Criterion #6
Area under Temporary crop outdoors or under low shelters	■					
Area under Temporary crop under green houses or high shelters	■					
Area under Temporary fallow	■					
Area under Temporary meadows and pastures	■					
Area under Kitchen gardens and backyards	■					
Area under Permanent crop outdoors or under low shelters	■					
Area under Permanent crop under green houses or high shelters	■					
Area under Permanent meadows and pastures	■					
Farm buildings and farmyard	■					
Forest and other wooded land	■					
Aquaculture on the holding	■					
Other area not elsewhere classified. Which includes:	■					
	■					
1.natural pasture/grassland;	■					
2.maintaining wildflower strips;	■					
3.stone and wood heaps;	■					
4. trees or hedgerows;	■					
5. natural ponds or wetlands.	■					
Use medically important antimicrobials as growth promoters		■				
Crops and livestock produced are organically certified or undergoing certification process			■			
Farm gate prices of each crop (up to 5) per unit				■		
Quantity of each crop (up to 5) per unit				■		
Farm gate prices of each by-product of crop (up to 5) per unit				■		
Quantity of each by-product of crop (up to 5) per unit				■		
Farm gate prices of each livestock (up to 5) and its products per unit				■		
Quantity/number (up to 5) of each livestock and its product				■		
Farm gate prices of each on-farm products (up to 5) per unit				■		
Quantity of each on-farm products				■		
Total value of farm production				■		
Value of output from temporary crops (qt.* price of products)				■		
Value of output from pastures				■		
Value of output from permanent crops				■		
Value of output from trees on farm				■		
Value of output from livestock and its products				■		
Value of output from aquaculture				■		
Percentage of agricultural area on which crop rotation or crop/pasture rotation involving at least two different crops/pastures of two different plant genus					■	
animal species #1: consist of locally adapted breeds						■
animal species #2: consist of locally adapted breeds						■
animal species #3: consist of locally adapted breeds						■

Source: Authors' own elaboration. 2023.

Content of each primary variables:

This subindicator relies on the calculation of six main criteria, four of which must be met in order for the area of the agricultural holding to be sustainable in terms of bio-diversity.

Criterion #1. In order to check whether the agricultural holding meets the first criterion, the total area of the holding must be computed as follows:

- temporary crop outdoors or under low shelters
- temporary crop under green houses or high shelters
- temporary fallow
- temporary meadows and pastures

- kitchen gardens and backyards
- permanent crop outdoors or under low shelters
- permanent crop under green houses or high shelters
- permanent meadows and pastures
- farm buildings and farmyards
- forest and other wooded land
- aquaculture on the holding (area not counted elsewhere)
- other area not elsewhere classified (unutilized, rocks, wetlands, including with natural vegetation)

The calculation procedure of this primary variable is summarized in table below, further refined by converting the land area into hectares.

Table 23. *Total area of the holding.*

HHID	Land use type	Area	Unit of measurement	Conversion factor to hectares	Area in hectare
001	Temporary crop outdoors or under low shelters				
001	Temporary crop under green houses or high shelters	2	Acres	0.40	0.81
001	Temporary fallow				
001	Temporary meadows and pastures				
001	Kitchen gardens and backyards	0.1	Acres	0.40	0.04
001	Permanent crop outdoors or under low shelters				
001	Permanent crop under green houses or high shelters	0.1	Acres	0.40	0.04
001	Permanent meadows and pastures				
001	Farm buildings and farmyards	x			
001	Forest and other wooded land	x			
001	Aquaculture on the holding (area not counted elsewhere)	x			
001	Other area not elsewhere classified (unutilized, rocks, wetlands, including with natural vegetation)	x			
Total area of the holding					0.89

Source: Pilot study, Bangladesh (2018–2019).

The second primary variable to be calculated concerns the total area of the agricultural holding that is left under natural or diverse vegetation, as per listed categories of natural or diverse vegetation (see matrix above). The calculation of this primary variables is based on the following question (asked in section B of the questionnaire) and requires the conversion into hectares, as it was done for the calculation of the total agricultural area of the holding:

B.17 In this agricultural holding, are there areas covered by natural or diverse vegetation? including one or a combination of the following:
Reference year: Last calendar year
(Read all options and fill in all that apply)

- ◯ 1 Natural pasture or grasslands
- ◯ 2 Wildflower strips
- ◯ 3 Stone or wood heaps
- ◯ 4 Trees or hedgerows
- ◯ 5 Natural ponds or wetlands
- ◯ 6 None of the above → **Go to B.19**

B.18 What is the total area of the holding covered by any of the natural or diverse vegetation identified above? (Please cross-check with II.2)
Reference year: Last calendar year

◯ Total area covered . . . . . **Area** [ ][ ][ ][ ].[ ][ ] **Unit of measure** [ ][ ][ ][ ][ ]

Table 24. Area of the holding under natural or diverse vegetation

HHID	Area of the holding under natural or diverse vegetation	Unit of measurement	Conversion factor to hectares	Land area in hectare
085	0.06	Acres	0.40	0.024
106	0.05	Acres	0.40	0.020
107	0.05	Acres	0.40	0.020
108	0.05	Acres	0.40	0.020
109	0.05	Acres	0.40	0.020
111	0.10	Acres	0.40	0.040
112	0.20	Acres	0.40	0.081

Source: Pilot study, Bangladesh (2018–2019).

Finally, we calculate the share of the total area of the holding which is under natural or diverse vegetation and we check whether the computed share is greater or lower than the 10 percent of the total area of the holding as per formula below.

$$\text{Holding area for natural or diverse vegetation} = \frac{Area\ of\ the\ holding\ under\ natural\ or\ diverse\ vegetation_i}{Total\ area\ of\ the\ holding_i}$$

The procedure is summarized in table below:

Table 25. Area of the holding under natural or diverse vegetation

HHID	Total holding area	Total holding area under natural/diverse vegetation	Percentage Area under natural/diverse vegetation	Criterion #1
124	1.214	0.041	3.33	0
137	6.070	0.041	0.67	0
138	2.109	1.214	57.57	1
139	5.868	0.041	0.69	0

Source: Pilot study, Bangladesh (2018–2019).

On the basis of the results from the calculation procedure of criterion #1, only one agricultural holding (holding identification number is 138) leaves or has more than 10 percent of the total area under natural or diverse vegetation.

Criterion #2. In order to check whether the agricultural holding is producing crops or livestock that are organically certified or undergoing organic certification.

B.21 Did the holding produce crops and/or livestock that are certified organic or undergoing the organic certification process during the reference period?

Reference year: Last calendar year

(Fill in one circle only)

◯ 1 Yes

◯ 2 No

As a next step a dummy variable must be computed accordingly from the above question to calculate criterion number 2. The dummy variable takes on value 1 if the agricultural holding is producing crops and livestock that are organically certified or undergoing the certification, and 0 otherwise.

The dataset for the final calculation of the second criterion will look like:

Table 26. Holding use of products organically certified or undergoing certification process

HHID	**Dummy**: Produce crops and livestock that are organically certified or undergoing certification process

057	0 (No)
058	0 (No)
059	0 (No)
060	0 (No)
061	0 (No)
062	0 (No)

Source: Made up example

The final count for the construction of criterion number 2 implies checking, for the computed dummy variable, whether it takes on value 1, as represented in table above.

Criterion #3. In order to check whether the agricultural holding meets the third criterion the following question is asked.

B.19 Are you using medically important antimicrobials as a growth promoter for your livestock?

Reference year: Last calendar year

(Fill in one circle only)

- ◯ 1 Yes
- ◯ 2 No
- ◯ 3 I don't know

As a next step a dummy variable must be computed accordingly from the above question to calculate criterion number 3. The dummy variable takes on value 1 if the agricultural holding does not use medically important antimicrobial as growth promoters, and 0 otherwise.

The dataset for the final calculation of the third criterion will look like:

Table 27. Holding use of medically important antimicrobes

HHID	**Dummy**: Use medically important antimicrobials as growth promoters
057	0 (Yes)
058	1 (No)
059	0 (Yes)
060	0 (Yes)
061	1 (No)
062	1 (No)

Source: Made up example

The final count for the construction of criterion number 3 implies checking, for the computed dummy variable, whether it takes on value 1, as represented in table above.

On the basis of the results presented in the table above, only three agricultural holding meet the third criterion (agricultural holding number 058, 061 and 062), meaning that they do not use medically important antimicrobials as growth promoters.

Criterion #4. In order to check whether the agricultural holding meets the fourth criterion, we need, first to calculate if the following contribute to farm production 1) temporary crops, 2) pasture, 3) permanent crops, 4) trees on farm, 5) livestock or animal products, and 6) aquaculture, over total value of farm production and, second, to check if each of them represents at least 10 percent of the value of the holding's production. The following three steps are implemented accordingly.

- **Step 1.** Calculate the total farm value of production, as follows.

The farm output value is calculated as the summation of the quantities ($\boldsymbol{q_{i,c}}$) of each: crop, by-product crop, livestock, by-product livestock and on-farm commodities of the *i-th* agricultural holding multiplied by the corresponding farm gate prices. The measure is expressed in local currency unit (LCU) and represents the numerator of the equation. Table 28 below show an example on how to calculate the farm output value using test data from the pilot survey conducted in Bangladesh (2018–2019)

Table 28. *Farm output value*

HHID	Description	Quantity Produced (in relevant units)	Farm gate price per unit	Farm output value
001	Trees (products)	80	750	60,000.00
001	Fish	50	650	32,500.00
001	Maize	35	780	27,300.00
001	Straw	60	480	28,800.00
001	Husk	20	400	8,000.00
			Total farm output value	**156,600.00**

Source: Pilot study, Bangladesh (2018–2019).

- **Step 2.** Calculate the total farm value of production from:

1) Value of output of crops and its by-products;
2) Value of output of pasture;
3) Value of output of tree products;
4) Value of output of livestock and animal products;
5) Value of output of aquaculture.

The calculation procedure is aligned with the total farm production calculated for subindicator 1 but it does not account for all of the commodities that are not listed among the four above-mentioned (i.e. 1) crop/pasture, 2) trees or tree products (including permanent crops like orchards or vineyards), 3) livestock or animal products and 4) fish).

- **Step 3.** Once both the total farm output value and the output value from 1) crop/pasture, 2) trees or tree products, 3) livestock or animal products and 4) fish/aquaculture has been calculated, the corresponding contribution is calculated as follows:

$$\%\ contribution\ from\ crop = \frac{farm\ output\ value\ from\ crop/by-products_i}{total\ farm\ output\ value_i}$$

$$\%\ contribution\ from\ pasture = \frac{farm\ output\ value\ from\ pasture_i}{total\ farm\ output\ value_i}$$

$$\%\ contribution\ from\ tree\ products = \frac{farm\ output\ value\ from\ tree\ products_{\ i}}{total\ farm\ output\ value_i}$$

$$\%\ contribution\ from\ livestock\ /livestock\ products = \frac{farm\ output\ value\ from\ livestock/products_{\ i}}{total\ farm\ output\ value_i}$$

$$\%\ contribution\ from\ fish/aquaculture = \frac{farm\ output\ value\ from\ fish/aquaculture_i}{total\ farm\ output\ value_i}$$

The final dataset for the final computation of criterion # 4 will look like:

Table 29. *Calculation of Criterion 4*

HHID	Contribution from Crop/by-products	Contribution from Pasture	Contribution from livestock/ animal products	Contribution from trees/tree product	Contribution from fish/aquaculture	Contribution from other	Criterion # 4
001	11	0	8	12	13	56	1
056	35	0	14	21	0	30	1
078	80	0	0	0	0	20	0
112	100	0	0	0	0	0	0
201	12	0	45	21	0	22	1

Source: Pilot study, Bangladesh (2018–2019).

According to the results obtained from the calculation procedure explained above, only three agricultural holding meet criterion number 4. In particular, the contribution from value of output of crop/pasture, value of output of livestock and animal products, value of output of trees/tree products and value of output of fish/aquaculture for the agricultural holding number 001 is 11%, 8%, 12% and 13%, respectively. Hence, the agricultural holding meets the fourth bio-diversity criterion. The same applies to agricultural holdings number 056 and 201, both of which contribute with 1) value of output of crops and pasture, 2) value of output of livestock/ animal products and 3) value of output of tree or trees products. The corresponding contribution of the three above-mentioned commodities represents more than 10 percent of the total value of the holding production. Hence, the two agricultural holdings meet the fourth criterion.

Criterion #5. In order to check whether the agricultural holding meets the fifth criterion, one dummy variables must be computed. The calculation of this primary variables is based on the following question (asked in section B of the SDG 2.4.1. survey questionnaire):

B.20: What is the percentage of the agricultural area on which crop rotation or crop/pasture rotation involving at least two different crops/pastures of two different plant genus is practiced?

Reference year: Last three calendar years
(Leave it bank if not practiced)

Percentage Area

◯ 1 Percentage of agricultural area . . . . . | | | | | | |

The dummy variable takes on value 1, if the percentage of the agricultural area on which crop rotation or crop/pasture rotation involving at least two different crops is practiced and then it estimated to be greater than 80 percent of the agricultural area of the holding. The dataset to be constructed in order to check whether the agricultural holding meets the fourth criterion will look like the one in table below, whose interpretation is straightforward:

Table 30. *Calculation of Criterion 5*

HHID	Percentage of the agricultural area on which crop rotation or crop/pasture rotation involving at least two different crops/pastures of two different plant families is practiced?	Percentage greater than 80 %	Criterion # 5
001	55	0 (No)	0
002	50	0 (No)	0
003	50	0 (No)	0
004	100	1 (Yes)	1
005	88	1 (Yes)	1
006	90	1 (Yes)	1
007	100	1 (Yes)	1
008	80	1 (Yes)	1
009	60	0 (No)	0

010	50	0 (No)	0
011	80	1 (Yes)	1
012	60	0 (No)	0
013	100	1 (Yes)	1
014	48	0 (No)	0
015	100	1 (Yes)	1
016	48	0 (No)	0

Source: Pilot study, Bangladesh (2018–2019).

Criterion #6. In order to ascertain whether (or not) the agricultural holding meets the sixth biodiversity criterion, the first step consists in identifying locally adapted breeds. The next step is to check if the number of livestock locally adopted breeds out of the total breeds (both local and foreign) is greater than 1. The calculation of criterion number 6 can be carried out according to the example shown below.

Table 31. Calculation of Criterion 6

HHID	Animal species	Total number of animal under each animal species	Animal breed	Animal breed (numb)	Share of animal breeds locally adopted or at risk of extinction
001	Cow	50	Sahiwal	25	50
			Friesian (local)	25	50
002	Hen	5	**Hen (local)**	1	20
			Hen (Mixed breed)	4	80

Source: Pilot study, Bangladesh (2018–2019).

Characterizing agricultural holding by sustainability status. In general, the sustainability status of agricultural holdings is determined depending on how many of the six bio-diversity criteria are met by the agricultural holding. This implies counting the total number of criteria which have been met by the agricultural holding and, finally, benchmark the total number of criteria met against the sustainability thresholds established by the methodology which, for ease of reference, are listed again below:

- Green (desirable): The agricultural holding meets at least [2/5 – for holdings with no organic certification] or [3/6 – for holdings with organic certification] of the above listed criteria.
- Yellow (acceptable): The agricultural holding meets at least [1/5 – for holdings with no organic certification] or at least [1/6 – for holdings with organic certification] of the above listed criteria.
- Red (unsustainable): The agricultural holding meets [0/5 - for holdings with no organic certification] or [0/6 – for holdings with organic certification] of the above listed respective criteria.

The sustainability status of each agricultural holding can be easily calculated, as in table below:

Table 32. Calculation of subindicator

HHID Holding Id.#	Criterion #1	Criterion #2	Criterion #3	Criterion #4	Criterion #5	Criterion #6	Total number of bio-diversity supportive practice met	Use of biodiversity-supportive practices
001	1	0	1	0	1	1	4	Sustainable
002	0	0	1	0	1	1	3	Acceptable
003	0	0	1	0	0	0	1	Unsustainable
004	0	0	1	0	0	0	1	Unsustainable
005	0	0	1	0	1	1	3	Acceptable
006	0	0	1	0	0	0	1	Unsustainable
007	0	0	1	0	0	0	1	Unsustainable
008	0	0	1	0	1	1	3	Acceptable
009	0	0	1	0	0	0	1	Unsustainable
010	0	0	1	0	1	1	3	Acceptable
011	0	0	1	0	1	1	3	Acceptable
012	0	0	1	0	0	0	1	Unsustainable
013	0	0	1	0	1	1	3	Acceptable
014	0	0	1	0	1	1	3	Acceptable
015	0	0	1	0	0	0	1	Unsustainable
016	0	0	1	0	1	1	3	Acceptable
017	0	0	1	0	0	0	1	Unsustainable
018	0	0	1	0	1	1	3	Acceptable
019	0	0	1	0	0	0	1	Unsustainable
020	0	0	1	0	0	0	1	Unsustainable
021	0	0	1	0	0	1	2	Acceptable

Source: Pilot study, Bangladesh (2018–2019).

In the example above, only the agricultural holding number 001 has met 4 criteria related to the use of biodiversity-supportive practices, which represent the minimum requirement in order for the agricultural holding to be categorize as “sustainable”.

Reporting

The reporting process of subindicator ‘’8’’ is based on the following steps:

First, the number of agro-biodiversity supportive practices adopted by the agricultural holdings are benchmarked against the sustainability criteria (table above).

The final step implies calculating the total agricultural area in the country under a given sustainability status and compute the corresponding proportion (over total agricultural area). The dashboard approach for reporting on this indicator will look like:

Table 33. Reporting subindicator #8

Sustainability status (subindicator #8)	**Agriculture area**	**Proportion of agricultural area**
Desirable	0.9	0.2
Acceptable	425.8	84
Unsustainable	83.0	16
Total	**509.8**	100

Source: Pilot study, Bangladesh (2018–2019).

2.9. Wage rate in agriculture

Rational behind the subindicator. The subindicator measures the proportion of agricultural area by sustainability status. The sustainability status is assigned on the basis of the daily wage rate (in local currency unit) paid by the farm to unskilled agricultural worker, once benchmarked against the national or agriculture sector minimum wage rate.

Sustainability criteria.

- Green (desirable): If the wage rate paid to unskilled labour is above the minimum national wage rate or minimum agricultural sector wage rate (if available). Default result for farms not hiring labour.
- Yellow (acceptable): if the wage rate paid to unskilled labour is equals to the minimum national wage rate or minimum agricultural sector wage rate (if available).
- Red (unsustainable): If the wage rate paid to unskilled labour is below the minimum national wage rate or minimum agricultural sector wage rate (if available).

From the formulation to the computation of primary variables. In general, information on the wage rate paid to unskilled workers hired by the agricultural holding are gathered from farm survey in terms of the daily wage rate that is paid in-cash and in-kind. The primary variables are combined with the information gathered from the farm survey, as in the matrix below.

Raw variables	Primary Variable			
	Wage (in cash)	Wage (in- kind)	Total daily wage	Employees working on the farm
Daily wage (in local currency unit) paid in cash				
Daily wage (in local currency unit) paid in kind				
Hired unskilled labour				

Content of the primary variables.

1. **Total daily wage**. This variable is obtained by adding up the daily wage in-cash and in-kind. In case the survey provide information on wages on a monthly basis, the latter must be divided by 22, i.e. the working days in a month.
2. **Employees working on the farm**. This variable is a dummy variable which takes on value 1 if the agricultural holding hires employees and 0 otherwise.

Characterizing agricultural holding by sustainability status. The sustainability status of agricultural holdings is determined by benchmarking the daily wage paid to each employee against the national minimum wage. It would highly preferred to benchmark the daily wage against the agricultural minimum wage, if available. Information on the minimum wage is typically provided by the National Statistical Offices or taken by official sources (e.g. ILO[4]). Table 35 below shows the sustainability status of the holding using real data from Bangladesh.

[4]https://www.ilo.org/ilostat/faces/oracle/webcenter/portalapp/pagehierarchy/Page27.jspx?subject=EAR&indicator=EAR_INEE_NOC_NB&datasetCode=A&collectionCode=YI&_afrLoop=1399681730372273&_afrWindowMode=0&_afrWindowId=13wn9g34if_1#!%40%40%3Findicator%3DEAR_INEE_NOC_NB%26_afrWindowId%3D13wn9g34if_1%26subject%3DEAR%26_afrLoop%3D1399681730372273%26datasetCode%3DA%26collectionCode%3DYI%26_afrWindowMode%3D0%26_adf.ctrl-state%3D13wn9g34if_57

Table 34. Sustainability status based on the minim wage threshold..

HHID	Employees hired	Daily wage	Minimum wage Bangladesh	Sustainability status
001	Yes	359.1	265	Desirable
101	Yes	179.5	265	Unsustainable
102	Yes	224.4	265	Unsustainable
280	No	0.0	265	Desirable
399	No	0.0	265	Desirable
400	Yes	448.9	265	Desirable
401	Yes	448.9	265	Desirable

Source: Pilot study, Bangladesh (2018–2019)

Reporting

The reporting process of subindicator "**9**" is as follows:

The total agricultural area in the country under a given sustainability status is computed alongside its corresponding proportion (over total agricultural area). The dashboard approach for reporting on this indicator will look like:

Table 35. Reporting on subindicator #9

Sustainability status (subindicator #9)	**Agriculture area in Hectare**	**Proportion of Agriculture area**
Desirable	501.3	98
Acceptable	0.0	0
Unsustainable	8.5	2
Total	509.8	100

Source: Pilot study, Bangladesh (2018–2019)

2.10. Food Insecurity Experience Scale

Rational behind the subindicator. This subindicators is meant to measure the severity of food insecurity experienced by the households of the holder of the holding, based on direct interviews.

Sustainability criteria. The Food Insecurity Experience Scale (FIES) subindicator, contextualised for the SDG 2.4.1, is based on the below sustainability criteria, that only apply to agricultural holdings belonging to the household sector:

- Green (desirable): Mild food insecurity[5]
- Yellow (acceptable)[6]: Moderate food insecurity
- Red (unsustainable): Severe food insecurity

From the formulation to the computation of primary variables. In general, information on the severity of food insecurity experienced by agricultural households are gathered from household surveys containing the 8 standardized FIES questions. These questions are used to compute 8 primary variables, as reported in the matrix below.

8 Questions: Raw variables	Primary variables							
	Worried	Healthy	Fewfood	Skipped	Ateless	Runout	Hungry	Whlday
During the last 12 months, was there a time when you (or any other member in the household) were worried that you would not have enough food to eat because of a lack of money?								
Still thinking about the last 12 months, was there a time when you (or any other member in the household) were unable to eat healthy and nutritious food because of a lack of money?								
Was there a time when you (or any other member in the household) ate only a few kinds of foods because of a lack of money or other resources?								
Was there a time when you (or any other member in the household) had to skip a meal because there was not enough money or other resources to get food?								
Still thinking about the last 12 months, was there a time when you (or any other member in the household) ate less than you thought you should because of a lack of money?								
Was there a time when you (or any other member in the household) ran out of food because of a lack of money or other resources?								
Was there a time when you (or any other member in the household) were hungry but did not eat because there was not enough money or other resources for food?								
During the last 12 months, was there a time when you (or any other member in the household) went without eating for a whole day because of a lack of money or other resources?								

Each primary variable derived from the 8 FIES questions allows capturing a specific item, which is latter associated with a certain degree of severity of food insecurity.

Content of the primary variables. Each primary variable is constructed as a dummy variable taking on value 1 if the household experienced any domain of the food insecurity, as described in table 37 below.

[5] Computation of food insecurity level is described in details in e-learning course on SDG 2.1.2: https://elearning.fao.org/course/view.php?id=360

[6] The terminology "Acceptable" must be read within the context of SDG 2.4.1; it should be interpreted as a situation that nevertheless merits attention and actions aimed at improvement.

Table 3624. Items, domain and assumed severity of food insecurity

FIES order of items	Variables	Variable description	Domains of the food insecurity	Assumed severity of food insecurity
1	**Worried**	Felt anxiety about having enough food at any time during the previous 12 months	uncertainty and worry about food	Mild
2	**Healthy**	Not able to eat healthy and nutritious food because of lack of money or other resources to get food	inadequate food quality	Mild
3	**Fewfood**	Consumed a diet based on only few kinds of foods because of lack of money or other resources to get food	inadequate food quality	Mild
4	**Skipped**	Did not eat breakfast, lunch or dinner [or skipped a meal] because there was not enough money or other resources to get food	insufficient food quantity	Moderate
5	**Ateless**	Ate less than they thought they should because of lack of money or other resources to get food	insufficient food quantity	Moderate
6	**Runout**	Household ran out of food because of lack of money or other resources to get food	insufficient food quantity	Moderate
7	**Hungry**	Felt hungry but didn't eat because there was not enough money or other resources for food	insufficient food quantity	Severe
8	**Whlday**	Went without eating for a whole day	insufficient food quantity	Severe

Characterizing agricultural holding by sustainability status. The sustainability status of agricultural holdings belonging to the household sector as based on the severity of food insecurity is calculated according to a 3 steps procedure, as below summarized.

1. **Preparing the data for analysis.** To add label to the 8 FIES questions.

2. **Parameter estimation:** To calculate the level of food insecurity severity associated with each question (item parameters) and each respondent (raw scores and respondent parameters).

3. **Calculation of the sustainability status of the agricultural holding:** Once a measure of severity of the food insecurity condition experienced by each respondent (household of the holder of agricultural holdings), based on their answers to the eight FIES questions, has been derived, the sustainability status of the holding (desirable, acceptable and unsustainable) as per SDG 2.4.1 methodology, can be derived accordingly.

Step 1. To prepare the data collected through the FIES survey module for analysis, each item should be coded, so that: 0 is used for a "no" response; 1 is used for a "yes" response. A crucial step is to add standard labels for the eight questions collected in the survey module 2.4.1, as in the example below (Bangladesh, pilot study (2018–2019)). Before labelling and coding, the dataset contains non-standardized codes for the 8 FIES questions: "yes" responses are coded as "1", whereas "no" responses are coded as "0". The below datasets (tables 38 and 39) show the way the dataset looks like before and after variables have standardized for the FIES analysis.

Table 37. Dataset for FIES analysis: before and after labelling and coding

HHID	C_C03000	C_C04000	C_C05000	C_C06000	C_C07000	C_C08000	C_C09000	C_C10000
001	1	1	1	0	1	0	0	0
002	0	0	0	0	0	0	0	0
003	1	0	0	0	0	0	0	0
004	0	0	0	0	0	0	0	0
005	1	1	1	0	0	0	0	0
006	0	0	0	0	0	0	0	0
007	0	0	0	0	0	0	0	0
008	0	0	0	0	0	0	0	0
009	0	0	0	0	0	0	0	0
010	0	0	0	0	0	0	0	0
011	1	1	1	0	1	1	0	0
012	1	0	0	0	0	0	0	0
013	1	1	0	0	0	0	0	1
014	1	0	0	0	0	0	0	0
015	1	1	1	1	1	1	1	1
016	1	1	0	0	0	0	0	0
017	1	1	0	0	0	0	0	0
018	1	0	0	0	0	0	0	0

Table 38. Dataset for FIES analysis: before and after labelling and coding

HHID	Worried	Healthy	Fewfood	Skipped	Ateless	Runout	Hungry	Whlday
001	Yes	Yes	Yes	No	Yes	No	No	No
002	No	No	No	No	No	No	No	No
003	Yes	No	No	No	No	No	No	No
004	No	No	No	No	No	No	No	No
005	Yes	Yes	Yes	No	No	No	No	No
006	No	No	No	No	No	No	No	No
007	No	No	No	No	No	No	No	No
008	No	No	No	No	No	No	No	No
009	No	No	No	No	No	No	No	No
010	No	No	No	No	No	No	No	No
011	Yes	Yes	Yes	No	Yes	Yes	No	No
012	Yes	No	No	No	No	No	No	No
013	Yes	Yes	No	No	No	No	No	Yes
014	Yes	No	No	No	No	No	No	No
015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
016	Yes	Yes	No	No	No	No	No	No
017	Yes	Yes	No	No	No	No	No	No
018	Yes	No	No	No	No	No	No	No

Source: Pilot study, Bangladesh (2018–2019)

Characterizing agricultural holding by sustainability status. In order to determine the sustainability status of agricultural holdings by the severity of food insecurity experienced, once data have been properly codified and labels added to the 8 FIES questions, the second step involve estimating the parameters associated to the 8 FIES items.

The methodology underlying the estimation of parameters for the prevalence of food insecurity is based on the Item Response Theory (IRT)[7], used to analyse responses to survey questions. The IRT is a quantitative measure of a non-observable construction --latent trait-- that can be derived from a set of dichotomous variable (i.e. they can only take on value 1 or 0). The IRT measurement model known as the Rasch model provides a theoretical base and a set of statistical tools to:

- assess the suitability of a set of survey items for scale construction.
- create a scale from the items, and compare performance of a scale in various populations and survey contexts.

The logic behind the Rasch model is that the likelihood of a respondent reporting an experience depends on the distance along the scale between the severity of that respondent and that of the item associated with that experience. The more severe a respondent's food insecurity is, relative to that of the item, the more likely they are to answer "yes" (give an affirmative response). In other words, the higher the probability to say “yes” to a specific question, the more severe a respondent’s food insecurity is relative to that item, which means that the more severe the food insecurity of given respondent, the higher the probability will respond “Yes”. The Rasch model can be formalized as follows:

$$\boldsymbol{Pr_{i,h} = 1/\theta_h, \beta_i}$$

The relative severity associated with each of the experiences (the parameters βi in the formula above) can be inferred from the frequency with which they are reported by a large sample of respondents, assuming that, all else being equal, more severe experiences are reported by fewer respondents. Once the severity of each experience is estimated, the severity of a respondent’s condition (the θh parameter) can be computed by noting how many of the items have been affirmed. The rationale for this is that, on average, it is expected that a respondent will answer affirmatively to all questions that refer to experiences that are less severe of their food insecurity situation, and negatively to questions that refer to situations that are more severe (see http://www.fao.org/3/c-i4830e.pdf).

[7] For more details, read the FAO publication “Introduction to item response theory applied to food security measurements” www.fao.org/3/a-i3946e.pdf.

The below output shows estimates of the parameters from the Rasch model using real data from the pilot survey conducted in Bangladesh and are further explained.

Table 39. Items parameters and model test results

Items	Difficulty parameters	std Err.	R1c	df	p-value	Standardized Outfit	Infit	U
Worried	-3.44452	0.32598	6.117	6	0.4102	0.265	1.410	0.986
Healthy	-3.15808	0.32482	74.523	6	0.0000	2.945	-0.351	5.100
Fewfood	-2.58639	0.32558	10.372	6	0.1098	2.380	0.737	3.088
Skipped	1.31492	0.41843	21.018	6	0.0018	-1.179	-0.872	-0.763
Ateless	-0.30206	0.34940	15.308	6	0.0180	-2.991	-3.218	-1.669
Runout	1.88428	0.45995	14.326	6	0.0262	-1.421	-0.789	-0.306
Hungry	2.60101	0.53205	14.307	6	0.0264	-1.488	-1.067	-0.101
Whlday	3.69083	0.71339	39.276	6	0.0000	-0.865	0.340	-1.261
R1c test			R1c= 216.118	42	0.0000			
Andersen LR test			Z= 54.889	42	0.0877			

Source: Pilot study, Bangladesh (2018–2019).

In the table above, the least severe parameter is "**worried**", whereas the most severe is "**whole day**". One more output from the Rasch model concerns estimates of the parameters of the raw score. The raw score is the number of affirmative responses given to the eight FIES questions, i.e. an integer number with a value between zero and eight. This is why the respondents' parameters are nine. A respondent's raw score is the basis for calculating the respondent parameter.

Important note: an essential point to understand is that every respondent who answers "yes" to the same number of questions (irrespective of which ones) will be assigned the same parameter. The raw scores can only be used as an ordinal measure of food insecurity, meaning that we know that someone with a raw score of 4 is more food insecure than someone with a raw score of 2, but we do not know the exact difference in food insecurity severity between these two respondents. Only the respondent parameter, which θh in formula 1 can tell us this, as it is an interval measure of food insecurity.

Table 40. Raw scores and respondent parameters

Group	Score	Ability parameters	std Err.	Freq.	Expected Score	ll
0	0	-5.093	1.750	292	0.37	
1	1	-3.628	1.175	57	1.15	-58.6220
2	2	-2.586	1.110	32	1.97	-30.8169
3	3	-1.272	1.192	14	2.97	-15.4243
4	4	0.271	1.134	9	4.08	-7.5744
5	5	1.411	1.046	6	5.05	-6.0684
6	6	2.385	1.046	4	5.95	-7.8792
7	7	3.442	1.176	2	6.83	0.0000
8	8	5.024	1.799	4	7.64	

Source: Pilot study, Bangladesh (2018–2019)

Once the item severity and raw score parameters have been estimated, standard metric to derive comparable food insecurity prevalence rates can be derived by filling the estimated parameters excel file developed by the FIES team at FAO (here). The excel file must be filled in as follows:

Table 41. Estimation of probabilities

Items	Difficulty parameters	std Err.	Rlc	df	p-value	Standardized Outfit	Infit	U
Worried	-3.44452	0.32598	6.117	6	0.4102	0.265	1.410	0.986
Healthy	-3.15808	0.32482	74.523	6	0.0000	2.945	-0.351	5.100
Fewfood	-2.58639	0.32558	10.372	6	0.1098	2.380	0.737	3.088
Skipped	1.31492	0.41843	21.018	6	0.0018	-1.179	-0.872	-0.763
Ateless	-0.30206	0.34940	15.308	6	0.0180	-2.991	-3.218	-1.669
Runout	1.88428	0.45995	14.326	6	0.0262	-1.421	-0.789	-0.306
Hungry	2.60101	0.53205	14.307	6	0.0264	-1.488	-1.067	-0.101
Whlday	3.69083	0.71339	39.276	6	0.0000	-0.865	0.340	-1.261
Rlc test			Rlc=	216.118	42	0.0000		
Andersen LR test			Z=	54.889	42	0.0877		

Item parameters and statistics for the 8 FIES items(Country 1)		
	* CELLS B10-B17 in RM.w output	
Item	Severity *	
WORRIED		
HEALTHY		
FEWFOOD		
SKIPPED		
ATELESS		
RUNOUT		
HUNGRY		
WHLDAY		

Table 42. Estimation of probabilities

Group	Score	Ability parameters	std Err.	Freq.	Expected Score	ll
0	0	-5.093	1.750	292	0.37	
1	1	-3.628	1.175	57	1.15	-58.6220
2	2	-2.586	1.110	32	1.97	-30.8169
3	3	-1.272	1.192	14	2.97	-15.4243
4	4	0.271	1.134	9	4.08	-7.5744
5	5	1.411	1.046	6	5.05	-6.0684
6	6	2.385	1.046	4	5.95	-7.8792
7	7	3.442	1.176	2	6.83	0.0000
8	8	5.024	1.799	4	7.64	

Raw score parameters and errors (Country 1)

	**** CELLS B20-B28 B10-B17 in RM.w output*	*****CELLS C20-C2 B10-B17 in RM.w output*	****** CELLS F20-F28 B10-B17 in RM.w output*
Raw score	Severity ***	Error ****	W cases *****
0			
1			
2			
3			
4			
5			
6			
7			
8			

Finally, once the parameters have been added to the excel sheet, we get the following output table:

Table 43. Estimation of probabilities (moderate and severe)

Raw score	Percentage of individuals	Probability (mod+sev)	Probability (sev)
0	69.5%	0	0
1	13.6%	0.008278	0.000000
2	7.6%	0.055022	0.000000
3	3.3%	0.349852	0.000000
4	2.1%	0.830267	0.000024
5	1.4%	0.983226	0.000447
6	1.0%	0.998881	0.008408
7	0.5%	0.999851	0.109798
8	1.0%	0.999411	0.530647

Source: Pilot study, Bangladesh (2018–2019)

The above table gives, for each raw score, the probability to be «**moderate + severe** » food insecure and the probability to be «**severe**» food insecure.

The very final step of this calculation procedure implies characterizing agricultural households by sustainability status according to the estimated probabilities. The following thresholds has been selected in order to categorize households by sustainability status of food insecurity:

FIES_Sub_indicator_10=Desirable (Mild food insecurity) if the **probability of a household of the holder of the holding to be moderate + severe food insecure is less than 0.5 and the probability to be severe food insecure is less than 0.5.**

FIES_Sub_indicator_10=Acceptable (Moderate food insecurity) if the **probability of a household of the holder of the holding to be moderate + severe food insecure is greater than 0.5 and the probability to be severe food insecure is less than 0.5.**

FIES_Sub_indicator_10=Unsustainable (Severe food insecurity) if the **probability of a household of the holder of the holding to be severe food insecure is greater than 0.5.**

For instance: HH «**0001**» has a prob. to be «moderate + severe» = 0 and a prob. To be «severe» = 0 -> sustainability status is «desirable»

HH «**0004**» has a prob. to be «moderate + severe» = 70% and a prob. To be «severe» almost = 0 -> sustainability status is «acceptable»

HH «**0013**» has a prob. to be «moderate + severe» = 99.6% and a prob. To be «severe» = 70.1 percent -> sustainability status is «Unsustainable»

Table 44. Estimation of probabilities (moderate and severe)

HHID	Worried	Healthy	Fewfood	Skipped	Ateless	Runout	Hungry	Whlday	score	Prob. mod_+_severe	Prob. severe	Sustainability Status
001	Yes	Yes	Yes	No	Yes	No	No	No	4	0.830260	0.000024	Acceptable
002	No	No	No	No	No	No	No	No	0	0.000000	0.000000	Desirable
013	Yes	Yes	No	No	No	No	No	Yes	3	0.349852	0.000000	Desirable
014	Yes	No	No	No	No	No	No	No	1	0.008278	0.000000	Desirable
015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8	0.999411	0.530647	Non-sustainable
016	Yes	Yes	No	No	No	No	No	No	2	0.055021	0.000000	Desirable
017	Yes	Yes	No	No	No	No	No	No	2	0.055021	0.000000	Desirable
033	No	No	No	No	No	No	No	No	0	0.000000	0.000000	Desirable
034	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8	0.999411	0.530647	Non-sustainable
035	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8	0.999411	0.530647	Non-sustainable
036	No	No	No	No	No	No	No	No	0	0.000000	0.000000	Desirable
037	No	No	No	No	No	No	No	No	0	0.000000	0.000000	Desirable
118	Yes	Yes	Yes	No	Yes	No	No	No	4	0.830260	0.000024	Acceptable
119	No	No	Yes	No	No	No	No	No	1	0.008278	0.000000	Desirable
120	Yes	Yes	Yes	No	No	No	No	No	3	0.349852	0.000000	Desirable
128	No	Yes	Yes	No	No	No	No	No	2	0.055021	0.000000	Desirable
129	Yes	Yes	Yes	No	Yes	No	No	No	4	0.830260	0.000024	Acceptable
130	Yes	Yes	Yes	No	Yes	No	No	No	4	0.830260	0.000024	Acceptable
131	No	Yes	Yes	No	No	No	No	No	2	0.055021	0.000000	Desirable
132	No	No	Yes	No	No	No	No	No	1	0.008278	0.000000	Desirable

Source: Pilot study, Bangladesh (2018–2019)

Reporting

The reporting process of subindicator ‘‘**10**’’ is as follows:

The total agricultural area in the country under a given sustainability status is computed alongside its corresponding proportion (over total agricultural area). The dashboard approach for reporting on this indicator will look like:

Table 45. Reporting on subindicator #10

Sustainability status (subindicator #10)	Agriculture area in Hectares	Proportion of Agriculture area
Desirable	486.8	95
Acceptable	17.2	3
Unsustainable	5.8	1
Total	509.8	100

Source: Pilot study, Bangladesh (2018–2019)

2.11. Secure tenure rights to land

Rational behind the subindicator. The subindicator measures the proportion of agricultural area by sustainability status, the latter defined with reference to ownership or secure rights over use of agricultural land areas operated by the holding.

Sustainability criteria.

- Green (desirable): has a formal document with the name of the holder/holding on it, or has the right to sell any of the parcel of the holding, or has the right to bequeath any of the parcel of the holding
- Yellow (acceptable): has a formal document even if the name of the holder/holding is not on it.
- Red (unsustainable): in all other cases I.e.no positive responses to any of the 4 questions asked about secure tenure rights to land (see below).

From the formulation of primary variables to the computation of primary variables. In general, information on ownership or secure rights over use of agricultural land areas are gathered usually using household and agricultural surveys through a set of standardized questions. Such questions are used to compute 4 primary variables, which in turn allows characterizing agricultural holding by their corresponding sustainability status, as reported in the matrix below.

	Primary variables				
Raw variables	Formal document	Name of the holder	Formal document with name of the holder	Right to sell	Right to bequeath
Does the holder/holding have a formal document for any of the agricultural land that it holds (alternatively 'possess, use, occupy) issued by the Land Registry/Cadastral Agency?					
Is the name of the holder or any other member of the holding is listed as an owner or use right holder on any of the legally recognized documents?					
Does the holder/holding have the rights to sell any of the parcel of the holding (alternatively 'parcel possessed, used or occupied')?					
Does the holder/holding have the rights to bequeath any of the parcel of the holding (alternatively 'parcel possessed, used or occupied')?					

Content of the primary variables. Each primary variable is constructed as a dummy variable taking on value 1 if the household 1) has a formal document; 2) has the name of the holder/holding listed as owner or use right on it; 3) has the right to sell any parcel of land and 4) has the right to bequeath. The dataset to be prepared for the analysis will look like the one reported in table below:

Table 46. Sustainability status, subindicator #11

HHID	Formal document	Name on it	Right to sell	Right to bequeath	Sustainability status
001	Yes	Yes	Yes	Yes	Desirable
002	Yes	No	No	No	Acceptable
050	Yes	Yes	Yes	Yes	Desirable
051	No	No	No	No	Unsustainable

Source: Pilot study, Bangladesh (2018–2019)

According to the sustainability criteria, agricultural holdings #001 and #050 have both a formal document with the name of the holder/holding on it, have the right to sell any of the parcel of the holding and, finally, have the right to bequeath any of the parcel of the holding. As such they are categorize as “desirable”. The agricultural holding #002 has on a formal document but it does not have the name of the holder on it, nor any rights to sell or bequeath any parcel of the holding. As such it categorizes as “acceptable”. Finally, household # 051 does not meet any of the requirements to be classified as “desirable” or “acceptable” and thus is classified as “unsustainable”.

Reporting

The reporting process of subindicator ‘’**11**’’ is as follows: The total agricultural area in the country under a given sustainability status is computed alongside its corresponding proportion (over total agricultural area). The dashboard approach for reporting on this indicator will look like:

Table 47. Reporting on SDG 2.4.1, subindicator #11

Table 47. Sustainability status, subindicator #11

Sustainability status (subindicator #11)	Agriculture area in Hectare	Proportion of Agriculture area
Desirable	437.0	86
Acceptable	58.0	11
Unsustainable	14.7	3
Total	509.8	100

Source: Pilot study, Bangladesh (2018–2019)

3. Final reporting: dashboard

Modality of reporting the indicator. The set of subindicators are presented in the form of a dashboard. The dashboard offers a response in terms of measuring sustainability at farm level and aggregating it at national level.

Final datasets. In order to construct the final dashboard, two datasets are derived. The first dataset contains the agricultural land area, as expressed in hectares and at national level, that is under a given sustainability status. For each subindicators, the agricultural area that is desirable, acceptable and Unsustainable is aggregated at the national level, as reported in table below for Bangladesh pilot tests (2018–2019).

Table 48. Deriving dashboard

Sustainability status of the holding	Area associated with Farm output value per hectare	Area associated with Net farm income	Area associated with Risk mitigation mechanisms	Area associated with Prevalence of soil degradation	Area associated with Variation in water availability	Area associated with Management of fertilizers	Area associated with Management of pesticides	Area associated with Use of biodiversity-supportive practices	Area associated with Wage rate in agriculture	Area associated with FIES	Area associated with Secure tenure rights to land
Desirable	55.9	237.5	286.3	259.8	443.0	240.0	102.9	0.0	501.3	486.8	437.0
Acceptable	93.7	250.0	148.9	147.0	11.3	108.7	123.6	425.8	0.0	17.2	58.0
Unsustainable	360.1	22.3	74.6	103.0	55.5	161.0	283.2	83.9	8.5	5.8	14.7
Total agricultural area*	**509.8**	**509.8**	**509.8**	**509.8**	**509.8**	**509.8**	**509.8**	**509.8**	**509.8**	**509.8**	**509.8**

Source: Pilot study, Bangladesh (2018–2019)

The second dataset contains, for each subindicator, the proportion of agricultural areas in total agricultural area that is desirable, acceptable and Unsustainable . This dataset is presented in table below.

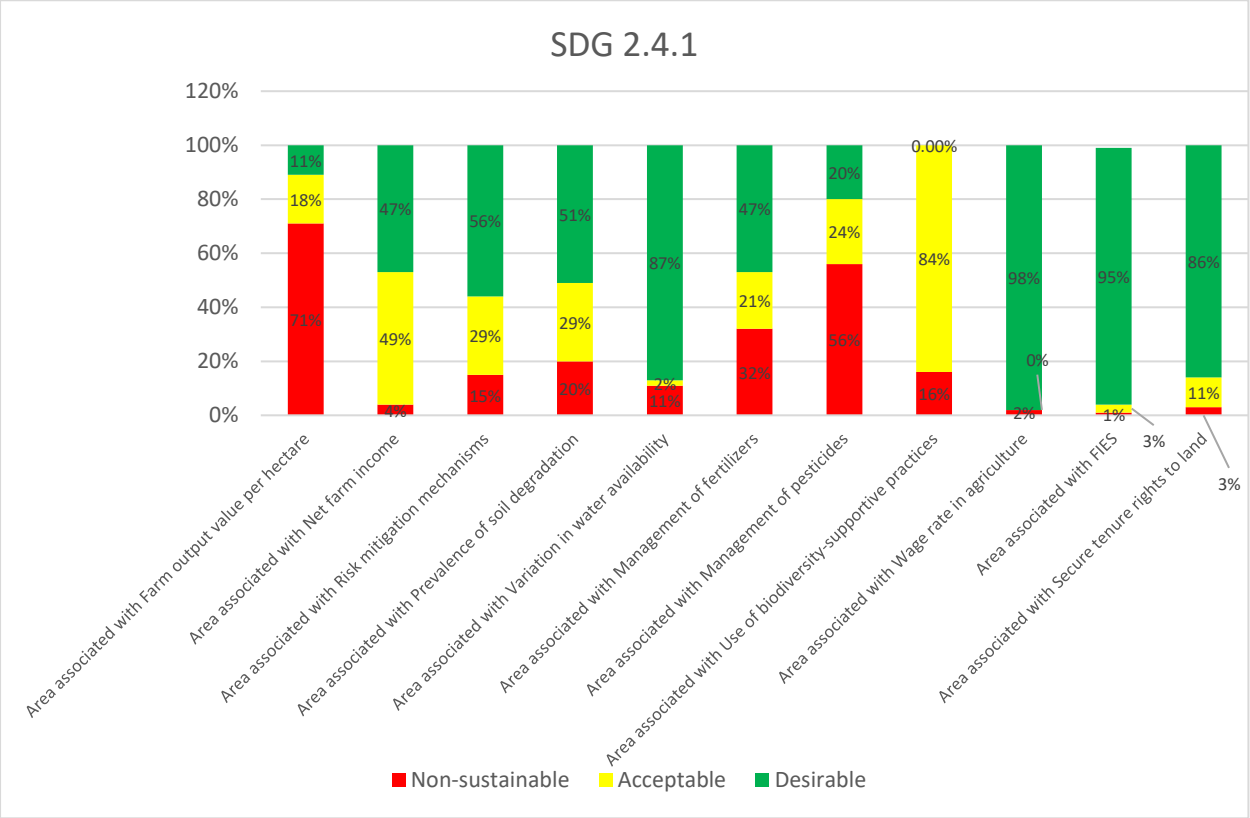
Table 49. Deriving dashboard

Sustainability status of the holding	Area associated with Farm output value per hectare	Area associated with Net farm income	Area associated with Risk mitigation mechanisms	Area associated with Prevalence of soil degradation	Area associated with Variation in water availability	Area associated with Management of fertilizers	Area associated with Management of pesticides	Area associated with Use of biodiversity-supportive practices	Area associated with Wage rate in agriculture	Area associated with FIES	Area associated with Secure tenure rights to land
Desirable	11	47	56	51	87	47	20	0.00	98	95	86
Acceptable	18	49	29	29	2	21	24	84	0	3	11
Unsustainable	71	4	15	20	11	32	56	16	2	1	3

Source: Pilot study, Bangladesh (2018–2019)

Computation of results and construction of the dashboard is performed for each subindicator separately: for each subindicator, aggregation at national level is done by summing the agricultural land area of all agricultural holdings by sustainability category (red, yellow or green), and reported as percentage of the total agricultural land area of the country (minus the common land, as discussed earlier)

Figure 4. Presentation of the final dashboard.



Source. Bangladesh pilot survey (2018–2019)

4. Building and reporting the aggregate indicator

In order to obtain the proportion of agricultural area that is sustainable at the national or subnational level, the assessment of the sustainability status should be made across all subindicators. The national or subnational level sustainability will be assigned based on the results of the most constraining across all subindicators. As explained in section III above, the national or subnational value of indicators 2.4.1 is derived from the dashboard, and is associated with the result of the subindicator that has a most limiting sustainability performance. This implies checking among all subindicators the one that has achieved the least "desirable + acceptable" sustainability level, or the highest level of unsustainability.

Using data from the pilot tests carried out in Bangladesh, it is straightforward to notice that the subindicator with the highest level of unsustainability is farm output value per hectare, with at least 71 percent of the agricultural area that classified as unsustainable. The final proportion of agricultural area under productive and sustainable agriculture can be calculated as:

$$\boldsymbol{SDG_{2.4.1_d}} = \min_{\boldsymbol{n:1-11}} \boldsymbol{SI_{d\,n}}$$

Where

$SDG_{2.4.1_d}$ is the proportion of agricultural land area that has achieved the "desirable level".

$SI_{d\,n}$ is the proportion of subindicator n that is classified as "desirable"

Min refers to the minimum level of $SI_{d\,n}$ at national elvel across all 11 subindicators

$$\boldsymbol{SDG_{2.4.1_{d+a}}} = \min_{\boldsymbol{n:1-11}} (\boldsymbol{SI_d} + \boldsymbol{SI_a})_{\boldsymbol{n}}$$

Where

$SDG_{2.4.1_{d+a}}$ is the proportion of agricultural land area that has achieved the "desirable + acceptable level".

$SI_{d\,n}$ is the proportion of subindicator n that is classified as "desirable"

$SI_{a\,n}$ is the proportion of subindicator n that is classified as "acceptbale"

Min refers to the minimum level of $(SI_d + SI_a)_n$ at national elvel across all 11 subindicators

$$\boldsymbol{SDG_{2.4.1_u}} = \boldsymbol{1} - \boldsymbol{SDG_{2.4.1_{d+a}}} = \max_{\boldsymbol{n:1-11}} \boldsymbol{SI_{u\,n}}$$

Where

$SDG_{2.4.1_u}$ is the proportion of agricultural land area that has achieved the " unsustainable level".

$SI_{u\,n}$ is the proportion of subindicator n that is classified as "unsustainable"

$SI_{d\,n}$ is the proportion of subindicator n that is classified as "desirable"

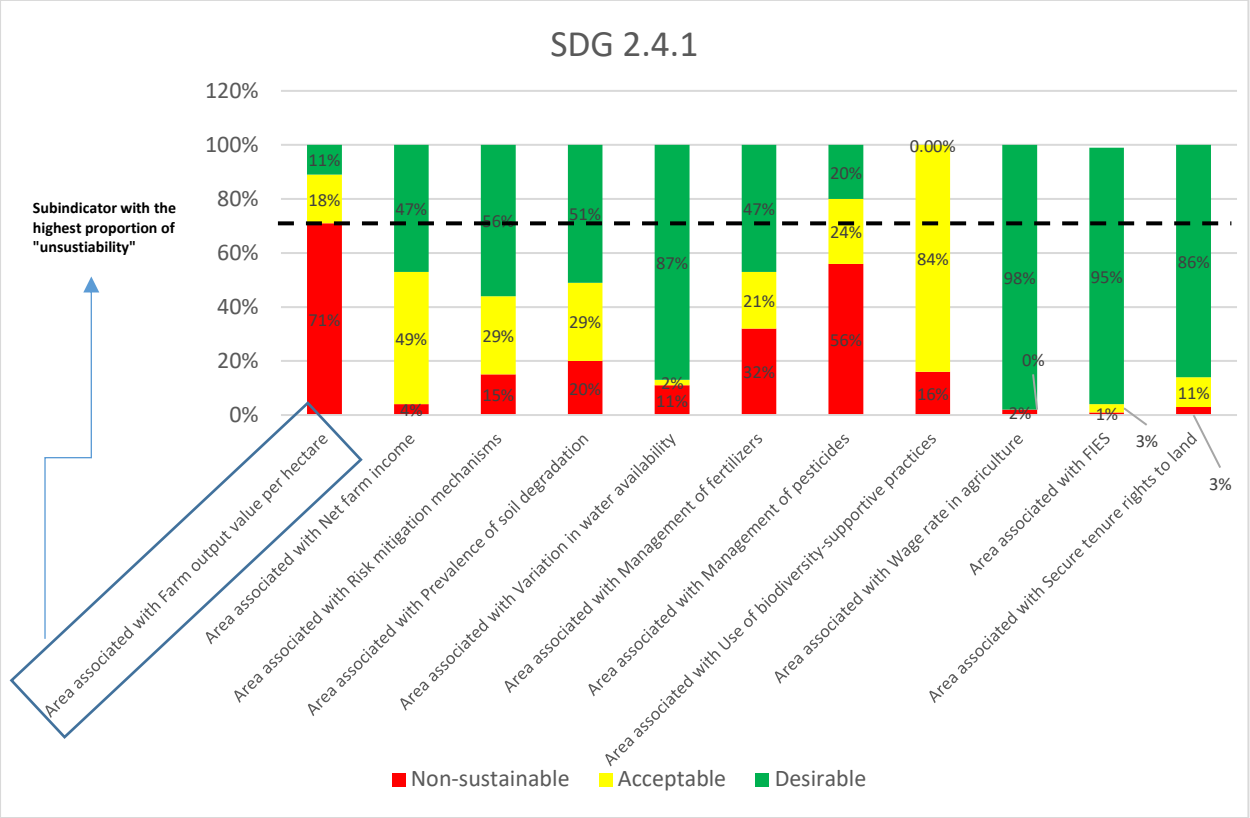
$SI_{a\,n}$ is the proportion of subindicator n that is classified as "acceptable"

Max refers to the highest level of $SI_{u\,n}$ at national elvel across all 11 subindicators

$SDG_{2.4.1_u}$ refers to the maximum level of agricultural area for which at least one subindicator has the highest unsustainable agricultural area.

The last formula above-indicated ($\boldsymbol{SDG_{2.4.1_u}}$) allows deriving the aggregate indicator, further reflected in figure 5 below. Based on the results of the analysis, subindicator number 1 (Farm Output Value Per-Hectare) is the one with the highest proportion of agricultural area (71 %) as unsustainable.

Figure 5. Presentation of the final dashboard.



Source. Bangladesh pilot survey (2018–2019).