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The Food and Land Use Coalition

2019 Report of the FABLE Consortium

Pathways to Sustainable Land-Use and Food Systems

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2019 Report of the FABLE Consortium

Pathways to Sustainable Land-Use and Food Systems in Rwanda by 2050

Rwanda

Fidèle Niyitanga*[1], Francois Xavier Naramabuye[1]

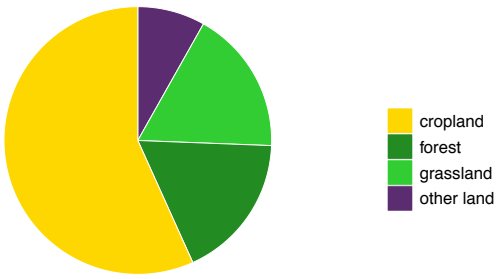
[1]University of Rwanda, Kigali, Rwanda
*Corresponding author: fniyitanga@yahoo.fr

Land and food systems at a glance

A description of all units can be found at the end of this chapter

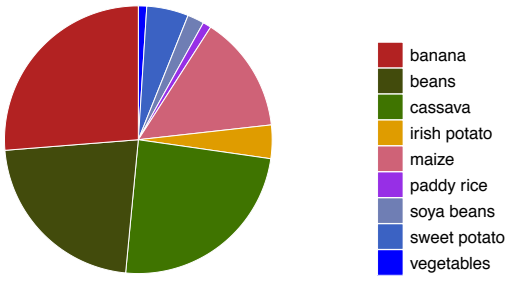
Land & Biodiversity

Fig. 1 | Area by land cover class in 2015



Source: FAOSTAT

Fig. 2 | Share of harvested area by crop in 2015



Source: NISR (2016)

Annual afforestation in 2015:
23 ha = 0.012% of total forest area

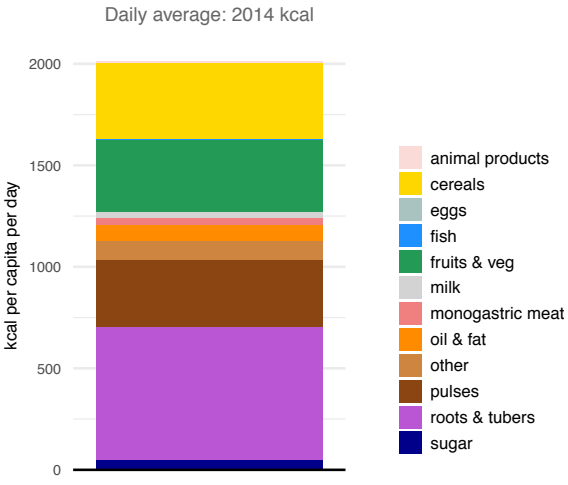
(National Institute of Statistics of Rwanda & Ministry of Environment and Ministry of Lands and Forestry, 2018)

Endangered species: 3 vascular plants, 9 mammals, and 9 breeding birds

(WRI, 2003)

Food & Nutrition

Fig. 3 | Daily average intake per capita at the national level in 2013



Source: Comprehensive Africa Agriculture Development Programme (2013)

Share of undernourished in 2015:
34%

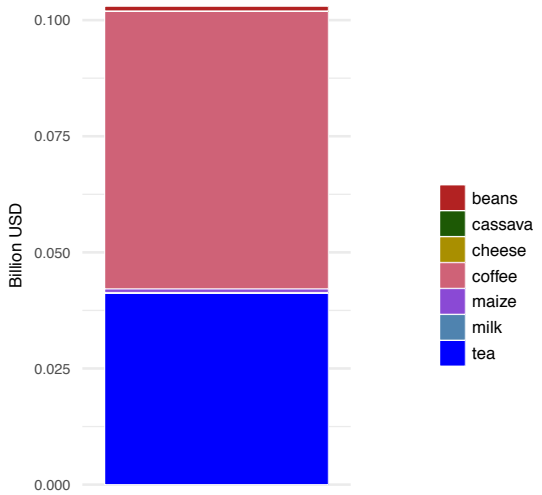
(World Bank, 2019)

Share of obese in 2016:
5.8%

(NISR, 2015)

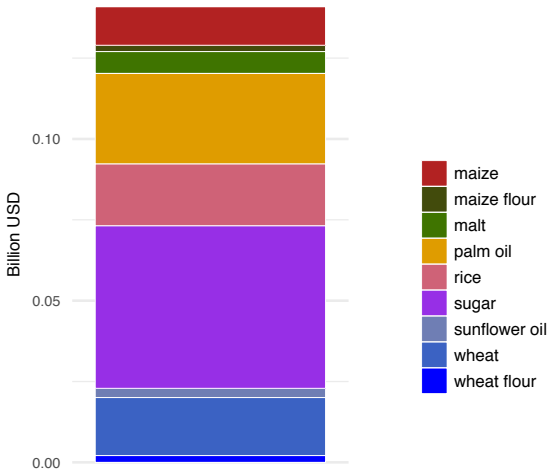
Trade

Fig. 4 | Main agricultural exports by value in 2015



Source: FAOSTAT

Fig. 5 | Main agricultural imports by value in 2015



Source: US Department of Commerce

Deficit in agricultural trade balance in 2015: USD 85.5 mln

(Commerce, 2019)

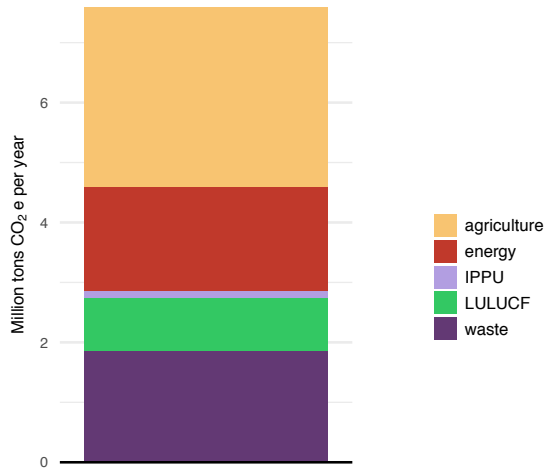
167th most important importer in the world in 2015
(OEC, 2019)

156th most important exporter in the world in 2017

(Central Intelligence Agency, 2017)

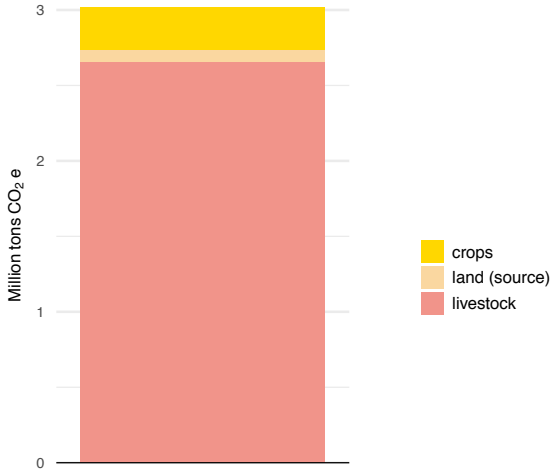
GHG Emissions

Fig. 6 | GHG emissions by sector in 2014



Source: ClimateLinks

Fig. 7 | GHG emissions from agriculture and land use change in 2015



Source: FAOSTAT

Main assumptions underlying the pathway towards sustainable land-use and food systems

For a detailed explanation of the underlying methodology of the FABLE Calculator, trade adjustment, and envelope analysis, please refer to sections 3.2: Data and tools for pathways towards sustainable land-use and food systems, and 3.3: Developing national pathways consistent with global objectives.

GDP GROWTH & POPULATION

	GDP per capita	Population
Scenario definition	GDP per capita is expected to increase by 73.38% from USD 714 in 2015 to USD 1,238 in 2050 (SSP2 scenario selected).	Population is expected to increase by 92.2% between 2015 and 2050 from 11.6 mln to 22.3 mln (SSP2 scenario selected).
Scenario justification	Based on World Bank (2018), the future drivers of growth in Rwanda (which are innovation, integration, agglomeration, and competition) could help sustain GDP growth. Rwanda's average GDP growth was around 7% from 2007-2017.	Our assumption is equivalent to a future average annual growth rate of 1.9%, which is lower than the annual population growth rate of 2.6% observed in the past decade (Ministry of Finance and Economic Planning, 2000; National Institute of Statistics of Rwanda, 2012).

TRADE

	Imports	Exports
Scenario definition	The share of total consumption which is imported increases: - from 48% in 2015 to 92% in 2050 for wheat. The share of total consumption which is imported remains stable at 2010 level for the other commodities.	The exported quantity increases: - from 23 kt in 2015 to 33 kt in 2050 for tea, - from 18 kt in 2015 to 26 kt in 2050 for coffee. Exported quantities remain stable at 2010 level for the other commodities.
Scenario justification	Based on IndexMundi (2019), which shows that Rwanda experienced higher imports for corn, wheat, and sorghum in the past.	The forecasted increase in coffee and tea exports is based on data from the Government of Rwanda (Ministry of Agriculture and Animal Husbandry, 2008; Ministry of Agriculture and Animal Resources, 2008), which focuses on the progress made in the coffee and tea sectors by increasing the quantity and quality of tea and fully and semi-washed coffee. The Rwanda national export strategy of 2012 also emphasizes the increase in coffee and tea exports (Ministry of Trade and Industry, 2012).

Scenario signs = no change → small change ↗ large change

LAND

	Land conversion	Afforestation
Scenario definition	Forests cannot be converted to agricultural land. There is no constraint on other natural land conversion beyond protected areas.	We did not take afforestation into account in this pathway.
Scenario justification	Based on Government of Rwanda (2018), the change in forestry land was very small (0.1%) from 2014 to 2015 and the Government of Rwanda wants to increase the forest area (Ministry of Lands and Forestry, 2017).	The national forestry policy aims to increase the forestry area from 18.7% to 30% of Rwanda's total land area through afforestation and reforestation by 2030 (Ministry of Lands and Forestry, 2018). However, we preferred to exclude this afforestation target. Since afforested land cannot be used for production in the Calculator, this would have created too much tension on the food markets.

BIODIVERSITY

	Protected areas
Scenario definition	The protected areas remain stable at 82 kha between 2015 and 2050.
Scenario justification	Our assumption is below the Government of Rwanda's (2000) target of protecting 10.3% of Rwanda's land mass to maintain biodiversity, which is equivalent to 260 kha of land under protection.

FOOD

	Diet	Food waste
Scenario definition	Between 2015 and 2050, the average daily calorie consumption per capita increases from 1,931 kcal to 2,219 kcal. Per capita consumption: - increases by 55% for cereals, - decreases by 8% for pulses, - increases by 25% for vegetable oil, - increases by 7% for pulses, - increases by 51% for sugar, - increases by 52% for milk, - increases by 264% for chicken and pork, - increases by 150% for eggs, - increases by 100% for fish, - remains stable for fruits and vegetables and beef.	Between 2015 and 2050, the share of final household consumption which is wasted decreases from 9% to 5%.
Scenario justification		There is very little research on food waste in Rwanda, so there is no data to compare this value with.

Scenario signs = no change → small change ↗ large change

PRODUCTIVITY

	Crop productivity	Livestock productivity	Pasture stocking rate
Scenario definition	Between 2015 and 2050, crop productivity increases: - from 15.8 t/ha to 24.9 t/ha for cassava, - from 15.5 t/ha to 28.3 t/ha for Irish potato, - from 10.8 t/ha to 19.4 t/ha for plantain, - from 3.1 t/ha to 11.1 t/ha for corn.	Between 2015 and 2050, the productivity per head increases: - from 26 kg/ head to 36 kg/ head for beef, - from 0.07 kg/head to 0.8 kg/head for chicken, - from 0.7 t/ head to 1.1 t/ head for milk.	The ruminant density stays constant at 2.35 TLU/ha over 2015-2050.
Scenario justification	Based on Niyitanga et al. (2015), there is room to further increase potato yield to 40 t/ha to help close the 76.4% yield gap for potato. This includes the adoption of improved agricultural practices by farmers to help increase crop productivity. The results are also in line with the national targets of increasing crop productivity through an intensification program (Ministry of Agriculture and Animal Resources, 2012).	Based on the International Livestock Research Institute (2017). These results are in accordance with national targets for increasing productivity and total production in livestock value chains for cow dairy, red meat-milk, poultry, and pork on the basis of using better genetics, feed, and the adoption of health services, among others. For example, the projected increase in national cow milk production will result from an increase in crossbred and pure exotic cows, including through artificial insemination and synchronization, combined with improved feed and health interventions.	No data on national average livestock stocking densities to compare this value with.

OTHER

	Harvest Intensity
Scenario definition	The average crop harvesting intensity remains constant at 1.29 over 2015-2050.
Scenario justification	

Scenario signs = no change → small change ↗ large change

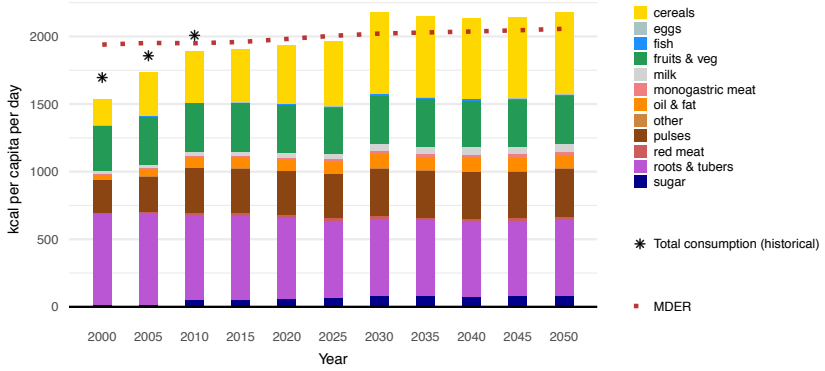
Results against the FABLE targets

The results for FABLE targets as well as "other results" are based on calculations before global trade harmonization.

Food security

Fig. 8 | Computed daily average intake per capita over 2000-2050

Note: The Minimum Daily Energy Requirement (MDER) is computed based on the projected age and sex structure of the population and the minimum energy requirements by age and sex for a moderate activity level. Animal fat, offal, honey, and alcohol are not taken into account in the computed intake.



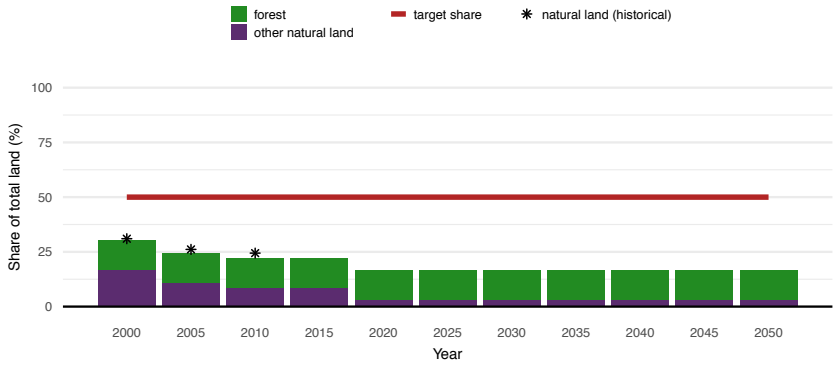
Historical data source: FAOSTAT

Our results show increasing average daily energy intake per capita from 1,903 kcal/cap/day in 2015 to 2,165 kcal/cap/day in 2050. This daily energy intake is above the MDER and the 2,100 kcal/dap/day requirement of the Comprehensive Africa Agriculture Development Programme (2013) from 2025 onwards.

Compared to the healthy diet, our results show higher consumption of roots and tubers, pulses and fruits and vegetables and lower consumption of cereals, animal products, and oil and fat.

Biodiversity

Fig. 9 | Computed share of the total land which could support biodiversity over 2000-2050



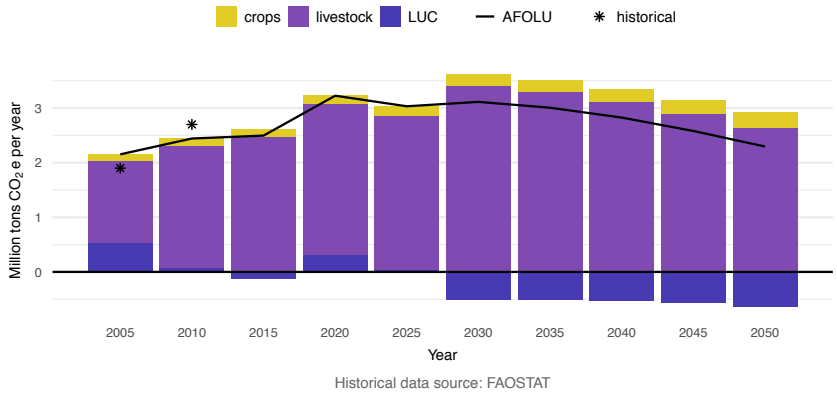
Historical data source: FAOSTAT

Our results show that the Share of Land which can support Biodiversity (SLB) decreased between 2000-2015 from 32.31% to 25.79%. This is slightly below FAO's data, which estimates forest area increase in 2005 and 2010 compared to 2000 (Republic of Rwanda, 2014). The lowest SLB is computed from 2020 onwards at 17% of total land. This is mostly driven by other non-managed land conversion to cropland/pasture. There is no more available other natural land outside protected areas after 2020 and based on historical data, we assume that agricultural land cannot expand on forest land. This is the reason why the SLB remains stable at 17% until the last period of simulation, 2046-2050.

Compared to the global target of having at least 50% SLB by 2050, our results are below the target. But this number could be compatible with the national target of having at least 10.3% of land area protected to maintain biodiversity by 2020 (Republic of Rwanda, 2014).

GHG emissions

Fig. 10 | Computed GHG emissions from land and agriculture over 2000-2050



Historical data source: FAOSTAT

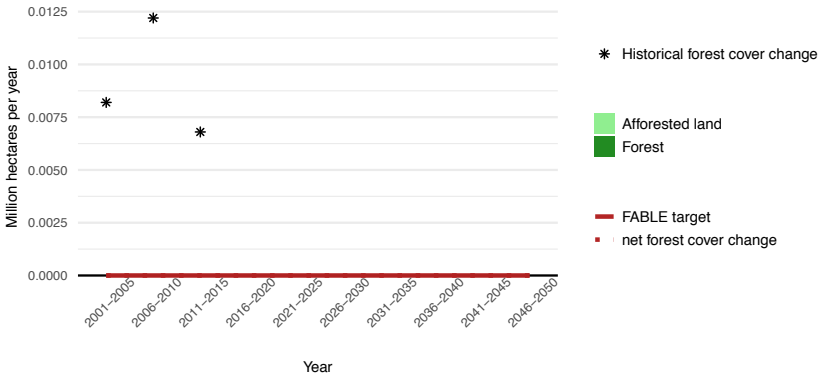
Note: AFOLU (Agriculture, Forestry and Other Land Use) is the sum of computed GHG emissions from crops, livestock and Land Use Change (LUC), emissions and sequestration from forestry are not included. Historical emissions include crops and livestock.

Our results show historical annual GHG emissions from agriculture at 1.2 $MtCO_2e$/year in 2000 and 2.4 $MtCO_2e$/year in 2010. This is 15% below FAO estimates in 2010 due to the underestimation of GHG emissions from the livestock sector. Peak AFOLU GHG emissions are computed for the period 2025-2030 at 3.2 Mt CO_2e/year. AFOLU GHG emissions decline, reaching 2.3 $MtCO_2e$/year in 2050: 2.9 from agriculture and -0.6 from LULUCF. Negative-net emissions from LULUCF by 2050 are mainly explained by pasture abandonment.

Compared to the global target of reaching zero or negative GHG emissions from LULUCF by 2050, our results are above the target. Our results show that AFOLU could contribute to as much as 95% of Rwanda's total GHG emissions reduction objective.

Forests

Fig. 11 | Computed forest cover change over 2000-2050



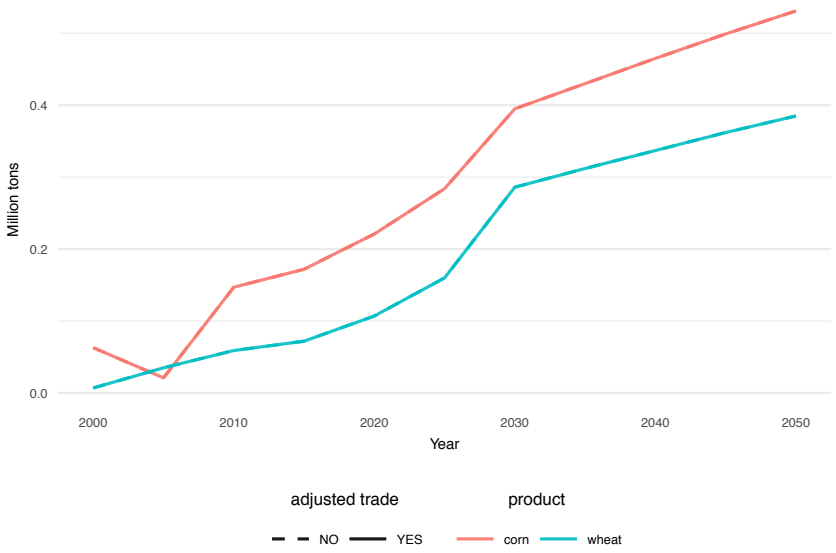
Source historical data: FAOSTAT

Our results show no deforestation between 2000 and 2050. This is consistent with FAO data. However, our results do not represent past afforestation efforts well.

Compared to the global target of having zero or positive net forest change after 2030, our results are at the target. Our results do not meet the national objectives of having forest covering 30% of national land by 2020 (Ministry of Lands and Forestry, 2018). Ambitious afforestation targets were removed from our simulations after they led to large negative impacts on food security. The fact that afforested area cannot be used for agricultural production in the Calculator could explain this contradiction between our results and past observations.

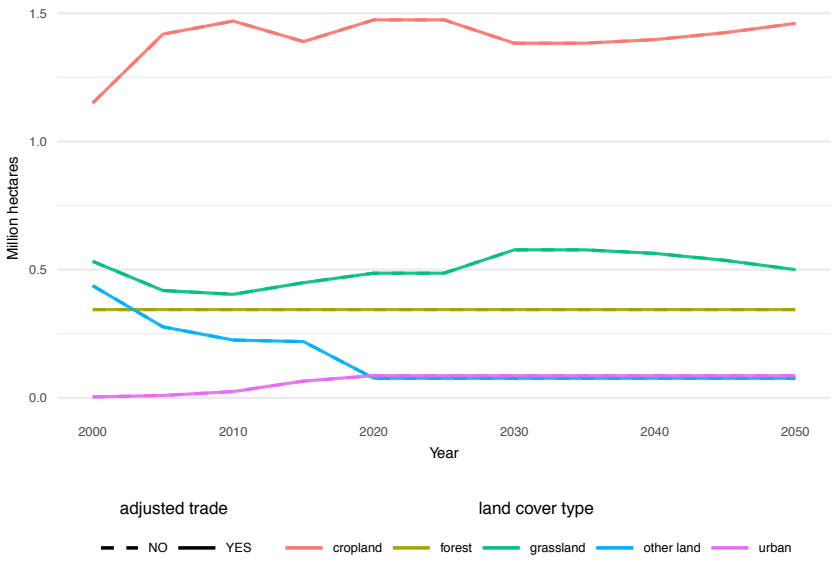
Impacts of trade adjustment to ensure global trade balance

Fig. 12 | Impact of global trade harmonization on main exported/imported commodities over 2000-2050



Trade adjustment does not impact exported or imported traded volumes for Rwanda.

Fig. 13 | Impact of global trade harmonization on land use over 2000-2050



Trade adjustment does not have any impact on overall land use in Rwanda.

Discussion and next steps

Under this pathway, Rwanda's GDP and population would continue to increase, as would crop and livestock productivity, imports and exports of key commodities, and the average daily food intake. Food waste would decline while protected land would remain stable.

We did not consider afforestation in this pathway as the FABLE Calculator does not allow afforested land to be used for agriculture, so an afforestation target would have led to tension on the food market. Agroforestry is a common agricultural practice in Rwanda which was not included as part of this analysis. These are limitations to the results and will need to be addressed going forward.

Rwanda's agriculture systems will likely shift from subsistence to professional agriculture and we see the opportunity for ambitious yield increases. Niyitanga et al. (2015) show that improved agricultural practices could go a long way towards closing the yield gap.

Additional technologies could enable Rwanda to raise the level of ambition of its objectives for sustainable land-use and food systems: settlement building technologies (housing stocks), technologies for improved water and fertilizer use, organic farming and conservation agriculture, food processing and storage, as well as policies to encourage the reduction of fertility rate.

Many policies are already in place that would support these suggested measures. The government has established free education up to 12 years of age and this has already yielded many positive impacts. Once a critical mass of people become better educated, good policies that are already in place will be further improved and implemented and will positively impact food security and environmental protection.

Units

% – percentage
bln – billion

cap – per capita

CO_2 – carbon dioxide

CO_2e – greenhouse gas expressed in carbon dioxide equivalent in terms of their global warming potentials

GHG – greenhouse gas

Gt – gigatons

ha – hectare

kcal – kilocalories

kg – kilogram

kha – thousand hectares

km^2 – square kilometer

kt – thousand tons

Mha – million hectares

mln – million

Mt – million tons

t – ton

TLU –Tropical Livestock Unit is a standard unit of measurement equivalent to 250 kg, the weight of a standard cow

t/ha – ton per hectare, measured as the production divided by the planted area by crop by year

t/TLU, kg/TLU, t/head, kg/head- ton per TLU, kilogram per TLU, ton per head, kilogram per head, measured as the production per year divided by the total herd number per animal type per year, including both productive and non-productive animals

tln – trillion

USD – United States Dollar

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