

# 2014 KiA Project: Methodology and Results

Nova

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# KIA Adaptation Framework

The Intergovernmental Panel on Climate Change (IPCC) predicts that during the next decades, billions of people, particularly those in developing countries, will face changes in rainfall patterns that will contribute to severe water shortages or flooding, and rising temperatures. This will increase food shortages and distribution of disease vectors, putting populations at greater health and life risks. This probable change in climate threatens to reverse the progress made so far in the fight against hunger and malnutrition and necessitates climate change adaptation. Climate change adaptation refers to changes in processes, practices and structures to moderate potential damages from climate change, or to benefit from opportunities associated with such changes.

Adaptation to climate change is not only a matter of changing current management practices, changing varieties or crops, or changing cropping zones under a particular future scenario. Adaptation to climate change starts from building resilient systems under present conditions. Climate change adaptation for agricultural cropping systems requires greater resilience to both surplus water (due to high intensity rainfall) and scarcity of water (due to prolonged dry periods) (FAO, 2007). To strengthen the resilience of these rain-fed production systems, adaptation methods focused on increased water infiltration, soil moisture retention, water collection would be necessary.

The most effective adaptation approaches in developing countries, as highlighted in UN Framework Convention on Climate Change (UNFCCC) meetings, are those that address a combination of environmental stresses and factors. Strategies, policies and programmes that are most likely to succeed need to link with coordinated efforts aimed at alleviating poverty, enhancing food security and water availability, combating land degradation and soil erosion, reducing loss of biological diversity and ecosystem services as well as improving adaptive capacity and improving the food production chain within the framework of sustainable development.

The Kia adaptation project was implemented in 2015 and 2015. Households selected the fruit tree to plant in their home. The households were trained on how to dig a hole, fertilize, prune and mulch. The Kia adaptation project main goal is strengthening resilience, reducing vulnerability, enhancing adaptive capacity and mainstreaming of climate change concerns into policies. The results can enhance our understanding of what works and what does not work, why, and under what circumstances, central to the learning process, as well as in guiding future adaptation efforts.

## Definitions

**Adaptive capacity** - The set of strengths, attributes and resources available to households and communities to deal with and respond to shocks and variability, with focus on longer-term and sustained adjustments

**climate change** - A variation in climate that is attributed directly or indirectly to human activity and which alters the composition of the global atmosphere (e.g. through increased carbon dioxide, nitrous oxides and methane), adding to the natural climate variability observed over long and comparable periods of time

**Food security** - Defined as existing when “all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”, depends on both food availability and food affordability.

**Resilience** - The ability of a system and its component parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration or improvement of its essential basic structures and functions

**Vulnerability** - The propensity or predisposition of someone or something to be adversely affected

Table 1: Kia adaptation indicator metric.

Input	Activity	Output	Outcome	Outcome.1	Impact
Capital	Distributing trees	Fruit trees	Fruits	Food security	Reduced vulnerability
			Shade	Cohesive society	Strengthened resilience
	Training	Training completed	Sustainable agricultural practices	Increased agricultural productivity	Enhanced adaptive capacity

# 1 Adaptation Indicators

## 1.1 Input Indicators

Input indicators seeks to measure the inputs of the project. This includes the number of households that ordered the trees and the number of trees distributed.

### 1.1.1 I.A.1.1: Number of households that ordered trees

#### **Kia adapt goal**

Strengthen resilience, reduce vulnerability and enhance adaptive capacity

#### **Sustainable development goal**

##### *1 No poverty*

Target 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters.

##### *2 Zero hunger*

Target 2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

Target 2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

##### *13 Climate action*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries”, “Producing, strengthening and distributing Assets

#### **Objective**

Producing, strengthening and distributing Assets

#### **Rationale**

This indicator measure the number of households that ordered trees. This is important to assess whether the project met demand of fruit trees in the community.

#### **Definitions**

#### **Baseline**

#### **Quality control**

### 1.1.2 I.A.1.2: The number of trees distributed

#### **Kia adapt goal**

Strengthen resilience, reduce vulnerability and enhance adaptive capacity

#### **Sustainable development goal**

##### *1 No poverty*

Target 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters.

## *2 Zero hunger*

Target 2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

Target 2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

## *13 Climate action*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries”, “Producing, strengthening and distributing Assets

### **Objective**

Producing, strengthening and distributing Assets

### **Rationale**

This indicator measure the number of trees distributed to the households. This can include number of trees distributed per village. Number of trees per species. Number of trees per household.

### **Definitions**

### **Baseline**

### **Quality control**

## 1.2 Output Indicators

Outcome type indicators seek to measure the outcomes of the project. These indicators include the number of fruit trees that distributed and the number of trees still alive in the monitoring year.

### 1.2.1 I.A.2.1: Number of trees received.

#### **Kia adapt goal**

Strengthen resilience, reduce vulnerability and enhance adaptive capacity

#### **Sustainable development goal**

##### *1 No poverty*

Target 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters.

##### *2 Zero hunger*

Target 2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

Target 2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

##### *13 Climate action*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries”, “Producing, strengthening and distributing Assets

#### **Objective**

Producing, strengthening and distributing Assets

#### **Rationale**

This indicator measure the number of trees distributed to the households. Measuring the number of trees at the beginning of the project is important in understating the overall success of the project.

#### **Definitions**

The term ‘assets’ refers to the fruits tree. The term ‘produced’ assumes the fruit trees were not there at the start of the intervention.

#### **Baseline**

#### **Quality control**

### 1.2.2 I.A.2.2: Number of trees alive in the monitoring year

#### **Kia adapt goal**

Strengthen resilience, reduce vulnerability and enhance adaptive capacity

#### **Sustainable development goal**

##### *1 No poverty*



Target 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters.

## *2 Zero hunger*

Target 2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

Target 2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

## *13 Climate action*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries”, “Producing, strengthening and distributing Assets

### **Objective**

Producing, strengthening and distributing Assets

### **Rationale**

This indicator assess the extent to which this project interventions has reached its objective to respond to climate change variability through distributing asset.

### **Definitions**

The term ‘assets’ refers to fruits tree the households received.

### **Baseline**

### **Quality control**

## 1.3 Outcome Indicators

The outcome indicators seeks to measure the outcome of the project. Outcome indicators are divided into three categories, resilience indicators, vulnerability indicators and adaptive capacity indicators.

### 1.3.1 Enhancing adaptive capacity

The adaptive capacity indicators seek to describe the modification in behaviors that enhance the people's ability to adapt to the changing climate. The lack of skills and sustainable practices in rural areas limits the adaptive capacity. The beneficiaries were trained in sustainable practices to enhance their adaptive capacity. Indicators like number of beneficiaries that received training and the percentage of the beneficiaries that practice the skill are used to measure the adaptive capacity.

#### 1.3.1.1 I.A.3.1.1: Number of household that use mulching Kia adapt goal

Enhance adaptive capacity

##### Sustainable development goal

*13 Climate action*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries", "Producing, strengthening and distributing Assets

Target 13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning

*15 Protect, restore and promote sustainable use of terrestrial ecosystems, sustain-ably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss*

Target 15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world

##### Objective

Households adopt environmentally sustainable agriculture practices

##### Rationale

Sustainable management practices are less harmful to the environment and cost effective. The benefits include increase productivity.

##### Definitions

Sustainable practice support ecological, human, and economic health and vitality.

##### Baseline

The baseline is set at 0.

##### Quality control

#### 1.3.1.2 I.A.3.1.2: Total number of households that attained at least one skill Kia adapt goal

Enhance adaptive capacity

##### Sustainable development goal

*13 Climate action*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries", "Producing, strengthening and distributing Assets

Target 13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning

*15 Protect, restore and promote sustainable use of terrestrial ecosystems, sustain-ably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss*

Target 15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world

**Objective**

Increase in number of households with skills

**Rationale**

This indicator determines whether the projects training skills has been retained

**Definitions**

**Baseline**

**Quality control**

### 1.3.2 Reducing vulnerability indicators

Vulnerability\_type indicators seeks to describe propensity or predisposition of someone or something to be adversely affected by climate change. In low-income settlements limited or lack of resources make household to be vulnerable to climate. This include lack of nutritious food all year round and stable income. The indicators in this category includes number of trees that bear fruits, number of months in a year where households have fruits, number of square metres of increased shade, percentage of households using shade and the percentage of households selling fruits.

#### 1.3.2.1 I.A.3.2.1: Total number of trees that bore fruits in the recent season. Kia adapt goal

Reduce vulnerability

##### Sustainable development goal

###### 1 No poverty

Target 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters.

###### 2 Zero hunger

Target 2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

Target 2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

###### 13 Climate action

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries”, “Producing, strengthening and distributing Assets

##### Objective

Increased ownership of productive assets

##### Rationale

This indicator measures the number of trees that bore fruits in the previous season. Although a tree can provide other benefits, the most important benefit is its ability to bear fruits.

##### Definitions

Productive means the ability of the tree to bear fruits

##### Baseline

The baseline is set at 0.

##### Quality control

#### 1.3.2.2 I.A.3.2.2: Total number of fruit bearing months Kia adapt goal

Reduce vulnerability

##### Sustainable development goal

###### 1 No poverty

Target 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters.

## *2 Zero hunger*

Target 2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

Target 2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

## *13 Climate action*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries”, “Producing, strengthening and distributing Assets

### **Objective**

Improve food security of rural households

### **Rationale**

This indicator measures the number of months the households have fruits in a year. This is important to ensure that they have nutrition needed all year round.

### **Definitions**

Food security is defined as existing when “all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life”, depends on both food availability and food affordability

### **Baseline**

The baseline is set at 0.

### **Quality control**

#### **1.3.2.3 I.A.3.2.3: Total area (m<sup>2</sup>) shade Kia adapt goal**

Reduce vulnerability

### **Sustainable development goal**

## *13 Climate action*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries”, “Producing, strengthening and distributing Assets

### **Objective**

Protecting households from extreme temperatures

### **Rationale**

This indicator measures the square metre of the shade of the fruit trees. Shade plays an important role in maintaining soil moisture due to cooler temperatures and protection from sunlight

### **Definitions**

Shade is comparative darkness or obscurity owing to interception of the rays of light by the fruit trees.

### **Baseline**

The baseline is set at 0.

## Quality control

### 1.3.2.4 I.A.3.2.4: Total area (m<sup>2</sup>) usable shade Kia adapt goal

Reduce vulnerability

#### Sustainable development goal

##### *13 Climate action*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries”, “Producing, strengthening and distributing Assets

#### Objective

Support low income households to become less vulnerable

#### Rationale

This indicator measures the total area of usable shade. Increasing temperatures and frequent heat waves affect people in rural areas.

#### Definitions

Heat wave is a period of abnormally hot weather generally lasting more than two days

#### Baseline

The baseline is set at 0.

## Quality control

### 1.3.2.5 I.A.3.2.4: Number of households selling fruits Kia adapt goal

Reduce vulnerability

#### Sustainable development goal

##### *1 No poverty*

Target 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters.

##### *2 Zero hunger*

Target 2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

Target 2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

##### *13 Climate action*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries”, “Producing, strengthening and distributing Assets

#### Objective

Increase income or avoid reduced income

#### Rationale

This indicator measures the number of households selling fruits. This indicator will not calculate the exact value obtained from selling fruit or the money saved from households as they no longer buy fruits.

**Definitions**

Selling is the activity of making products and services available so that people buy them.

**Baseline**

The baseline is set at 0.

**Quality control**

### 1.3.3 Strengthening resilience indicators

Resilience-type indicators generally seek to describe characteristics or attributes that affect people's or systems' propensity to cope with or be harmed by shocks and stresses. Limited number of people with resources and division in the society has been identified as an aspects that display low resilience, as well as areas that are considered a priority for resilience building. The ability to share fruits is recognized as households' and communities' strengths that can be leveraged to reinforce and build resilience. The indicators are number of beneficiary supported, which measures number of people with resources and percentage of households sharing fruits which measures the cohesiveness of the society.

#### 1.3.3.1 I.A.3.3.1: Number of beneficiaries supported. Kia adapt goal

Strengthen resilience

##### Sustainable development goal

###### 1 No poverty

Target 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters.

###### 2 Zero hunger

Target 2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

Target 2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

###### 13 Climate action

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries", "Producing, strengthening and distributing Assets

##### Objective

Support low income households to become climate resilient

##### Rationale

This indicator seeks to measure the number of people who have received an input of fruits tree from the project as a proxy for strengthening resilience to respond to the impact of climate change. It does not seek to measure the output of whether the fruit tree is still alive and bearing fruits or dead or alive but not bearing fruits or the impact of reducing their vulnerability to climate change.

##### Definitions

A fruit tree is a woody plant that produces edible fruits.

##### Baseline

The baseline is set at 0, since no people were supported by the Kia project before the implementation.

##### Quality control

#### 1.3.3.2 I.A.3.3.2: Number of households sharing fruits Kia adapt goal

Strengthen resilience

##### Sustainable development goal



### *1 No poverty*

Target 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social, and environmental shocks and disasters.

### *2 Zero hunger*

Target 2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round

Target 2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons

### *13 Climate action*

Target 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries”, “Producing, strengthening and distributing Assets

#### **Objective**

Ensure cohesive society

#### **Rationale**

This indicator measures degree of how cohesive the society is. cohesion is important because cohesive societies tend to respond well to climatic stress

#### **Definitions**

social cohesion is the strength of relationships and the sense of solidarity among members of a community

#### **Baseline**

The baseline is set at 0.

#### **Quality control**

## **1.4 Impact Indicator**

### **1.4.1 I.A.4: Combined Adaptation Indicator**

Two or more indicators were developed to measure each of the three subgoals from the KiA Adaptation goal. The three subgoals are:

- Strengthen resilience
- Reduce vulnerability
- Enhance adaptive capacity

The combined adaptation indicator aggregates these individual indicators to give a single impact indicator.

## **2 Mitigation Indicator**

### **2.1 I.M: Total carbon stock**

#### **Definitions**

Climate change mitigation involves actions to reduce or prevent greenhouse gas emissions from human activities.

## 3 Calculation method

### 3.1 Adaptation Indicators

#### 3.1.1 Input indicators

##### *I.A.1.1 Number of households that ordered trees*

Absolute numbers will be used. The number of households that ordered trees will be counted from project records.

##### *I.A.1.2 The number of trees distributed*

Absolute numbers will be used. The number of trees that households ordered will be counted from project records.

#### 3.1.2 Output indicators

The following formulas will be used to estimate  $t = \sum_{h=1}^H t_h$  the overall population total for each of the output and outcome indicators.

$\hat{t}_{str}$  is the estimated indicator value and is used to estimate  $t$  the population indicator value.

$\hat{t}_{str}$  is calculated as:

$$\hat{t}_{str} = \sum_{h=1}^H \sum_{j \in S} \frac{N_h}{n_h} y_{hj} = \sum_{h=1}^H \sum_{j \in S} w_{hj} y_{hj}$$

An unbiased estimator for the variance of  $\hat{t}_{str}$  is calculated as:

$$\hat{V}(\hat{t}_{str}) = \sum_{h=1}^H \left(1 - \frac{n_h}{N_h}\right) N_h^2 \frac{s_h^2}{n_h}$$

The standard error of  $\hat{t}_{str}$  is the square root of the estimated variance  $SE(\hat{t}_{str}) = \sqrt{\hat{V}(\hat{t}_{str})}$

The lower and upper limits for a large sample  $100(1 - \alpha)\%$  confidence interval for  $t_{str}$  is given by

$$LL = \hat{t}_{str} - z_{\frac{\alpha}{2}} \times SE(\hat{t}_{str})$$

$$UL = \hat{t}_{str} + z_{\frac{\alpha}{2}} \times SE(\hat{t}_{str})$$

The precision associated with an estimate is  $(estimate - LL) = (UL - estimate) = 0.5 \times (UL - LL)$ . The relative precision is the precision expressed relative to the estimate.

$$relprec = \frac{\frac{1}{2}(UL - LL)}{\hat{t}_{str}}$$

Where

- $H$  is the number of strata
- $N_h$  is the number of population households in stratum  $h$
- $S_h$  is the set of households from stratum  $h$  included in the sample
- $n_h$  is the number of sampled households in stratum  $h$

- $(1 - \frac{n_h}{N_h})$  is the finite population correction for stratum  $h$
- $y_{hj}$  is the indicator value for household  $j$  in stratum  $h$ . The definition of  $y_{hj}$  for each of the output and outcome indicators are given in Tables ?? and ??.
- $w_{hj} = \frac{N_h}{n_h}$  is the sampling weight for household  $j$  in stratum  $h$
- $s_h^2$  is the sample variance in stratum  $h$
- $z_{\frac{\alpha}{2}}$  is the  $(1 - \frac{\alpha}{2})$ th percentile of the standard normal distribution

### Description of the output indicators

code	abbreviation	definition.y_hj
I.A.2.1	trees.nr	number of trees bought and planted by household $j$ in stratum $h$
I.A.2.2	skill	number of trees at household $j$ in stratum $h$ that are alive in the monitoring year

### 3.1.3 Outcome indicators

The same formulas that were given in Section 3.1.2 are used to estimate  $t = \sum_{h=1}^H t_h$  the overall population total for each of the outcome indicators listed below.

### Description of the outcome indicators

code	abbreviation	definition.y_hj
I.A.3.1.1	mulch	1 if household $j$ in stratum $h$ practise mulching, 0 if household $j$ in stratum $h$ do not practise mulching
I.A.3.1.2	skill	1 if household $j$ in stratum $h$ attained at least one skill from the project, 0 if household $j$ in stratum $h$ did attain any skill from the project
I.A.3.2.1	fruit.total	The number of trees from household $j$ in stratum $h$ that bore fruit in the past season.
I.A.3.2.2	fruit.months	The number of months in the past season that household $j$ in stratum $h$ had fruit from one or more trees
I.A.3.2.3	shade.total	The total area ( $m^2$ ) shade from the trees for household $j$ in stratum $h$
I.A.3.2.4	shade.use	The total area ( $m^2$ ) shade from trees utilized by household $j$ in stratum $h$
I.A.3.2.5	fruit.sell	1 if household $j$ in stratum $h$ sell fruit from the trees, 0 if household $j$ in stratum $h$ do not sell fruit from the trees
I.A.3.3.1	beneficiaries.nr	The number of people from household $j$ in stratum $h$ who benefit from the trees.
I.A.3.3.2	fruit.share	1 if household $j$ in stratum $h$ share fruit, 0 if household $j$ in stratum $h$ do not sell fruit

### 3.1.4 Impact Indicator

The calculation of the *Combined adaptation indicator* comprise of five steps:

#### Step 1

Choose the contribution of each of the KiA subgoals to the composite adaptation indicator to reflect the relative importance of each subgoal within the KiA adaptation environment.

$$\sum_{i=1}^3 c_i = 1 \quad i = 1 \dots 3$$

Where

$c_i$  is the contribution of subgoal  $i$  to the composite adaptation indicator.

## Step 2

Within each subgoal, give weights to the individual indicators to reflect the relative importance of the indicator within the subgoal environment.

$$\sum_{j=1}^{n_i} u_{ij} = 1 \quad i = 1 \dots 3 \quad j = 1 \dots n_j$$

$$\sum_{j=1}^{n_i} w_i u_{ij} = c_i$$

Where

- $u_{ij}$  is the weight for indicator  $j$  within subgoal  $i$ .
- $c_i$  is the contribution of subgoal  $i$  to the composite adaptation indicator
- $w_i$  is the weight for subgoal  $i$

With  $c_i$  and  $u_{ij}$  specified, the subgoal weights can be calculated:

$$w_i = \frac{c_i}{\sum_{j=1}^{n_i} u_{ij}} \quad j = 1 \dots n_j$$

Table 4: Weights for indicators within subgoals

subgoal	contribution(ci)	code	abbreviation	weight(uij)
Strengthen resilience	0.2	I.A.3.1.1	mulch	1.0
	0.2	I.A.3.1.2	skill	1.0
Reduce vulnerability	0.4	I.A.3.2.1	fruit.total	1.0
	0.4	I.A.3.2.2	fruit.months	1.0
	0.4	I.A.3.2.3	shade.total	0.2
	0.4	I.A.3.2.4	shade.use	0.8
	0.4	I.A.3.2.5	fruit.sell	1.0
Enhance adaptive capacity	0.4	I.A.3.3.1	beneficiaries.nr	0.2
	0.4	I.A.3.3.2	fruit.share	1.0

Table 5: Subgoal contribution and subgoal weights

subgoal	contribution(ci)	weight(wi)
Strengthen resilience	0.2	0.1000
Reduce vulnerability	0.4	0.1000
Enhance adaptive capacity	0.4	0.3333

## Step 3

Specify the ideal outcome for each indicator in terms of the number of households that took part in the project or the number of trees that was originally distributed.

$$pop.ideal_i = ideal.coef.ficient_i \times pop.nr$$

Where

- $pop.ideal_i$  is the ideal outcome for the  $i^{th}$  indicator given the project population
- $pop.nr$  is either the number of households that took part in the project, or the number of trees that were originally distributed by the project and is determined by whether the indicator is defined in terms of the number of households or the number of trees.
- $ideal.coefficient_i$  is the fraction of the population number to achieve the ideal outcome

Table 6: Ideal numbers

subgoal	code	abbreviation	pop.parm	ideal.coefficient
Strengthen resilience	I.A.3.1.1	mulch	total.hh	0.50
	I.A.3.1.2	skill	total.hh	0.90
Reduce vulnerability	I.A.3.2.1	fruit.total	total.tree	0.70
	I.A.3.2.2	fruit.months	total.hh	4.00
	I.A.3.2.3	shade.total	total.tree	4.95
	I.A.3.2.4	shade.use	total.tree	0.99
	I.A.3.2.5	fruit.sell	total.hh	0.10
Enhance adaptive capacity	I.A.3.3.1	beneficiaries.nr	total.hh	3.40
	I.A.3.3.2	fruit.share	total.hh	0.60

<sup>a</sup> the ideal coefficient for shade.total is calculated as  $0.7*(\pi)*(0.5*1.5)*(0.5*1.5)$

<sup>b</sup> the ideal coefficient for shade.use is 0.2 times the ideal coefficient for shade.total

<sup>c</sup> the ideal coefficient for beneficiaries.nr is  $0.85*4$

### Explanation of the ideal coefficients

abbreviation	pop.parm	ideal.coefficient	explanation
mulch	total.hh	0.5	50% of population households make use of mulching.
skill	total.hh	0.9	90% of the population households attained at least one skill from the project.
fruit.total	total.tree	0.7	70% of the trees originally distributed under the project bore fruit in the recent season.
fruit.months	total.hh	4	on average every population household has fruit available for 4 months of the year from at least one of the project trees.
shade.total	total.tree	4.95	70% of the trees originally distributed under the project have a shade of at least 7.07 metres squared, that is equivalent to a round shade with a radius of 1.5 metres.
shade.use	total.tree	0.99	20% of the total shade from the project trees are used by the project households.
fruit.sell	total.hh	0.1	10% of the population households sell fruit from the project trees either informally or at the local market.
beneficiaries.nr	total.hh	4	85% of the population households with an average of 4 people per household benefit in some other way from the project trees.
fruit.share	total.hh	0.6	60% of the population households share fruit from the project trees with family, friends, neighbours and the community.

### Step 4

For each indicator, calculate the ratio of the estimate of the indicator from the sample to the ideal value of the estimator. The composite adaptation indicator is then calculated as:

$$AdaptationIndicator = \sum_i^3 \sum_j^{n_j} u_{ij} w_i \frac{\hat{t}_{str(ij)}}{pop.ideal_{ij}}$$

Where

- $w_i$  is the weight for subgoal  $i$
- $u_{ij}$  is the weight for indicator  $j$  within subgoal  $i$ .
- $\hat{t}_{str(ij)}$  is the estimated population value for the  $j^{th}$  indicator of subgoal  $i$ . These values were calculated in Section 3 for the individual outcome indicators.

- *pop.ideal* is the ideal value for the  $j^{th}$  indicator of subgoal  $i$ .

NOTE: The Adaptation Indicator if the ideal has been reached for all the indicators is 1:

$$AdaptationIndicator = \sum_i^3 \sum_j^{n_j} u_{ij} w_i \frac{pop.ideal_{ij}}{pop.ideal_{ij}} = \sum_i^3 \sum_j^{n_j} u_{ij} w_i = 1$$

### Step 5

Calculate the project credits:

$$Credits = AdaptationIndicator \times Number.households$$

## 3.2 Mitigation Indicator

*I.M Total carbon stock*

A/R Small-scale Methodology: **Afforestation and reforestation project activities implemented on lands other than wetlands (AR-AMS0007)** together with the approved methodological tools are used to estimate the GHG removal from the project implementation.

Equation 4 (AR-TOOL14-Appendix 1) is used to estimate tree biomass:

$$B_{TREE,l,j,h,t} = f_j(x_{1,l}, x_{2,l}, x_{3,l}, \dots) * (1 + R_j)$$

Where

- $B_{TREE,l,j,t}$  Biomass of tree  $l$  of species  $j$  in household  $h$ , (in t d.m. (tonne dry matter))
- $f_j(x_{1,l}, x_{2,l}, x_{3,l}, \dots)$  Above-ground biomass of the tree returned by the allometric equation for species  $j$  relating the measurements of tree  $l$  to the above-ground biomass of the tree; (in t d.m.)
- $R_j$  Root-shoot ratio for tree species  $j$ ; (dimensionless)

Default allometric equation used for estimating above-ground biomass (AR-AMS0004 - Appendix B) :

$$AGB = \exp\{-1.996 + 2.32 \ln(DBH)\}$$

Where

- AGB is the biomass per fruit tree (in td.m.)
- DBH is the diameter at breast height (in cm)
- The value of  $R_j$  is estimated as:

$$R_j = \frac{e^{-1.085+0.9256 \ln(b)}}{b}$$

Equation 12 (AR-TOOL14) is used to estimate the total carbon stock:

$$C_{TREE} = \frac{44}{12} * C_{FTREE} * B_{TREE}$$

Where

- $C_{TREE}$  Carbon stock in trees in the tree biomass estimation household; (in  $tCO_2e$  (tonne  $CO_2$  equivalent))
- $CF_{TREE}$  Carbon fraction of tree biomass; (in  $tC (td.m.)^{-1}$  (tonne carbon per tonne dry matter)). A default value of 0.47 is used.
- $B_{TREE}$  Tree biomass in the tree biomass estimation household; (in  $td.m$ ).  
Estimation of total  $CO_2e$  sequestered by the trees is calculated using the equations in Section 3.1.2.

## 4 Results

### 4.1 Adaptation Indicators

#### 4.1.1 Input indicators

##### *I.A.1.1 Number of households that ordered trees*

Table 8 gives the number of households that took part in the 2015 project. These households were approached during the first survey.

Table 8: Number of households per village that took part in the 2015 project

village	number of households
Berlyn	12
Bonn	36
Mafarana	26
Mafarana_2	46
Mulati	50
Ntsako	31
Sedan	48
Total	249

Table 9 gives the number of households per village that ordered trees during the 2014 tree planting project. These households were sampled during the second survey.

Table 9: Number of households per village that took part in the 2014 project

village	number of households
Berlyn	44
Bonn	58
Mafarana	58
Mafarana 2	95
Mulati	50
Ntsako	47
Sedan	86
Total	438



### I.A.1.2 The number of trees distributed

Table 10 gives the number of trees per species that were ordered during the 2015 tree planting project. These households were approached during the first survey.

Table 10: The number of trees originally distributed per village and per species for the 2015 project

village	Avo	Grapefruit	Guava	Kid_Mango	Litchi	Macadamia	Mandarin	Mango	Naartjie	Orange	Total
Berlyn	5	1	0	0	5	0	0	1	4	1	17
Bonn	13	14	0	0	21	3	1	2	14	6	74
Mafarana	11	0	0	0	15	2	1	4	10	6	49
Mafarana_2	10	0	0	0	26	2	1	6	21	3	69
Mulati	14	3	1	4	40	1	0	11	14	7	95
Ntsako	17	1	0	0	21	1	0	4	15	2	61
Sedan	15	9	0	0	27	4	1	4	18	5	83
Total	85	28	1	4	155	13	4	32	96	30	448

Table 11 gives the number of trees per species that were ordered during the 2014 tree planting project. These households were sampled during the second survey.

Table 11: The number of trees originally distributed per village and per species for the 2014 project

village	Avo	Banana	Grapefruit	Litchi	Macadamia	Mandarin	Mango	Naartjie	Orange	Total
Berlyn	13	3	0	31	0	0	7	15	3	72
Bonn	17	0	0	55	0	4	4	33	5	118
Mafarana	21	1	2	49	2	4	4	21	5	109
Mafarana 2	36	0	1	93	0	2	1	53	8	194
Mulati	21	1	2	41	2	15	8	20	6	116
Ntsako	7	1	0	43	0	17	4	11	7	90
Sedan	38	3	0	67	0	1	3	58	17	187
Total	153	9	5	379	4	43	31	211	51	886

## 4.1.2 Output indicators

### I.A.2.1 Number of trees received

Table 12 is the summary statistics per survey for the number of trees received. This is followed by Table 13 that gives the estimated number of trees received for the relevant project period.

Table 12: Summary statistics for the number of trees bought and planted

indicator	stratum	N	n	weight	sum_str	t_hat	sd
tree_nr	S1	249	194	1.3	355	455.6	1.1
	S2	438	132	3.3	227	753.2	0.9

Table 13: Inference for the number of trees the number of trees bought and planted

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
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tree_nr	687	326	1208.87	30.07	1.96	1149.93	1267.81	58.94	4.88
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#### I.A.2.2 Number of trees alive in the monitoring year

Table 14 is the summary statistics per survey for the number of trees alive in the monitoring year. This is followed by Table 15 that gives the estimated number of trees that are alive in the monitoring year.

Table 14: Summary statistics for the number of trees alive in the monitoring year

indicator	stratum	N	n	weight	sum_str	t_hat	sd
tree_alive_nr	S1	249	194	1.3	211	270.8	1.1
	S2	438	132	3.3	127	421.4	1.0

Table 15: Estimated number of trees alive in the monitoring year

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
tree_alive_nr	687	326	692.23	34.25	1.96	625.1	759.36	67.13	9.7

### 4.1.3 Outcome indicators

#### I.A.3.1.1 Number of household that use mulching

Table 16 is the summary statistics per survey for the number of households that use mulching. This is followed by Table 17 that gives the estimated number of households that use mulching.

Table 16: Summary statistics for the number of households that continue to use mulching to retain soil moisture

indicator	stratum	N	n	weight	sum_str	t_hat	sd
tree_mulching	S1	249	194	1.3	52	66.7	0.4
	S2	438	132	3.3	4	13.3	0.2

Table 17: Estimated number of households that continue to use mulching to retain soil moisture

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
tree_mulching	687	326	80.02	6.63	1.96	67.02	93.01	12.99	16.24

#### I.A.3.1.2 Total number of households that attained at least one skill

The summary statistics for the number of households that attained at least one skill is given in Table 18 and the estimated number of households that attained at least one skill is given in Table 19.

Table 18: Summary statistics for the number of households that learned at least one skill as a result from the project

indicator	stratum	N	n	weight	sum_str	t_hat	sd
skill	S1	249	194	1.3	175	224.6	0.3
	S2	438	132	3.3	97	321.9	0.4

Table 19: Estimated number of households that learned at least one skill as a result from the project

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
skill	687	326	546.48	14.34	1.96	518.37	574.58	28.1	5.14

#### I.A.3.2.1 Total number of trees that bore fruits in the recent season

Table 20 is the summary statistics per survey for the number of trees that bore fruit in the recent season. This is followed by Table 21 that gives the estimated number of trees that bore fruit in the recent season.

Table 20: Summary statistics for the number of trees that bore fruit in the most recent season

indicator	stratum	N	n	weight	sum_str	t_hat	sd
fruit.nr	S1	249	194	1.3	184	236.2	1.0
	S2	438	132	3.3	95	315.2	0.9

Table 21: Estimated number of of trees that bore fruit in the most recent season

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
fruit.nr	687	326	551.39	29.73	1.96	493.12	609.66	58.27	10.57

#### I.A.3.2.2 Total number of fruit bearing months

See Table 22

A summary per survey for the total number of fruit bearing months is shown in Table 22 and Table 23 gives the estimated number of fruit bearing months.

Table 22: Summary statistics for the number of fruit bearing months in the most recent season

indicator	stratum	N	n	weight	sum_str	t_hat	sd
n.fruit.month	S1	249	194	1.3	276	354.2	1.3
	S2	438	132	3.3	181	600.6	1.5

Table 23: Estimated number of fruit bearing months in the most recent season

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
n.fruit.month	687	326	954.84	50.36	1.96	856.13	1053.54	98.7	10.34

#### I.A.3.2.3 Total area ( $m^2$ ) shade

Table 24 is the summary statistics per survey for the total area ( $m^2$ ) shade. This is followed by Table 25 that gives the estimated total area ( $m^2$ ) shade.

Since the shade measurements were wrongly measured during the first two days of the first survey, the shade measurement were recorded as NA for these households.

Table 24: Summary statistics for the total area shade ( $m^2$ )

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indicator	stratum	N	n	weight	sum_str	t_hat	sd
shade.total	S1	249	194	1.3	1534.8	1969.9	10.6
	S2	438	132	3.3	1179.4	3913.6	12.9

Table 25: Estimated total area shade ( $m^2$ )

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
shade.total	687	326	5883.53	421.43	1.96	5057.53	6709.54	826	14.04

#### I.A.3.2.4 Total area ( $m^2$ ) usable shade

Table 26 is the summary statistics per survey for the total area ( $m^2$ ) usable shade and Table 27 shows the estimated total area ( $m^2$ ) usable shade.

Since the shade measurements were wrongly measured during the first two days of the first survey, the shade measurement were recorded as NA for these households.

Table 26: Summary statistics for the total area shade ( $m^2$ ) used

indicator	stratum	N	n	weight	sum_str	t_hat	sd
shade.use	S1	249	194	1.3	201.4	258.5	3.6
	S2	438	132	3.3	388.1	1287.9	9.0

Table 27: Estimated total area shade used ( $m^2$ )

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
n.fruit.month	687	326	954.84	50.36	1.96	856.13	1053.54	98.7	10.34

#### I.A.3.2.5 Number of households selling fruits

The summary statistics for the number of households that sell fruit are given in Table 28 and the estimated number of households that sell fruit is given in Table 29.

Table 28: Summary statistics for the number of households that sell fruit informally or on the local market

indicator	stratum	N	n	weight	sum_str	t_hat	sd
fruit.sell	S1	249	194	1.3	2	2.6	0.1
	S2	438	132	3.3	0	0.0	0.0

Table 29: Estimated number of households that sell fruit informally or on the local market

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
fruit.sell	687	326	2.57	0.85	1.96	0.9	4.23	1.67	64.86

#### I.A.3.3.1 Number of beneficiaries supported

Table 30 gives the summary statistics for the number of people per survey and per age group that benefit

from the trees, whereas Table 31 gives the summary statistics per survey and sex group and Table 32 is the summary statistics per survey for the total number of people that benefit from the trees.

The estimated total number of people that benefit from the trees is given in Table 33.

Table 30: Summary statistics for the number of people within age group that benefit from tree/s

indicator	stratum	agegroup	N	n	weight	sum_str	t_hat	sd
count.benefit	S1	age(0,2)	249	194	1.3	11	14.1	0.3
	S1	age[2,18)	249	194	1.3	175	224.6	1.3
	S1	age[18,65)	249	194	1.3	222	284.9	1.3
	S1	age65+	249	194	1.3	81	104.0	0.6
	S2	age(0,2)	438	132	3.3	1	3.3	0.1
	S2	age[2,18)	438	132	3.3	103	341.8	1.2
	S2	age[18,65)	438	132	3.3	140	464.5	1.3
	S2	age65+	438	132	3.3	59	195.8	0.7

Table 31: Summary statistics for the number of people within sex group that benefit from tree/s

indicator	stratum	sexgroup	N	n	weight	sum_str	t_hat	sd
count.benefit	S1	Female	249	194	1.3	263	337.6	1.5
	S1	Male	249	194	1.3	226	290.1	1.3
	S2	Female	438	132	3.3	170	564.1	1.4
	S2	Male	438	132	3.3	133	441.3	1.3

Table 32: Summary statistics for the number of people that benefit from tree/s

indicator	stratum	N	n	weight	sum_str	t_hat	sd
count.benefit	S1	249	194	1.3	489	627.6	1.1
	S2	438	132	3.3	303	1005.4	1.0

Table 33: Estimated number of people that benefit from tree/s

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
count.benefit	687	326	1633	33.6	2	1567.2	1698.9	65.9	4

#### I.A.3.3.2 Number of households sharing fruits

The summary statistics for the number of households that share fruit can be seen in Table 34 and the estimated number of households that share fruit is given in Table 35.

Table 34: Summary statistics for the number of households that share fruit

indicator	stratum	N	n	weight	sum_str	t_hat	sd
fruit.share	S1	249	194	1.3	86	110.4	0.5
	S2	438	132	3.3	65	215.7	0.5

Table 35: Estimated number of households that share fruit

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
fruit.share	687	326	326.1	16.5	2	293.7	358.5	32.4	9.9

#### 4.1.4 Impact Indicator

##### I.A.4 Combined adaptation indicator

Table 36 illustrates the calculation of the population ideal. The population ideal values are used in the calculation of the combined adaptation indicator.

Table 36: Calculation of population ideal

subgoal	code	abbreviation	pop.parm	ideal.coefficient	pop.nr	pop.ideal
Strengthen resilience	I.A.3.1.1	mulch	total.hh	0.50	687	343.50
	I.A.3.1.2	skill	total.hh	0.90	687	618.30
Reduce vulnerability	I.A.3.2.1	fruit.total	total.tree	0.70	1334	933.80
	I.A.3.2.2	fruit.months	total.hh	4.00	687	2748.00
	I.A.3.2.3	shade.total	total.tree	4.95	1334	6600.64
	I.A.3.2.4	shade.use	total.tree	0.99	1334	1320.13
	I.A.3.2.5	fruit.sell	total.hh	0.10	687	68.70
Enhance adaptive capacity	I.A.3.3.1	beneficiaries.nr	total.hh	3.40	687	2335.80
	I.A.3.3.2	fruit.share	total.hh	0.60	687	412.20

Table 37 gives the values for the calculation of the combined adaptation indicator using the formula

$$AdaptationIndicator = \sum_i^3 \sum_j^{n_j} u_{ij} w_i \frac{\hat{t}_{str(ij)}}{pop.ideal_{ij}}$$

Column 1 gives the subgoals and column two gives the weight for each subgoal. Columns three and four give the codes and the abbreviations for die individual adaptation indicators. The weights for indicator  $j$  within subgoal  $i$  are given in column 5. Column 6 is the ideal value for the  $j^{th}$  indicator of subgoal  $i$ . Column 7 gives  $\hat{t}_{str(ij)}$ , the estimated population value for the  $j^{th}$  indicator of subgoal  $i$  and the last column is the ratio of  $\hat{t}_{str(ij)}$  to the population ideal.

Table 37: Calculation of the combined adaptation indicator

subgoal	weight(wi)	code	abbreviation	weight(uij)	pop.ideal	t.str_hat	ratio
Strengthen resilience	0.10	I.A.3.1.1	mulch	1.0	343.50	80.02	0.23
	0.10	I.A.3.1.2	skill	1.0	618.30	546.48	0.88
Reduce vulnerability	0.10	I.A.3.2.1	fruit.total	1.0	933.80	551.39	0.59
	0.10	I.A.3.2.2	fruit.months	1.0	2748.00	954.84	0.35
	0.10	I.A.3.2.3	shade.total	0.2	6600.64	5883.53	0.89
	0.10	I.A.3.2.4	shade.use	0.8	1320.13	1546.34	1.17
	0.10	I.A.3.2.5	fruit.sell	1.0	68.70	2.57	0.04
Enhance adaptive capacity	0.33	I.A.3.3.1	beneficiaries.nr	0.2	2335.80	1633.04	0.70
	0.33	I.A.3.3.2	fruit.share	1.0	412.20	326.06	0.79

For the current project the AdaptationIndicator is 0.63.

The project credits is

$$Credits = AdaptationIndicator \times Number.households$$

For the current project this is  $0.63 \times 687 = 432.81$

## 4.2 Mitigation Indicator

### *I.M Total carbon*

Since the dbh was wrongly measured during the first two days of survey S1, the dbh measurement were recorded as NA for these households.

Table 38 gives the summary statistics for the *above-ground biomass per fruit tree (in td.m)* (TB), the *root-shoot ratio* (R) and the *total biomass per fruit tree (in td.m)* (TB).

Table 38: Summary statistics for mitigation

variable	n	mean	sd	CV	max	min	median	NAs
AGB	572	0.04	0.04	91.59	0.52	0.00	0.03	247
R	572	0.44	0.03	7.90	0.80	0.35	0.43	247
TB	572	0.06	0.05	88.51	0.70	0.00	0.05	247

\*NOTE: n is the number of trees in the sample. The NA's include the dead trees, the trees that were given away and the trees that were never planted.

Table 39 is the summary statistics for the total carbon stock (in  $tCO_2e$  (tonne  $CO_2$  equivalent)) and Table 40 is the estimated total carbon stock (in  $tCO_2e$ ).

Table 39: Summary statistics for the total carbon

indicator	stratum	N	n	weight	sum_str	t_hat	sd
total.CS	S1	249	194	1.3	19.0	24.4	0.2
	S2	438	132	3.3	14.3	47.4	0.1

Table 40: Estimated total carbon

indicator	N	n	t.str_hat	sderror	critval	LL	UL	precision	relprec
total.CS	687	326	71.8	4.7	2	62.7	80.9	9.1	12.7