# Concept note on Methodology to Estimate Direct Economic Losses from Hazardous Events to Measure the Achievement of Target C of the Sendai Framework for Disaster Risk Reduction: A Technical Review

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**The United Nations Office for Disaster Risk Reduction**

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## Overview

This document outlines a methodology to estimate the value of direct economic losses caused by hazardous events. The Open-ended Intergovernmental Expert Working Group on Indicators and Terminology Related to Disaster Risk Reduction requested the UNISDR to propose a methodology at the first session, held in Geneva on 29-30 September 2015, as informed by the "Indicators to monitor global targets of the Sendai Framework for Disaster Risk Reduction 2015-2030 - a technical review". (UNISDR, 2015a).

The purpose of this document is to support discussion by Member States on the selection and design of indicators to monitor progress and achievement of the global target C of the Sendai Framework for Disaster Risk Reduction 2015-2030.

**Target C:** ***Reduce direct disaster economic loss in relation to global gross domestic product (GDP) by 2030***

The methodology described here is based on the work published in the Global Assessment Report on Disaster Risk Reduction (GAR) editions of 2013 and 2015 (UNISDR, 2013b and 2015c; Velazquez, et.al 2014), which is a simplified and adapted version of the ECLAC methodology (UN-ECLAC, 2014) and built on continuing work with scientific partners including the team of scientists that developed UNISDR Probabilistic Global Risk Model. The methodology has been tested with datasets of 56 and 82 countries, respectively. In the latest round of tests, UNISDR produced the economic assessment of 350,000 reports of small, medium and large scale disasters.

Disaster loss economic assessments have been conducted and reported by different actors using different approaches, with the notable exception of UN-ECLAC and World Bank post-disaster damage and loss assessments (DaLA's and PDNA's), which proposes a uniform, rigorous and consistent methodology, however conducted only for large scale disasters.

This lack of uniform approach is reflected in inconsistencies in economic losses currently reported by both national and international data sources. In the cases these estimates are present it is most often difficult to know which elements of loss were taken into consideration and the methodology, criteria and parameters used for estimation.

The methodology proposed here will allow assigning a **consistent**, **conservative** and **homogeneously** estimated economic value to physical losses in hundreds of thousands of disasters at all scales expected to be reported as part of the Sendai Framework Targets monitoring process.

This methodology proposes the collection and use of **simple and uniform physical indicators of damage (counts of assets affected)** as starting point of the calculations, instead of requesting countries to directly evaluate the economic value of direct losses. A centralized and common approach to estimate direct economic losses will result in homogeneous and consistent indicator.

National Disaster loss databases, the source of data used in this methodology to estimate

direct economic loss, usually contain a large number of hazardous events records at all scale including quantitative and qualitative indicators of physical damage. The experience working with disaster loss databases covering around 85 countries indicate that simple physical damage indicators are in general robust.

The economic evaluation methodology is presented for each of the Indicators proposed. Each section generally contains a brief explanation of the three steps (data collection, conversion of physical value into economic value and conversion from national currency into US dollars) while identifying challenges and suggesting options for countries to consider how to address them.

The following are the indicators for which an economic valuation is proposed in this guideline:

**C1**: Direct Economic loss due to hazardous events in relation to global gross domestic product
**C2**: Direct agricultural loss due to hazardous events
**C3**: Direct economic loss due to industrial facilities damaged or destroyed by hazardous events
**C4**: Direct economic loss due to commercial facilities damaged or destroyed by hazardous events
**C5**: Direct economic loss due to houses damaged by hazardous events
**C6**: Direct economic loss due to houses destroyed by hazardous events
**C7**: Direct economic loss due to damage to critical infrastructure/public infrastructure caused by hazardous events, to be calculated based on the following indicators D2 to D4.
**D2:** Number of health facilities destroyed or damaged by hazardous events
**D3:** Number of educational facilities destroyed or damaged by hazardous events
**D4**: Number of transportation infrastructures destroyed or damaged by hazardous events

Newly proposed indicators in the 1st meeting of open-ended intergovernmental working group are as follows. UNISDR is examining measurability and economic evaluation methodology and therefore the methodology are not included in this guideline.

**C8** –Direct economic loss due to cultural heritage damaged or destroyed by hazardous events
**C9** – Direct economic loss due to environment degraded by hazardous events

## What is a "direct economic loss indicator"?

An indicator, as the word itself suggests, is a number that gives an **indication** of the size of certain phenomena[1], in this case it **estimates the value** of direct economic losses that occur in each disaster.

It is important to emphasize that **no indicator will provide an absolutely precise, accurate and exhaustive measure of losses**. It would be impossible to get rid of certain level of inaccuracy from direct economic loss estimations, depending on the methodology and criteria used to assign monetary value to the assets damaged or destroyed and the exhaustiveness of the data collection. In this sense, the loss estimated is always an approximate value (a "proxy").

The indicators to measure direct economic losses for the Sendai Framework aim to meet following important criteria:

**Consistent over time:** The target requires the comparison of losses of two different decades. Losses over a period of 25 years have to be calculated in a consistent way in the entire span of the measurements so that no biases are introduced.

**Consistent across countries: I**t must be applicable to any country in the world, allowing as much as possible comparisons among countries or regions, and feasible to calculate independently of the level of development or income of each country.

**SMART: S**pecific, **M**easurable, **A**chievable, **R**elevant, **T**ime Bound.

**Reliable**: Results can be trusted and a measure of dispersion, and for which a certain uncertainty measure can be determined.

**Transparent**: The methodology used is well known, with caveats weaknesses and limitations along with strengths, and the economic assessment biases can be determined.

**Verifiable**: The estimated economic value can be traced back to the original indicators of damage.

**Feasible**: Easy to collect data in a practical and realistic way, without imposing an extraordinary or even impossible burden to countries.

**Taking advantage of existing data**: Many countries have already collected standardized data. Taking advantage of this fact is more practical than having everyone start from zero.

**Can be refined/improved over time:** when better information is made available, or improved methodologies are developed the economic estimation can be revised to reflect the improvement.

[1] http://www.oxforddictionaries.com/es/definicion/learner/indicator

**Useful**: Results can be used not only for measuring the achievement of targets but also for DRR strategy planning, awareness raising, risk assessments and other DRR policies.

## Common methodology proposed: Direct economic losses using replacement cost approach

The methodology proposed is the conversion of physical damage value into economic value using replacement cost to monitor direct economic losses. The methodology is consistent with DALA and PDNA methodology.

Sendai Framework Target C specifically requires "**direct economic loss"** to be estimated**.** For the purposes of this methodology, the term "*Direct economic loss"* and related key terms are defined as proposed by the " Proposed Updated Terminology on Disaster Risk Reduction: A Technical Review" background paper submitted to the Open-ended Intergovernmental Working Group of the Sendai Framework (UNISDR, 2015d).

**Economic loss:** *Total economic impact that consists of direct economic loss and indirect economic loss.*

Comments: Direct and indirect economic loss are two complementary parts of the total economic loss.

**Direct economic loss:** *The monetary value of total or partial destruction of physical assets existing in the affected area.*

Comments: Examples of physical assets include homes, schools, hospitals, commercial and governmental buildings, transport, energy, telecommunications infrastructures and other infrastructure; business assets and industrial plants; production such as standing crops, agricultural infrastructure and livestock. They may also encompass environment and cultural heritage.

**Indirect economic loss:** *Declines in value added as a consequence of direct economic loss and/or human and environmental impacts. Indirect economic loss is part of disaster impact.*

Comments: Indirect economic loss includes micro-economic impacts (e.g. revenue declines owing to business interruption), meso-economic impacts (e.g. revenue declines owing to impacts on a supply chain or temporary unemployment) and macro-economic impacts (e.g. price increases, increases in government debt, negative impact on stock market prices, and decline in GDP). Indirect losses can occur inside or outside of the hazard area and often with a time lag.

Note from UNISDR: In DALA and PDNA methodologies, direct economic loss is called "damage" while indirect economic loss is called "loss".

**Replacement Cost:** *The cost of replacing damaged assets with materials of like kind and quality.*

Comments: This includes both private and public assets. Replacement is not necessarily an exact duplicate of the subject but serves the same purpose or function as the original (not taking into account build back better).

The methodology basically consists in the following three steps. We identify challenges in each step.

**Step 1**: Collect good quality of data, ideally disaggregated, on physical damage per hazardous event.
**Step 2**: Apply replacement cost per unit to estimate economic value
**Step 3:** Convert the economic value from the one expressed in national currency into the one expressed into US dollars

With difference in details, the basic formula common to all indicators is as follows:

**Direct economic loss =**
**(a) Number of physical assets affected** (e.g. number of facilities damaged)
*** (b) Size of the physical assets**
*** (c) Unit Cost** (e.g. per square meters, per kilometres, per hectare)

As the formula shows, it is required to collect three critical data for estimation. In Step 1, the data (a) is collected from national disaster loss databases. In step 2, the data (b) and (c) are collected mainly from disaster loss databases or national socio-economic statistics. In case the data does not exist, it is suggested to be estimated using global methodology.

(a) **Number of physical assets damage**: The data is collected and reported from national disaster loss database. The level of disaggregation will enhance the accuracy of economic loss estimation while increasing the data collection burden. Several options are suggested in the section of each indicator.

(b) **Size of physical assets:** The most accurate estimate is possible if countries collect and report data on individual size of physical assets affected on each hazardous event. However, this involves a huge effort on data collection which is believed not feasible nor practical.

Countries are recommended to provide as proxy average size of physical assets (e.g. average size of housing, average size of commercial facility, average weight of livestock, average). Usually such data are found in official statistics or other statistics compiled by sectoral ministries. For example, average size of housing data can be often found in housing statistics.

In some cases, instead of average, using the median (middle value in the data set) or mode (the value most often observed in the data set) might be appropriate. If countries additionally report “distribution of assets by certain category” (e.g. type of crops, size category), weighted

averages can be also proposed.
When countries cannot provide data from their related socio-economic statistics, as the last resort, UNISDR proposes the use of global data, or application of methodology based on the work from Global Assessment Report.

(c) **Unit cost**: As the majority of countries will collect only the number of facilities affected, countries are recommended to provide a proxy construction cost per unit (e.g. housing construction cost per square meter, school construction cost per square meter). If the asset is public assets, usually ministries in charge of the public asset have the data. For example, Ministry of Public Work would have standard road construction cost per kilometre. In case of private assets such as industrial facility, it is more difficult to find such data. However, related ministries or association of construction business are likely to have the data.

It is of note that construction cost per unit is usually different across sectors (e.g. industrial vs housing) and within sectors (urban vs rural, industrial sector, building structure). While enhancing reporting these details will significantly improve accuracy of loss estimate, it may raise the costs required to obtain this information.

When countries cannot report data from their related socio-economic statistics, as the last resort, UNISDR proposes the use of global data, or application of methodology based on the long lasting work for Global Assessment Report (See Annex I).

For element (c), ideally, a matrix *similar* to the one below should be filled up.

**Table: Suggested MINIMUM REQUIREMENT: proxies to be provided by countries for Step 2 of C3 to C7 indicators**
(The number and data source filled in is a sample value to show the image of reporting.)

| Type of buildings | average size of facilities (m2) (a) | construction cost per m2 (b) | Data source |
|---|---|---|---|
| Industrial (for C3) | 2,000 | 1,200 | (a) Ministry of Economy<br>(b) Application of national proxy formula |
| Commercial (for C4) | 700 | 800 | (a) Ministry of Commerce<br>(b) National Construction Association |
| Housing<br>(for C5 and C6) | 55 | 500 | (a) Ministry of Housing<br>(b) Global Compass Data |
| Health (for C7) | 60 | 800 | (a) Application of recommended fixed value<br>(b) Ministry of Health |
| Education (for C7) | 200 | 300 | (a)(b) Ministry of Education |
| **National Proxy**<br>(When data is not provided by countries nor global database) | - | **Estimate based on COMPASS data** | **UNISDR** |

Depending on data availability on each country, and on the level of detail of the actual physical damage data collection, these proxies could be disaggregated to enhance the quality of the estimates.

For example, if a country collects disaggregated data on physical damage for housing sector in rural and urban categories, then countries are recommended to provide both sizes and prices corresponding to each category.

***Evolution of price over time***

How to assure proper comparison across time? It is important to distinguish what part of the change in economic loss data stems from a change in the quantities affected and what part is accrued to a change in prices. Let's suppose the case that the housing loss is worth USD 10,000 in the first year and USD 12,000 in the second. It is important to know if this 20% loss increase is due to an increase in the number of housing affected or to an increase in its price.

The price factor, in this case, the construction cost per unit, change across time due to technical development and other market related factors (e.g. price increase of construction material in relation to other goods and services). General Price level change such as inflation will also influence unit price.

When the main objective of monitoring direct economic loss is observing the trend of physical damage, whether it is increased or not, it is recommend to use constant price in all the periods, with inflation adjusted.

If the main objective is monitoring the impact of disaster loss on overall economy, nominal price should be used and compared with nominal GDP. The percentage of loss to GDP matters and be compared across time.

However, these two directions might not be an issue of selecting either one or the other. As long as the original data is collected, it is easy to estimate both.

C-1 indicator is expressed in relation to GDP while others are not. It might need alignment between these two types of indicators.

Lastly, the loss expressed in national currency needs to be converted into US dollars. As the main objective is not cross-country comparison but global summation, it is suggested to simply use official exchange rate without taking into consideration of Purchasing Power Parities.

## C1 –Direct Economic loss due to hazardous events in relation to global gross domestic product

Indicator C1 will be calculated as follows.

C1 = (C2 + C3 + C4 +C5 + C6 + C7) /global GDP

***Challenge 1:***
Should price adjustment be added?

***Options suggested to be considered and discussed:***

**Option 1**: The proportion of loss to GDP matters to estimate the possible impact of disaster loss on the global economy. Therefore, the nominal loss and GDP value is suggested to be taken to monitor progress.

**Option 2:** In addition to the proportion of loss to GDP to assume the possible impact of disaster loss on the global economy, the countries might be interested in monitoring trend of direct economic loss. In that case, UNISDR suggests to compare inflation-adjusted loss and GDP values by dividing nominal value by GDP deflator.

***Challenge 2:***
Review of summation. It is already expected that building baseline for indicators C3 and C4 would be extremely difficult. Because it is important to monitor industrial and commercial loss, it would be meaningful and important to have these indicators. However, in the headline indicator C1, should we add C3 and C4?

***Options suggested to be considered and discussed:***

**Option 1:** Retain the current formula. Develop methodology to estimate baseline for C3 and C4.

**Option 2:** Drop C3 and C4 from the current formula. In this case, it is of note that the resulting value would significantly underestimate the loss to industrialized developed countries.

## C2 – Direct agricultural loss due to hazardous events

From 347,000 records in the 85 national databases analysed in GAR 2015, 26% (91,686) register quantitative indicators (expressed as number of hectares of crops affected and livestock lost) or qualitative (yes/no indicator) about the existence of direct damages to the agricultural sector. Most of agricultural damage (98.5%) is associated to weather-related hazards. Three disaster types, namely flood, drought and forest fire, represent 82 % of the damages with a total of more than 209 million of hectares affected. The importance of agricultural loss due to disasters is undeniable, especially when looking at accumulated impact of small scale but frequent events.

This indicator can be calculated based on two indicators, one for crop loss and the second for livestock losses (c2b):

**C2 = Direct agricultural loss due to crops affected**
**+ Direct agricultural loss due to livestock lost**

The physical damage data that countries will be requested to collect are:

**C2a**=the number of hectares of crops affected
**C2b**=the number of livestock lost

These are usually reported by emergency management authorities or ministries of agriculture and are the most available data in disaster reports, especially in small and medium scale disasters.

### C2-1 Direct agricultural loss due to crops affected (damaged or destroyed)

The general formula proposed is:

**Loss on crops = number of hectares affected (C2a) * direct cost per hectare * 0.25**

It is proposed that direct costs per hectare (which are very difficult to obtain) would be estimated using crop output. Output is, simply said, price per unit times quantity (yield). Price consists of three elements: variable cost, fixed cost and profit.

Cost of crops (direct losses) should include variable cost such as labour and machinery operating costs, costs of raw ingredients, including seeds, fertilizer and pesticides and fixed costs such as damage to productive soil, irrigation infrastructure, machinery and equipment, storage infrastructure, and damages to stored fertilizers and seed. As it can be seen, the methodology simplifies the calculation of all these elements as they are all included in the output.

Thus, a more specific formula proposed is:

**Loss on crops = number of hectares affected (C2a) * average crop output per hectare * 0.25**

**where**
**Average crop output per hectare = average yield per hectare * price per ton**

***Step 1: Collect good quality of data, ideally disaggregated, on physical damage***

The minimum requirement data proposed to estimate direct loss in crops is:

**C2a=**Number of hectares of crops affected (damaged or destroyed)

*Challenges:*

a) Agricultural losses are not recorded as thoroughly as other losses such as human related loss or housing damage and destruction. Further involvement of authorized data sources for all hazardous events will increase the coverage, and thus the reliability of the indicator.
b) Disaster loss databases don't record, with a few exceptions, the type of crops damaged. Additional efforts to capture for each hazardous event the number of hectares affected per type of crop will be beneficial, but will introduce additional workload and complexity for data collection.
c) Disaster loss databases don't record the level of affectation. Additional efforts to capture for each hazardous event the level of damage as a percentage (or simply dividing into partially damaged and totally destroyed crops) would be beneficial.
d) Collecting separately other physical damages, such as those to irrigation and equipment could result in better measurements. However, introducing more sub-indicators may pose additional challenges of comparability and the possibility of consolidation.
e) Damage to crops is also very dependent of the growth cycle of the crop. Damage varies depending on the intensity of the hazard but also on how early or late in this cycle the disaster hits the crops. For example, FAO (2012) introduces "*At various stages of growth, the estimated reduction in harvest per hectare of a specific crop caused by, say, floods can be varied. For instance, a flood that will submerge newly planted taro for 2 to 3 days may cause a 100% reduction in harvest while the same flood may cause only a 50% reduction in harvest of taro at maturing stage."*
f) Currently the national disaster loss database compiles forest area damage caused by forest fire. In GAR 2015, losses associated to forests damaged were priced same as farmland. However, forest area losses may be very different from crop losses, therefore it is suggested that losses of forest fires pricing be reviewed, and/or kept separated from agricultural losses. The GAR consolidated database for 82 countries has 253,035,883 hectares lost, about 10% of which (23,003,834 hectares) were forests/grasslands.

*Options suggested to be considered and discussed:*

Given the benefit and cost of collecting further data, the scope of loss data collection should be decided by countries.

***Step 2: Apply average output per hectare to estimate direct crop losses***

As mentioned earlier, with few exceptions, the type of crop damaged is not recorded. The price "producer price per ton" is of course not equal for all crops in a country, and can be very different by country. For example, in El Salvador, the producer price per ton is 30 times higher for green coffee than oranges (USD 4,160 per ton for green coffee, USD 132 per ton for oranges).

For GAR 2015 UNISDR devised a methodology to valuate farmland damage that aims at designing a proxy value for crop losses using publicly available datasets from FAO Statistics, which may also be obtained nationally in ministries of Agriculture.

At first, a **weighted average agricultural output per hectare (Aoha)** of all types of crops is recommended to be calculated per country based on the three variables. Only crops for which all variables are available are taken into account (in most cases, all three are available).

$$\text{Aoha} = \sum \left(\frac{Area_i * Yield_i * Price_i}{Total\ Area}\right)$$

Where:
$Area_i$ is the total area planted of each crop type i
$Yield_i$ is the yield per hectare for crop type i (expressed in ton)
$Price_i$ is the producer price per ton for crop type i
Annual Producer Prices or prices received by farmers for primary crops as collected at the farm-gate or at the first point of sale (based on FAO definition)

Then, this approach suggests **to multiply a conservative percentage (25%)** to the output under normal conditions to derive direct loss per damaged hectare (UNISDR, 2015c).

The first reason to apply 25% is that the affected farmland does not necessarily imply total crop destruction. The second, much minor reason compared to the first reasons is that cost (variable cost + fixed cost) can be estimated as the total price minus profit. Profit is regarded as indirect loss, it should be excluded. However, profit margin of agriculture is not very high in many countries. Even in the US, 70% of farmers have less than 10% profit margin[2].

Lastly, Aoha x 25% is multiplied by C2a to derive total agriculture crop direct loss.

[2]http://www.ers.usda.gov/amber-waves/2015-januaryfebruary/profit-margin-increases-with-farm-size.aspx#.Vjb6y_kvfIU, accessed as of 3 November 2015.

*Challenge 1:*

a) Determining the direct cost per type of crop and per hectare is extremely difficult given the lack of sources of information and the diversity of crops and agricultural technologies, from pure manual to highly mechanized.

*Options suggested to be considered and discussed:*

**Option 1:** Countries report three variables (the total area planted for each crop type, the average yield per hectare for each crop type and the producer price per ton for each crop type). It is expected that ministries of Agriculture will be able to supply the required statistical data for the Sendai Framework targets and indicators to enhance the quality and accuracy of the estimate.

**Option 2:** Utilize global data from **FAO statistics** (http://faostat.fao.org/). It is suggested to utilize data only when three variables are available (usually the most common). The caveat is missing statistical data: Unfortunately the FAO statistics coverage is not global, and in several countries is not complete, i.e. not exhaustive in terms of types of crops.

**Complementary method for both options 1 and 2:** For those countries for which these statistics are not available, UNISDR designed a method which extrapolates a good proxy indicator for the producer price by using a set of regressions of known prices against GDP per capita.

To further improve the methodology, UNISDR grouped countries by income groups using World Bank's income group classification (high income (OECD), high income (non-OECD), upper middle income, lower middle income and low income).

The calibration via GDP per capita plus income groups leads to results that go from USD 6,875/ha ($y = 0.0344x + 3051.3$) for high income (OECD) countries to USD 720 /ha ($y = 0.6891x + 565.8$) for low income countries. This method gives a proxy price for all countries with missing FAO data.

*Challenge 2:*

Direct losses as a percentage of output: The percentage chosen (25%) is an expert criteria based on different factors. If more information on damage level and general profit margin is available, the ratio can be refined to enhance the quality of estimate.

*Challenge 3:*

How to assure proper comparison across time? The agriculture output will change in terms of volume and price due to different reasons from disasters. Technical development will increase the yield per hectare. Price level changes such as inflation will influence unit price. Technical development or other factors in agriculture product market will influence relative price of agriculture product higher or lower

compared to other goods and services. Should the methodology apply nominal price per unit or the same unit price for all period?

*Options suggested to be considered and discussed:*

**Option 1:** The relative unit price increase of agricultural goods in relation to other goods and services indicates the increased influence of agriculture loss on overall economy. Impact of general inflation will be considered in C1 if agreed so. Suggested to use nominal per unit price in each moment of time.

**Option 2:** Simply to observe affected volume trend, use the same unit price for all the moments from baseline period until 2030.

***Step3: Convert the value expressed in national currency into the one in USD and derive global loss value***

It is recommended to convert the value expressed in national currency into USD by using the official exchange rate at the year of event (Data source: Official exchange rate of the World Bank Development indicator).

Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).

**C2-2 Direct agricultural loss due to livestock lost**

It is proposed that total price to producer of livestock lost would indicate the direct agricultural loss due to livestock.

The price[3] per livestock is, simply said, price per kilo times weight of livestock. The general formula proposed is:

**Loss on livestock = number of livestock lost * average weight per animal * average price per kilogram**

For the purposes of assessing the direct losses in livestock, it is necessary to convert headcount of livestock to total weight of meat taken from livestock and multiply it by average price per kilo.

***Step 1: Collect good quality of data, ideally disaggregated, on physical damage***

National disaster loss databases typically record losses of 4-legged animals such as goats, sheep, cows, buffalos and horse. The minimum requirement data proposed to estimate direct loss to livestock is
**C2b=**Number of livestock lost

[3] the concept of price here is equivalent to the concept of "output" in economic theory.

*Challenges:*

a. Livestock losses are not recorded as thoroughly as other losses such as human related loss or housing damage and destruction. Further involvement of authorized data sources for all hazardous events will increase the coverage and thus the reliability of the indicator.
b. Disaster loss databases don't record, with a few exceptions, the type of livestock damaged. Additional efforts to capture the number of livestock lost per type of livestock will be beneficial, but will introduce additional workload and complexity for data collection.
c. Collecting separately other physical damages, such as those to farm equipment could result in better measurements. However, introducing more sub-indicators may pose additional challenges of comparability and the possibility of consolidation.
d. Damage to livestock is also very dependent of the growth cycle of the livestock. Damage varies depending on how early or late in this cycle the disaster hits the livestock.

*Options suggested to be considered and discussed:*

Given the benefit and cost of collecting further data, the scope of livestock loss data collection should be decided by countries.

***Step 2: Apply average price per kilo and average weight per livestock to estimate economic value***

As in the case of agricultural crops the economic value of these animals has high variance in terms of price per kilo and number of kilos per animal, which in general determines its value.

In order to obtain and average price per kilo, if data is available, a weighted average could be used. Average price of livestock (i.e. price of one animal) to producer per kilo (Apkg) is

$$\textbf{Apkg} = \sum \left(\frac{Stock_i * Weight_i * Price_i}{Total\ Stock * Weight}\right)$$

Where:

$Stock_i$ is the headcount number of livestock type i (ex. 1 million cows)
$Weight_i$ is the average weight of livestock type i (ex. 350 kg per cow)
$Price_i$ is the producer price per kilo for meat of livestock type i (ex. 10 USD per kilo of beef)

If data is not available, it is suggested a simple average of producer price per kilogram (Apkg) be calculated.

The simple average can be calculated as

$$\textbf{Apkg} = (\sum \text{Price\_i})/n \qquad \textbf{i=1...n}$$

Where *Price_i* is the producer price per kilo for meat live weight of livestock type i

n is the number of livestock type in a country

Accuracy of the estimation can be greatly improved using an average weight, but it requires the existence of livestock data in the country. The average weight can also be calculated as a weighted average:

$$\textbf{Awkg} = \sum \left(\frac{Stock_i * Weight_i}{Total\ Stock}\right)$$

Where:

$Stocki$ is the headcount number of livestock type i in the country
$Weigh$ is the average weight of livestock type i
*Total Stock* is the total headcount number of all types of livestock n the county

Price and weight can also be potentially determined as the simple average, median or the mode of the prices and weights.

Therefore the final formula would look like:

**Loss on livestock = number of livestock lost * Awkg * Apkg**

***Challenge 1:***

a) Determining the price per kilo of meat of livestock is difficult given the lack of sources of information.

*Options suggested to be considered and discussed:*

**Option 1:** Countries report the number of livestock per type, average meat prices per kilogram and average livestock weight. It is expected that ministries of Agriculture will be able to supply the required statistical data for the Sendai Framework targets and indicators to enhance the quality and accuracy of the estimate.

**Option 2:** Utilize global data from **FAO statistics** (http://faostat.fao.org/). It is suggested to utilize this data only when data for most meat types are available. To calculate average price of meat using the 2011 FAO datasets, the following variable is used:

**Producer price per ton in USD per type of livestock**, which is defined as "Annual Producer Prices or prices received by farmers for live animals and livestock primary products as collected at the farm-gate or at the first point of sale." (FAO).

For GAR 2015, in order to obtain one unique value per country, the average producer price per ton has been calculated. For Bulgaria, the average price per ton is USD 2,215.35 with a maximum of USD 3,464.7/ton for sheep and USD 1,572.3/ton for Buffalo (FAO, 2011). An average price per ton in USD (at 2011 price) is obtained for 82 countries, ranging from USD 746/ton for Slovak Republic to USD 8,735.85/ton for

Japan.

The caveat is missing statistical data. Unfortunately, the FAO statistics coverage is not global, and in several countries is not complete, i.e. not exhaustive in terms of types of livestock.

**Option 3: Complementary methods for options 1 and 2:** There are, however, several countries for which these statistics are not available in national sources, nor in FAO. To extrapolate a proxy for the price of meat for such countries, UNISDR conducted a set of FAO data regressions against GDP per capita and produced proxy values which allow estimation of livestock loss.

Countries can be grouped by income groups from the World Bank income group classification (high income (OECD), high income (non-OECD), upper middle income, lower middle income and low income). The calculation for missing FAO data using calibration via GDP per capita plus income groups leads to results that go from USD 424/100 kg ($y = 0.0022x + 179.78$) for high income (OECD) countries to USD 73/100kg for low income countries ($y = 0.3439x - 4.5952$). The regression using the equations per income groups calibrated with GDP per capita gives an artificial price for all countries with missing FAO data.

***Challenge 2:***

The average weight per livestock is an extremely important element in the estimation of direct loss of livestock. However, the global data by country does not exist. There are several alternatives as follows:

*Options suggested to be considered and discussed:*

**Option 1**: Countries report the average weight per livestock. It is expected that ministries of Agriculture will be able to supply the required statistical data for the Sendai Framework targets and indicators.

**Option 2**: Utilize FAO data in countries where it is provided, and in those countries not covered by FAO statistics, use a world weighted average of weight based on other countries for which data is available.

**Option 3:** Use the GAR 2015 average size of **75 Kg per animal**. The weight is an expert criteria based on different factors.

***Challenge 3:***

How to assure proper comparison across time? The agriculture output will change in terms of volume and price due to different reason from disasters. Technical development will increase the output per unit. Price level change such as inflation will influence unit price. Technical development or other factors in agriculture

product market will also influence relative price of agriculture product higher or lower compared to other goods and services.

*Options suggested to be considered and discussed:*

**Option 1**: The relative unit price increase of agricultural goods in relation to other goods and services indicates the increased influence of agricultural loss on overall economy. Impact of general inflation will be considered in C1 if agreed so. Suggested to use nominal per unit price in each moment of time.

**Option 2**: Simply to observe affected volume trend, use the same unit price for all the moments from baseline period until 2030.

***Step3: Convert the value expressed in national currency into the one in USD and derive global loss value***

It is recommended to convert the value expressed in national currency into USD by using the official exchange rate at the year of event (Data source: Official exchange rate of the World Bank Development indicator).

Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).

## C3 - Direct economic loss due to industrial facilities damaged or destroyed by hazardous events

The methodology proposed here to evaluate damage to industrial facilities is also a broad simplification of the DALA/PDNA methodology which suggests that basic estimation would take into account the area of the affected premises, the construction cost per square meter and the estimated value of equipment and products (raw materials and finished product) stored in these premises. The data are usually reported by emergency management authorities and/or ministries of economy.

The general formula proposed is:

***Loss = Number of affected facilities * average size of the facilities * construction cost per square meter * affected ratio***

***Step 1: Collect good quality of data, ideally disaggregated, on physical damage***

The size of industrial and manufacturing facilities can have large variations in terms of construction cost. The ECLAC handbook suggests three typologies based on number of employees: large establishments employing 200 workers or more; medium-sized establishment employing between 199 and 40 workers; and small establishments employing 39 or fewer workers

Depending on availability of data countries can collect information on physical damage with increasing levels of detail. The minimum requirement would be to collect data on total number of affected industrial facilities (Option 1 below) and the maximum level of detail would be to collect separately the damage level and size category of facility (Option 4). There could be intermediate levels of data collection (Table):

**Option 1:** Total number of facilities damaged or destroyed is collected and reported. **(Minimum Requirement)**

**Option 2:** The number of facilities damaged and destroyed are collected and reported separately.

**Option 3:** The number of facilities damaged or destroyed is collected and reported by each category of size (i.e. number of large industrial facilities damaged/destroyed, number of medium facilities damaged/destroyed, number of small facilities damaged/destroyed).

**Option 4:** The number of facilities affected is collected reported separately by damaged or destroyed and by each category of size.

Table: Damage data collection and reporting options

| Size | Damaged | Destroyed | Affected (damaged or destroyed) |
|---|---|---|---|
| Small facilities | Option 4 | Option 4 | Option 3 |
| Medium facilities | Option 4 | Option 4 | Option 3 |
| Large facilities | Option 4 | Option 4 | Option 3 |
| Total number | Option 2 strongly recommended | Option 2 strongly recommended | Option 1 MINIMUM REQUIREMENT |

***Step 2: Apply replacement cost per unit to estimate economic value***

*Challenge 1*

UNISDR could not find the global data on the average size of industrial facility and construction cost per square meter. The country is recommended to report information on the average size of facility and construction cost per square meter, if possible, for each size category.

If the reporting of size and price information is not possible, several alternatives are suggested below. Each subsequent alternative involves more work and challenges in the data collection but provides a more accurate estimation of the losses.

*Options suggested to be considered and discussed*

**Option 1:** (MINIMUM REQUIREMENT) Total number of facilities damaged or destroyed is reported.

**C3a:** number of industrial facilities damaged or destroyed

***Loss = C3a * average size of the facilities * construction cost per square meter * affected ratio***

Where:
***average size of the facilities*** can be
- The average size of facilities in the country **(if reported by the country).**
- The **median** or **mode** of the sizes of facilities in the country. **(if reported by the country)**
- A fixed value defined on the design of a very small and conservative Industrial facility, for example 100 square meters

***construction cost per square meter*** *can be* :
- The average value of construction cost per square meter nationally **(if**

**reported by the country)**

- Application of the formula for housing construction cost per square meters.

***affected ratio***: calculated from the estimated percentage of damaged facilities out of total damaged/destroyed facilities. Assuming 20% of the industries reported are totally destroyed and the rest (80%) suffered some degree of damage (suggested to be estimated the same as in the housing sector, 25%), then the overall affected ratio would be the composite of 100% damage for 20% of premises plus 25% damage to 80% of premises, **40%**:

**Option 2:** The number of facilities damaged and destroyed are reported separately

**C3b:** number of industrial facilities damaged
**C3c:** number of industrial facilities destroyed

***Loss = C3b * average size of damaged facilities * construction cost per square meter * damage ratio***
***+ C3c * average size of destroyed facilities * construction cost per square meters***

where
***damage ratio***: The percentage of the total value of the premise that would represent the damage, suggested to be the same as in the housing sector, **25%**
**Average size of damaged facilities, construction cost per square meter**: Same method used as the option1.

**Note for damage ratio:** Ideally, damage ratio (0-100%) and size ($m^2$) of each facility affected is collected and reported separately.

In this case total damage would be estimated as:

$$C3=\sum (Size_i * Damage\,ratio_i * construction\,cost\,per\,square\,meters)$$

for Industries facilities affected i=1...n

**Option 3:** The total number of facilities damaged or destroyed is reported by each category of size (i.e. number of large industrial facilities damaged/destroyed, number of medium facilities damaged/destroyed, number of small facilities damaged/destroyed).

**C3d:** number of **Large** industrial facilities damaged or destroyed
**C3e:** number of **Medium** industrial facilities damaged or destroyed
**C3f:** number of **Small** industrial facilities damaged or destroyed

*Loss = **C3d** * average size of large facilities * construction cost per square meters * affected ratio*
*+ **C3e** * average size of medium facilities * construction cost per*

*square meters * affected ratio*

\+ ***C3f*** ** average size of small facilities * construction cost per square meters * affected ratio*

where
***Average size*** *is specified* for each size range.
***Construction cost per each size category*** (if reported by country). If not reported, apply the same value to all, based on the option 1 method.
***Affected ratio*** would be same as in Option 1.

**Option 4:** The total number of facilities damaged or destroyed is reported separately by each category of size:

**C3g:** number of **Large** industrial facilities damaged
**C3h:** number of **Medium** industrial facilities damaged
**C3i:** number of **Small** industrial facilities damaged
**C3j:** number of **large** industrial facilities *destroyed*
**C3k:** number of **Medium** industrial facilities *destroyed*
**C3l:** number of **Small** industrial facilities *destroyed*

*Loss =* ***C3g*** ** average size of large facilities* construction cost per square meter * damage ratio*

\+ ***C3h*** ** average size of medium facilities * construction cost per square meter * damage ratio*

\+ ***C3i*** ** average size of small facilities * construction cost per square meter * damage ratio*

\+ ***C3j*** ** average size of large facilities* construction cost per square meter*

\+ ***C3k*** ** average size of medium facilities * construction cost per square meter*

\+ ***C3l*** ** average size of small facilities* construction cost per square meter*

where
***Average size*** *is specified* for each size range.
***Construction cost per each size category*** (if reported by country). If not reported, apply the same value to all, based on the option 1 method.
***Damage ratio*** would be same as in Option 2.

More sophisticated approaches can be devised (for example using types of industries) that could make the estimation more accurate, **but would exponentially increase the burden of data collection in countries**. Methodologies that could be feasible only in developed, information-rich countries would not be recommended.

*Challenge 2:*

How to estimate the overhead of equipment and stored assets?

*Option suggested to be considered and discussed:*

As in the case of the Housing Sector (see Indicators C5 and C6) an additional loss has to be assigned corresponding to the value of equipment, associated urban infrastructure and products stored in premises. An **overhead of 25% is proposed to be used in the case of industrial facilities.**

*Challenge 3:*

How to assure proper comparison across time? The construction cost per square meter will change across time due to technical development and other market related factors (e.g. price increase of construction material in relation to other goods and services). Price level change such as inflation will also influence unit price.

*Options suggested to be considered and discussed:*

> **Option 1:** The relative unit price increase of construction cost in relation to other goods and services indicates the increased influence of industrial facility loss on overall economy. Impact of general inflation will be considered in C1 if agreed so. Suggested to use nominal per unit price in each moment of time.
>
> **Option 2:** Simply to observe affected volume trend, use the same unit price for all the moments from baseline period until 2030.

***Step3: Convert the value expressed in national currency into the one in USD and derive global loss value***

It is recommended to convert the value expressed in national currency into USD by using the official exchange rate at the year of event (Data source: Official exchange rate of the World Bank Development indicator).

Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).

## C4 - Direct economic loss due to commercial facilities damaged or destroyed by hazardous events

As with previous indicators, the methodology proposed for commercial facilities is also a broad simplification of the DALA/PDNA methodology, which suggests that basic estimation would take into account the area of the affected premises, the construction cost per square meter and the estimated value of equipment and products (raw materials and finished product) stored in these premises. The data are usually reported by emergency management authorities and/or ministries of economy or commerce.

The general formula proposed is:

***Loss = Number of affected facilities * average size of the facilities * construction cost per square meter * affected ratio***

***Step 1: Collect good quality of data, ideally disaggregated, on physical damage***

In this methodology the term "Commercial Facility" is defined as any building or real estate property that is used for business activities classified in ISIC Code G (wholesale and retail trade) (Rev.4). Commercial properties fall into many categories and include including department store, big shopping centres and malls, super market and individual small shops. It is suggested that when a shopping centre is affected it is reported as the sum of individual shops affected within a shopping centre.

While the size of *individual shops* has a relevant variation, the variance is not as high as the industrial facilities. Except for small number of department store and large supermarkets, the great majority of commercial establishments will fit a more or less uniform pattern in most countries. Therefore, compared to industrial facilities, there is less benefit to collect and report affected facilities by size category at global level.

Depending on the desired accuracy of the evaluations countries should collect and report the following possible data:

**Option 1:** (MINIMUM REQUIREMENT) Total number of facilities damaged or destroyed is reported.
**Option 2:** The number of facilities damaged and destroyed are reported separately
**Option 3:** Damage level and size of each facility affected is collected separately.

***Step 2: Apply replacement cost per unit to estimate economic value***

*Challenge 1: Construction cost estimate*

To estimate the economic value, it is necessary to have information on the average size of facilities and construction cost per square meter. UNISDR could not find the global data on the average size of facility and construction cost per square meters. The country needs to collect and report the information on the size of commercial facilities (average or ideally,

affected) and construction cost per square meter (average). It is expected that ministries of Economy will be able to supply the required statistical data for the Sendai Framework targets and indicators.

If this is not possible the option is to simply apply construction cost per square meter for housing using formula explained in Annex for each of the options below. There are several alternatives which require different levels of work. The more detailed assessment is possible, however, it means more workload for data collection in Step1.

It is estimated that average size of commercial facilities would be 25 square meters (the design of a very small and conservative commercial facility, comprising as one sales area of 4x4 m2 plus storage and miscellaneous usage (washroom, administrative) area of 3x3 m2).

To account for the associated urban infrastructure, equipment and product stored in the commercial facility it is proposed to add the same overhead as applied for industrial facilities to this basic cost of 25%. Adding this element raises average size of establishment to 35 square meters.

*Options suggested to be considered and discussed*

**Option 1:** Total number of commercial facilities damaged or destroyed is reported. (MINIMUM REQUIREMENT)

**C4a** - Number of commercial facilities damaged or destroyed by hazardous events

*Loss =* ***C4a*** ** average size of facilities * construction cost per square meter * affected_ratio*

Where:

***Average size of the facilities*** can be

- The average size of facilities in the country **(if reported by the country).**
- The **median** (middle value in the data set) or **mode** (the value most often observed in the data set) of the sizes of facilities in the country. **(if reported by the country)**
- A fixed value defined on the design of a very small and conservative commercial facility, for example 35 square meters, see above.

***Construction cost per square meter*** *can be* :

- The average value of construction cost per square meter nationally **(if reported by the country)**
- Application of the formula for housing construction cost per square meter.

***Affected ratio***: calculated from the estimated percentage of damaged facilities out of total damaged/destroyed facilities. Assuming 20% of the industries reported are totally destroyed and the rest (80%) suffered some degree of damage (suggested to be estimated the same as in the housing sector, 25%), then the overall affected ratio would be the composite of 100% damage for 20% of premises plus 25% damage to 80% of premises, **40%**:

**Option 2:** The number of facilities damaged and destroyed are reported separately
C4b - Number of commercial facilities damaged by hazardous events
C4c - Number of commercial facilities destroyed by hazardous events

The economic loss would be calculated as:

*Loss = **C4b** * average size of damaged facilities * construction cost per square metre * damage ratio*
*+ **C4c** * average size of destroyed facilities * construction cost per square meter*

where
***Damage ratio***: The percentage of the total value of the premise that would represent the damage, suggested to be the same as in the housing sector, **25%**
**Average size of damaged facilities, construction cost per square meter**: Same method used as the option1.

**Note for damage ratio:** Ideally, damage ratio (0-100%) and size ($m^2$) of each facility affected is collected and reported separately.

In this case total damage would be estimated as:

$$C4=\sum (Size_i * Damage\,ratio_i * construction\,cost\,per\,square\,meters)$$

for commercial facilities affected i=1...n

*Challenge 2:*

How to estimate the overhead of equipment and stored assets?

*Option suggested to be considered and discussed:*

As in the case of the Housing Sector (see Indicators C5 and C6) an additional loss has to be assigned corresponding to the value of equipment, products stored in premises and associated urban infrastructure. An **overhead of 25% is proposed to be used for commercial facilities.**

*Challenge 3:*

How to assure proper comparison across time? The construction cost per square meter will change across time due to technical development and other market related factors (e.g. price increase of construction material in relation to other goods and services). Price level change such as inflation will also influence unit price.

*Options suggested to be considered and discussed:*

**Option 1:** The relative unit price increase of construction cost in relation to other goods and services indicates the increased influence of commercial facility loss on overall economy. Impact of general inflation will be considered in C1 if agreed so. Suggested to use nominal per unit price in each moment of time.

**Option 2:** Simply to observe affected volume trend, use the same unit price for all the moments from baseline period until 2030.

***Step3: Convert the value expressed in national currency into the one in USD and derive global loss value***

It is recommended to convert the value expressed in national currency into USD by using the official exchange rate at the year of event (Data source: Official exchange rate of the World Bank Development indicator).

Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).

## C5 - Direct economic loss due to houses damaged by hazardous events

## C6 - Direct economic loss due to houses destroyed by hazardous events

The methodology proposed here to evaluate damage to the housing is a broad simplification of the DALA/PDNA methodology which suggests that basic economic loss estimation would take into account the sizes of houses, the value of construction cost per square meter and the estimated value of equipment and associated urban infrastructure.

It is proposed to estimate direct economic loss of housing damaged and destroyed using the following formula:

**C5 = number of houses damaged * average size of damaged facilities * construction cost per square metre * damage ratio**

**where**

damage ratio is 25%. Following suggestions in the DALA/PDNA methodologies the average losses of partially damaged houses is evaluated as 25% of the loss of a completely destroyed house.

**C6 = number of houses destroyed * average size of destroyed facilities * construction cost per square meter**

***Step 1: Collect good quality of data, ideally disaggregated, on physical damage***

*Challenge*

Given the benefit and cost of collecting further data, the scope of loss data collection should be decided by countries.

*Options suggested to be considered and discussed:*

**Option 1:** Total number of houses damaged and destroyed collected separately (MINIMUM REQUIREMENT). However, housing can have large variations in terms of the size and structure and therefore construction cost though not being as large as industrial and commercial facilities.

**Option 2:** Total number of houses damaged and destroyed collected separately and disaggregated by other criteria such as urban/rural, income level, type of construction structure or other characteristics, when this criteria is relevant for the estimation of the loss.

Disaggregated data, for example housing loss by structural type would provide basis for building vulnerability assessment and evidence for strengthening enforcement of building codes or retrofitting policy. Disaggregated data collection could make the estimation more accurate and more usable for policy making, but countries need to be aware it would exponentially increase the burden of data collection.

***Step 2: Apply replacement cost per unit to estimate economic value***

*Challenge1*

Determining the construction cost per square meter and size of housing affected is extremely difficult given the lack of sources of information and the diversity of housing structure from concrete to wooden barrack.

*Options suggested to be considered and discussed:*

**Option 1 (highly recommended)**: Countries report the necessary two variables (i.e. construction cost per square meter, average size of housing in the country). If the disaggregated data is collected, a weighted average of house size in the country taking into account distribution of each size segment (income, structural type or range of size) and the average size of the houses on each segment would increase the reliability of the indicator and would solve to a large extent the issue of choosing a fixed house size. If it is difficult to obtain price information from private market, construction cost of social housing might provide a useful benchmark. It is expected that ministries of housing will be able to supply the required statistical data for the Sendai Framework targets and indicators to enhance accuracy of the estimate.

**Option 2:** When the housing construction cost per square meter is missing, it is suggested to utilize global data sources regarding unit cost information. After a review of different sources, we recommend to use "Global Construction Cost and Reference Yearbook 2012" from *Compass International* to determine the construction cost per square meter. However, unfortunately the COMPASS statistics coverage is not global, and in several countries is not complete, i.e. not exhaustive in terms of types of constructions.

To extrapolate a proxy for the unit cost for countries for which no information is available, the following formula is proposed, as explained in the Annex in more detail.

$$1m^2 = 304 + 0.0118 * \text{GDP per capita}.$$

**Option3:** When the average size is not reported, based on GAR methodology, it is suggested to apply a small 'social housing solution' and its associated equipment and urban infrastructure (furniture, water network, power, communications, etc.) as estimation methodology.

The concept of a "Social Interest Housing solution "has been used in many types of risk assessments (CIMNE, 2013). It is inspired by the fact that in many cases the state, acting as ultimate insurer of losses especially for the poorest segments of the population, tends to provide homogeneously small housing solutions and/or compensation packages.

The concept and size of social housing varies by country. But for the purpose of a homogeneous estimation across countries it is proposed the **size of a social housing to be set to 45 square meters** – i.e. a very small housing solution.

In order to assess the value of the equipment of the house and the additional urban infrastructure associated to loss of houses (such as connection to road networks, water, sewage, green areas, energy and communications infrastructure that usually results damaged in disasters), an additional **40%** is proposed to be added to the 45 square meters (CIMNE, 2012), raising the estimated average size of housing to the equivalent of **63 square meters**.

*Challenge 2:*

How to assure proper comparison across time? The construction cost per square meter will change across time due to technical development and other market related factors (e.g. price increase of construction material in relation to other goods and services). Price level change such as inflation will also influence unit price.

*Options suggested to be considered and discussed:*

**Option 1:** The relative unit price increase of construction cost in relation to other goods and services indicates the increased influence of housing loss on overall economy. Impact of general inflation will be considered in C1 if agreed so. Suggested to use nominal per unit price in each moment of time.

**Option2:** Simply to observe affected volume trend, use the same unit price for all the moments from baseline period until 2030.

***Step3: Convert the value expressed in national currency into the one in USD and derive global loss value***

It is recommended to convert the value expressed in national currency into USD by using the official exchange rate at the year of event (Data source: Official exchange rate of the World Bank Development indicator).

Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).

## C7 – Direct economic loss due to damage to critical infrastructure/public infrastructure caused by hazardous events, to be calculated based on the following indicators D2 to D4.

Proposed indicator C7 is suggested to be calculated based on the indicators D2, D3 and D4 (road only).

**C7 = the sum of the direct economic loss estimated for indicators D2 to D4 (road only)**

### D2 - Number of health facilities destroyed or damaged by hazardous events

The general formula proposed is:

***Loss = Number of affected facilities * average size of the facilities * construction cost per square meter * affected ratio***

***Step 1: Collect good quality of data, ideally disaggregated, on physical damage***

*Challenge*

Health facilities range from small clinics, rural health posts and doctor's offices to urgent care centres and large hospitals with advanced emergency rooms and trauma centres. The size of these facilities and replacement costs are varied more than housing sector.

*Options suggested to be considered and discussed.*

Additional effort can be invested in collecting disaggregated data per size/type of health facility damaged on each hazardous event. Several categories can be established (regional (large) hospital, local (medium) hospital, health centre, clinic, etc.), with typical sizes and economic replacement values. While disaggregated data collection could make the estimation more accurate, **countries need to be aware it would exponentially increase the burden of data collection, which may not justify the additional accuracy of the indicator**.

Depending on availability of data countries can collect information on physical damage with increasing levels of detail (See table below). The minimum requirement would be to collect data on total number of affected health facilities (Option 1 below) and the maximum level of detail would be to collect separately by damaged/destroyed and per size category (Option 4). There could be intermediate levels of data collection:

**Option 1:** Total number of health facilities damaged or destroyed is collected and reported. (MINIMUM REQUIREMENT)

**Option 2:** The number of health facilities damaged and destroyed are collected and reported separately

**Option 3:** The total number of facilities affected (damaged or destroyed) is collected and reported by each category of size (i.e. number of large health facilities damaged/destroyed, number of medium facilities damaged/destroyed, number of

small facilities damaged/destroyed)
**Option 4:** The total number of facilities affected is reported separately by damaged or destroyed and by each category of size

Table: Physical damage data collection and reporting options

| Size | Damaged | Destroyed | Affected (damaged or destroyed) |
|---|---|---|---|
| Small health facilities | Option 4 | Option 4 | Option 3 |
| Medium health facilities | Option 4 | Option 4 | Option 3 |
| Large health facilities | Option 4 | Option 4 | Option 3 |
| **Total number** | Option 2 strongly recommended | Option 2 Strongly recommended | Option 1 **MINIMUM REQUIREMENT** |

***Step 2: Apply replacement cost per unit to estimate economic value***

The DALA/PDNA methodology suggests that the value of the physical damage to the buildings of health facilities can be calculated based on the size of the premise (area), the construction cost per square meter and an overhead to estimate the value of losses in equipment in the premises.

*Challenge1:*

It is necessary to have information on the average size of facilities and construction cost per square meter. UNISDR could not find the global data on the average size of facility and construction cost per square meter. The country needs to report the information on the size of facilities and construction cost per square meter, if possible, for each size category. The easier option is to simply apply construction cost per square meter for housing using formula explained in Indicators C6 and Annex for each of the options below. There are several alternatives which requires different level of work. The more detailed assessment is possible however it means more workload for data collection.

*Options suggested to be considered and discussed:*

**Option 1 (highly recommended):** Countries collect and report the two variables (average size of facilities and construction cost per square meter). It is expected that ministries of Health will be able to supply the required statistical data for the Sendai Framework targets and indicators. If not possible, countries are recommended to consider the options below.

**Option 2:** When construction cost per square meter is missing, it is suggested to utilize housing formula as explained in the Annex in more detail.

$1m^2$=304 + 0.0118*GDP per capita.

**Option3:** <u>When the average size (existing or affected) is not reported</u>, based on GAR methodology, it is suggested to apply a small conservative minimum unit scenario and its associated equipment and urban infrastructure (e.g. connection to water network, power, communications). The idea behind this is that in the developing world health facilities are often small and very inexpensive (GAR 2013). UNISDR recognizes values of minimal size used in the GAR will not likely to apply for developed countries where these facilities tend to be much larger.

**Size of minimum unit** is characterized as a small outpatient clinic consisting of a waiting room of 3x4 meters (12 $m^2$), a consulting room of 3x4 meters (12 $m^2$), an operating/first aid section of 5x4 meters (20 $m^2$), with a medicine depot and maintenance area (4 $m^2$), for a total of 48 $m^2$.

In order to assess the value of the equipment of the facility and the additional urban infrastructure associated to loss of facilities (e.g. connection to road networks, water, sewage, green areas, energy and communications infrastructure that usually results damaged in disasters), an additional 25% is proposed to be added to the 45 square meters (CIMNE, 2012), raising the estimated average size of facility to the equivalent of **60 square meters**.

*<u>Summary</u>*

Depending on the options taken in Step 1 and 2 above, the following options can be suggested:

**Option 1:** (MINIMUM REQUIREMENT) Total number of health facilities damaged or destroyed is reported.

**D2a** number of health facilities damaged or destroyed

*Loss =* ***D2a*** ** average size * construction cost per square meter * affected ratio*

Where:

***average size of the facilities*** can be

- The average size of facilities in the country **(if reported by the country).**
- The **median** (middle value in the data set) or **mode** (the value most often observed in the data set) of the sizes of facilities in the country. **(if reported by the country)**
- A fixed value defined on the design of a very small and conservative Industrial facility, for example 60 square meters

***construction cost per square meter*** *can be:*

- The average value of construction cost per square meter nationally **(if reported by the country)**
- Application of the formula for housing construction cost per square meters.

***affected ratio***: calculated from the estimated percentage of damaged facilities out of total damaged/destroyed facilities. Assuming 20% of the industries reported are totally destroyed and the rest (80%) suffered some degree of damage (suggested to be estimated the same as in the housing sector, 25%), then the overall affected ratio would be the composite of 100% damage for 20% of premises plus 25% damage to 80% of premises, **40%**:

**Option 2:** The number of health facilities damaged and destroyed is reported separately.

**D2b** number of health facilities damaged
**D2c** number of health facilities destroyed

*Loss =* ***D2b*** ** average size of damaged facilities * construction cost per square meter * damage ratio*
*+* ***D2c*** ** average size of destroyed facilities * construction cost per square meter*

where
***damage ratio***: The percentage of the total value of the premise that would represent the damage, suggested to be the same as in the housing sector, **25%**
**Average size of damaged facilities, construction cost per square meter**: Same method used as the option1.

**Note for damage ratio:** Ideally, damage ratio (0...100%) and size ($m^2$) of each facility affected is collected and reported separately.

In this case total damage would be estimated as:

$$D2=\sum (Size_i * Damage\,ratio_i * Construction\ cost\ per\ square\ meters)$$

for health facilities affected i=1...n

**Option 3:** The total number of health facilities damaged or destroyed is reported by each category of size (i.e. number of large health facilities damaged/destroyed, number of medium facilities damaged/destroyed, number of small facilities damaged/destroyed).

**D2d** number of **Large** health facilities damaged or destroyed
**D2e** number of **Medium** health facilities damaged or destroyed
**D2f** number of **Small** health facilities damaged or destroyed

*Loss =* ***D2d*** ** average size of large facilities* construction cost per square meter * affected ratio*
*+* ***D2e*** ** average size of medium facilities * construction cost per square meter * affected ratio*
*+* ***D2f*** ** average size of small facilities * construction cost per*

*square meter * affected ratio*

where
***Average size** is specified* for each size range.
***Affected ratio*** would be same as in Option 1.
***Construction cost per each size category*** (if reported by country). If not reported, apply the same value to all, based on the option 1 method.

**Option 4:** The total number of health facilities damaged or destroyed is reported separately by each category of size.

**D2g** number of **Large** health facilities damaged
**D2h** number of **Medium** health facilities damaged
**D2i** number of **Small** health facilities damaged
**D2j** number of **Large** health facilities *destroyed*
**D2k** number of **Medium** health facilities *destroyed*
**D2l** number of **Small** health facilities *destroyed*

*Loss =* ***D2g*** ** average size of large facilities damaged * construction cost per square meter * damage ratio*
+ ***D2h*** ** average size of medium facilities damaged* construction cost per square meter * damage ratio*
+ ***D2i*** ** average size of small facilities damaged * construction cost per square meter * damage ratio*
+ ***D2j*** ** average size of large facilities destroyed* construction cost per square meter*
+ ***D2k*** ** average size of medium facilities destroyed * construction cost per square meter*
+ ***D2l*** ** average size of small facilities damaged * construction cost per square meter*

where
***Average size** is specified* for each size range.
***Damage ratio*** would be same as in Option 2.
***Construction cost per each size category*** (if reported by country). If not reported, apply the same value to all, based on the option 1 method.

It is clear that more sophisticated approaches can be devised (for example using types of health facility) that could make the estimation more accurate, **but would exponentially increase the burden of data collection in countries**. Methodologies that could be feasible only in developed, information-rich countries would not be recommended.

*Challenge 2:*

How to estimate the overhead of equipment and stored assets?

*Option suggested to be considered and discussed:*

As in the case of the Housing Sector (see Indicators C5 and C6) an additional loss has to be assigned corresponding to the value of equipment, stocks in premises and associated urban infrastructure. While the overhead of equipment and stock would be larger in health facilities than in housings, given the lack of information, **the same overhead of 25% is proposed to be used for health facilities.**

*Challenge 3:*

How to assure proper comparison across time? The construction cost per square meter will change across time due to technical development and other market related factors (e.g. price increase of construction material in relation to other goods and services). Price level change such as inflation will also influence unit price.

*Options suggested to be considered and discussed:*

**Option 1:** The relative unit price increase of construction cost in relation to other goods and services indicates the increased influence of industrial facility loss on overall economy. Impact of general inflation will be considered in C1 if agreed so. Suggested to use nominal per unit price in each moment of time.

**Option 2:** Simply to observe affected volume trend, use the same unit price for all the moments from baseline period until 2030.

***Step3: Convert the value expressed in national currency into the one in USD and derive global loss value***

It is recommended to convert the value expressed in national currency into USD by using the official exchange rate at the year of event (Data source: Official exchange rate of the World Bank Development indicator).

Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).

### D3 - Number of educational facilities destroyed or damaged by hazardous events

The general formula proposed is:

***Loss = Number of affected facilities * average size of the facilities * construction cost per square meter * affected ratio***

***Step 1: Collect good quality of data, ideally disaggregated, on physical damage***

*Challenge:*

Schools range from small rural schools to large universities with similar variances as seen in the health sector, therefore these facilities have a much higher variance than houses in size and therefore in economic value.

Depending on availability of data countries can collect information on physical damage with increasing levels of detail. The minimum requirement would be to collect data on total number of affected educational facilities (Option 1 below) and the maximum level of detail would be to collect separately the damage level and size category of facility affected (Option 4).

For the purposes of the data collection it is proposed to consider three categories of sizes:

- Small schools (up to 100 students), similar to rural schools and other small education and training facilities.
- Medium schools (100-700 students), similar to urban elementary or secondary schools
- Large educational compounds like university campuses.

*Options suggested to be considered and discussed:*

While disaggregated data collection could make the estimation more accurate, **countries need to be aware it would exponentially increase the burden of data collection**.

There could be several options for data collection (see table below):

**Option 1:** Total number of education facilities damaged or destroyed is reported. (MINIMUM REQUIREMENT)

**Option 2:** The number of education facilities damaged and destroyed are reported separately

**Option 3:** The total number of facilities affected (damaged or destroyed) is reported by each category of size (i.e. number of large education facilities damaged/destroyed, number of medium facilities damaged/destroyed, number of small facilities damaged/destroyed)

**Option 4:** The total number of facilities affected is reported separately by damaged or destroyed and by each category of size

Table: Damage data collection and reporting options

| Size | Damaged | Destroyed | Affected (damaged or destroyed) |
|---|---|---|---|
| Small education facilities | Option 4 | Option 4 | Option 3 |
| Medium education facilities | Option 4 | Option 4 | Option 3 |
| Large education facilities | Option 4 | Option 4 | Option 3 |

| **Total number** | Option 2 strongly recommended | Option 2 strongly recommended | Option 1 **MINIMUM REQUIREMENT** |
|---|---|---|---|

***Step 2: Apply replacement cost per unit to estimate economic value***

The DALA/PDNA methodology suggests that the value of the physical damage to the buildings of education facilities can be calculated based on the size of the premise (area), the price per square meter of construction and an overhead to estimate the value of losses in equipment in the premises.

*Challenge1:*

It is necessary to have information on the average size of facilities and construction cost per square meter. UNISDR could not find the global data on the average size of facility and construction cost per square meter. The country needs to report the information on the average size of facilities and construction cost per square meter, if possible, for each size category. The easier option is to simply apply construction cost per square meter for housing using formula explained in Annex for each of the options below. There are several alternatives which requires different level of work. The more detailed assessment is possible however it means more workload for data collection.

*Options suggested to be considered and discussed:*

**Option 1 (highly recommended):** Countries collect and report the two variables (average size of facilities and construction cost per square meters) from countries. It is expected that ministries of Education will be able to supply the required statistical data for the Sendai Framework targets and indicators. If not possible, countries are recommended to consider the options below.

**Option 2:** When the construction cost per square metre is missing, it is suggested to utilize housing formula as explained in the Annex in more detail.

$$1m^2=304 + 0.0118*\text{GDP per capita}.$$

**Option3:** When the average size (existing or affected) is not reported, based on GAR methodology, it is suggested to apply a small conservative minimum unit scenario and its associated equipment and urban infrastructure (furniture, water network, power, communications, etc.). The idea behind this is that in the developing world school facilities tend to be small and inexpensive (GAR 2013). UNISDR recognizes values of minimal size used in the GAR will not likely apply for developed countries where these facilities tend to be much larger.

In order to assess the value of the equipment of the facility and the additional urban infrastructure associated to loss of facilities (e.g. connection to road networks, water,

sewage, green areas, energy and communications infrastructure that usually results damaged in disasters), an additional 25% is proposed to be added to the 60 square meters (CIMNE, 2012), raising the estimated average size of facility to the equivalent of **75 square meters**.

*Summary*

Depending on the options taken in Step 1 and 2 above, the following options can be suggested:

**Option 1:** (MINIMUM REQUIREMENT) Total number of educational facilities damaged or destroyed is reported.

**D3a** number of educational facilities damaged or destroyed

*Loss = **D3a** * average size * construction cost per square meter * affected ratio*

Where:
***average size of the facilities*** can be
- The average size of facilities in the country **(if reported by the country).**
- The **median** (middle value in the data set) or **mode** (the value most often observed in the data set) of the sizes of facilities in the country. **(if reported by the country)**
- A fixed value defined on the design of a very small and conservative educational facility, for example 75 square meters

***construction cost per square meter*** *can be:*
- The average value of construction cost per square meter nationally **(if reported by the country)**
- Application of the formula for housing construction cost per square meters.

***affected ratio***: calculated from the estimated percentage of damaged facilities out of total damaged/destroyed facilities. Assuming 20% of the industries reported are totally destroyed and the rest (80%) suffered some degree of damage (suggested to be estimated the same as in the housing sector, 25%), then the overall affected ratio would be the composite of 100% damage for 20% of premises plus 25% damage to 80% of premises, **40%**:

**Option 2:** The number of educational facilities damaged and destroyed are reported separately.

**D3b** number of educational facilities damaged
**D3c** number of educational facilities destroyed

*Loss = **D3b** * average size of damaged facilities * construction cost per square meter * damage ratio*
*+ **D3c** * average size of destroyed facilities * construction cost per square meter*

where

***damage ratio***: is the percentage of the total value of the premise that would represent the damage, suggested to be the same as in the housing sector, **25%**
**Average size of damaged facilities, construction cost per square meter**: Same method used as the option1.

**Note for damage ratio:** Ideally, damage ratio (0...100%) and size ($m^2$) of each facility affected is collected and reported separately.

In this case total damage would be estimated as:

$$D2= \sum (Size_i * Damage\,ratio_i * construction\ cost\ per\ square\ meters)$$

for educational facilities affected i=1...n

**Option 3:** The total number of educational facilities damaged or destroyed is reported by each category of size (i.e. number of large educational facilities damaged/destroyed, number of medium facilities, number of small facilities)

**D3d** number of **Large** educational facilities damaged or destroyed
**D3e** number of **Medium** educational facilities damaged or destroyed
**D3f** number of **Small** educational facilities damaged or destroyed

*Loss =* ***D3d*** ** average size of large facilities* construction cost per square meter * affected ratio*
+ ***D3e*** ** average size of medium facilities * construction cost per square meter * affected ratio*
+ ***D3f*** ** average size of small facilities * construction cost per square meter * affected ratio*

where
***Average size*** *is specified* for each size range.
***Affected ratio*** would be same as in Option 1.
***Construction cost per each size category*** (if reported by country). If not reported, apply the same value to all, based on the option 1 method.

**Option 4:** The total number of educational facilities damaged or destroyed is reported separately by each category of size:

**D3g** number of **Large** educational facilities damaged
**D3h** number of **Medium** educational facilities damaged
**D3i** number of **Small** educational facilities damaged
**D3j** number of **Large** educational facilities *destroyed*
**D3k** number of **Medium** educational facilities destroyed
**D3l** number of **Small** educational facilities *destroyed*

*Loss = **D3g** * average size of large facilities damaged * construction cost per square meter * damage ratio*

+ ***D3h** * average size of medium facilities damaged* construction cost per square meter * damage ratio*
+ ***D3i** * average size of small facilities damaged * construction cost per square meter * damage ratio*
+ ***D3j** * average size of large facilities destroyed* construction cost per square meter*
+ ***D3k** * average size of medium facilities destroyed * construction cost per square meter*
+ ***D3l** * average size of small facilities damaged * construction cost per square meter*

where
***Average size** is specified* for each size range.
***Damage ratio*** would be same as in Option 2.
***Construction cost per each size category*** (if reported by country). If not reported, apply the same value to all, based on the option 1 method.

It is clear that more sophisticated approaches can be devised (for example using types of educational facility) that could make the estimation more accurate, **but would exponentially increase the burden of data collection in countries**. Methodologies that could be feasible only in developed, information-rich countries would not be recommended.

*Challenge 2:*

How to estimate the overhead of equipment and stored assets?

*Option suggested to be considered and discussed:*

As in the case of the Housing Sector (see Indicators C5 and C6) an additional loss has to be assigned corresponding to the value of equipment, stocks in premises and associated urban infrastructure. While the overhead of equipment and stock would be smaller in educational facilities than in housings, given the lack of information, **the same overhead of 25% is proposed to be used for educational facilities.**

*Challenge 3:*

How to assure proper comparison across time? The construction cost per square meter will change across time due to technical development and other market related factors (e.g. price increase of construction material in relation to other goods and services). Price level change such as inflation will also influence unit price.

*Options suggested to be considered and discussed:*

**Option 1:** The relative unit price increase of construction cost in relation to other goods and

services indicates the increased influence of industrial facility loss on overall economy. Impact of general inflation will be considered in C1 if agreed so. Suggested to use nominal per unit price in each moment of time.

**Option 2:** Simply to observe affected volume trend, use the same unit price for all the moments from baseline period until 2030.

***Step3: Convert the value expressed in national currency into the one in USD and derive global loss value***

It is recommended to convert the value expressed in national currency into USD by using the official exchange rate at the year of event (Data source: Official exchange rate of the World Bank Development indicator).

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### D4 - Number of transportation infrastructures (roads) destroyed or damaged by hazardous events

The general formula proposed for loss in roads is:

**Loss on roads= Number of kilometres affected * average rehabilitation cost per kilometre**

***Step 1: Collect good quality of data, ideally disaggregated, on physical damage***

For the economic cost estimation of transportation infrastructures damaged, the current UNISDR methodology has proposed to use the following sub-indicator only due to limited data availability for several other transport infrastructures:

D4a Number of kilometres of road destroyed or damaged per hazardous event. (MINIMUM REQUIREMENT)

It is recommended to collect only length of roads affected. Other road infrastructure such as bridges are not taken into account due to complexity of cost estimation. UNISDR recognizes roads are the most universal basic transportation infrastructure while railways, ports and airports might have global variance in terms of the importance and presence in different countries.

Additional effort can be invested in collecting disaggregated data per type of road affected on each hazardous event. Several categories can be established (Highway, main paved road, paved road, unpaved).

***Step 2: Apply replacement cost per unit to estimate economic value***

The DALA/PDNA methodology suggests that the value of the physical damage can be calculated based on the size of the damage and the construction cost per unit.

*Challenge:*

Determining the construction cost per kilometre is extremely difficult.

*Options suggested to be considered and discussed:*

**Option 1:** Countries report the average construction cost per kilometre for paved and unpaved roads, and if possible, other related information. It is expected that ministries of Infrastructure or Transport will be able to supply the data for the Sendai Framework targets and indicators.

Though UNISDR recognizes classifying roads in paved and unpaved may be too simplistic in countries where the road network is very developed, it is assumed to be the minimum cost information.

**Option 2:** It is suggested to utilize global data from the ROad Costs Knowledge System (ROCKS) developed by the Transport Unit (TUDTR) of the World Bank (accessible at http://www.worldbank.org/transport/roads/tools.htm). The ROCKS Worldwide Database compiles data collected primarily from World Bank financed projects and has more than 1,500 records from 65 developing countries. ROCKS compiles cost estimates for maintenance work (renovation, rehabilitation and improvement of existing roads) and for development work (construction of new roads). Roads are categorized as paved and unpaved.

The cost of road rehabilitation is proposed to be a proxy for replacement cost, as most of the work on roads after disasters must be considered as rehabilitation, despite in some cases a full reconstruction of the roads have to be undertaken. Rehabilitation cost is more conservative than development cost.

In order to reflect the significant cost difference in cost between paved and unpaved roads (Table below), UNISDR proposes to assume that distribution of road damage on each category would roughly follow the same pattern as the national distribution of roads. It is recommended to use the latest year data published by the World Bank for the percentage of the road network of the country that are paved ("paved ratio" in the formulas below), reported on annual basis (see http://data.worldbank.org/indicator/IS.ROD.PAVE.ZS). The distribution of paved and unpaved roads does not change significantly over the years, and does not justify the additional complexity in the calculation by updating the data annually.

Table Road related costs (global average costs per km, expressed in the USD of year 2002)

| PAVED Roads | UNPAVED Roads |
|---|---|
| Seals USD 20,000 /km | Regravelling USD 11,000/km |
| Functional Overlays USD 56,000 /km | Improvement USD 72,000/km |
| Structural Overlays USD 146,000 /km | |
| Rehabilitation USD 214,000 /km | Rehabilitation USD 31,000 /km |
| Construction USD 866,000 /km | Paving USD 254,000/km |

Source: World Bank, ROCKS database

The caveat of ROCKS is missing statistical data: Unfortunately the data coverage is not global. However, ROCKS summarizes the data by World Bank regions. While the averages per region are slightly different, the number of records per region per type of work is not statistically representative enough in certain regions with very few projects; therefore UNISDR proposes to use global averages instead of the regional averages instead of the regional average of rehabilitation costs.

The current formula to estimate direct cost of damage using replacement cost is:

Loss on roads=((rehabilitation cost paved per Km*paved ratio)+
(rehabilitation cost unpaved per Km*(1-paved ratio))* Kilometres affected

*Challenge 2:*

How to assure proper comparison across time? The construction cost per kilometre will change across time due to technical development and other market related factors (e.g. price increase of construction material in relation to other goods and services). Price level change such as inflation will also influence unit price.

*Options suggested to be considered and discussed:*

**Option 1:** The relative unit price increase of construction cost in relation to other goods and services indicates the increased influence of road loss on overall economy. Impact of general inflation will be considered in C1 if agreed so. Suggested to use nominal per unit price in each moment of time.

To adjust inflation factor, the ROCKS are expressed in 2002 US dollars. UNISDR assumes that relative price of construction materials and other elements for road construction remains stable from the simplicity reason under the current data limitation.

**Option 2:** Simply to observe affected volume trend, use the same unit price for all the moments from baseline period until 2030.

***Step3: Convert the value expressed in national currency into the one in USD and derive global loss value***

It is recommended to convert the value expressed in national currency into USD by using the official exchange rate at the year of event (Data source: Official exchange rate of the World Bank Development indicator).

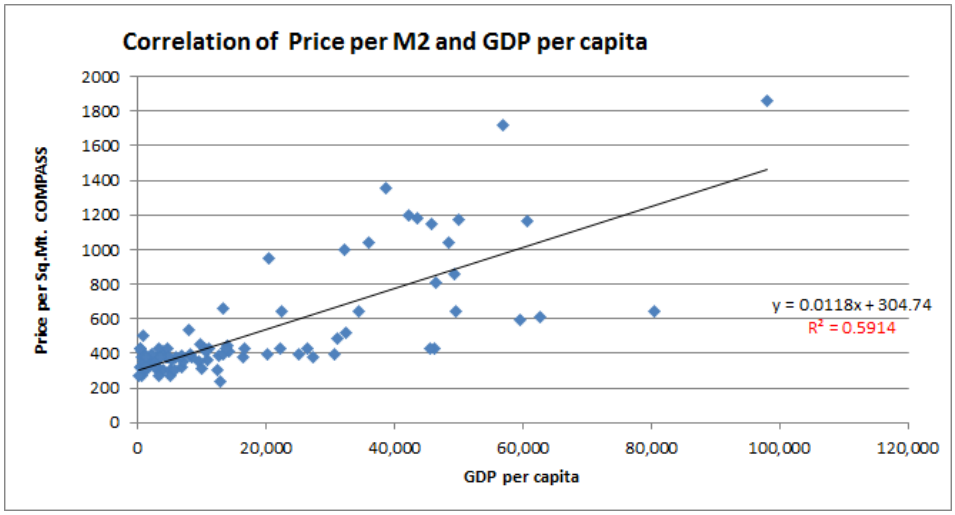
Official exchange rate refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).

## ANNEX I: Method to derive a national proxy construction cost per square meter for all sectors in case no cost information is reported by countries

Especially for countries that are likely to face difficulty reporting construction cost for each type of sector, UNISDR and scientific partners devised a methodology aimed to obtain a ***national*** **proxy construction cost per square meter** that could be used *as approximation* to be applied for each of these sectors that the cost information is missing.

The method is based on data analysis of global housing construction cost database "Global Construction Cost and Reference Yearbook 2012" (Compass International, 2012).[4] The housing construction cost per square meter for more than 90 countries in Compass and GDP per capita showed a moderate but sufficiently high correlation factor (about 60%). (See Figure below)

Figure: Correlation between housing construction cost per square meter and GDP per capita




The statistical regression produced the following formula to assess the construction cost per square meter in the 85 countries of the GAR sample:

**Construction cost per square meter = 304 + 0.0118*GDP per capita.**

This formula is suggested to be applied to all facilities in case construction cost for each sector cannot be obtained.

[4] This is the only source that contains multiple country information with a documented and consistent methodology. This publication is used worldwide by consulting engineering firms to estimate initial budgets of construction projects.

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