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# Policy Brief: food loss and waste reduction strategies to fill the protein gap

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## I. Background information

Food loss and waste (FLW) reduction is an important matter which is not only relevant to food and nutrition security e.g., [1,2,3] but also climate change [4,5,6]. Reducing FLW and the associated environmental impacts can be approached from the angle of waste prevention, namely preventing FLW from happening in the first place. It can also be addressed by waste valorization, namely reusing FLW for other value-added applications, for example, feed application.

In this study, Wageningen University and Research (WUR) investigated the FLW reduction strategies both from the prevention and valorization perspectives. Firstly, we looked into the protein potentials of using the FLW to directly fill the protein gaps at the country level. If all the FLW of a country are avoided, to what extent the protein gap of that country could be closed. Then, we investigated the alternative scenario of feeding all the FLW to chickens to see if the converted chicken proteins can fill the protein gap in that country.

## II. Methodology and Data

The same methodology as in (Guo et al., 2020) was applied to calculate the FLW and the associated GHG emissions with the 2018's FAO food balance sheets data including the primary production, processing, and domestic food distribution of different food items. Storage & handling, and consumption of the food were calculated using the data from other three stages following the mass balance principle. By multiplying the quantities of food items in each chain stage to the stage-specific FLW factors, we derived the FLW in each stage and country. Then the CO2 emission factors were multiplied to the FLWs to obtain the FLW-associated GHG emissions. For more details, please refer to the methodology section of (Guo et al., 2020).

For the protein potentials estimation, we first calculated the protein content per food item. In FAO FBS, the protein supply quantity (g/capita/day) per item per country is recorded. Information on the size of the population for each country is also registered. With those two parameters, the yearly protein mass supply for a certain food item in a certain country can be calculated. FBS also registers the yearly mass of domestic food supply by item and country, the protein content can be derived through dividing the yearly mass of protein by the yearly mass of domestic food supply. The derived protein content for each food item is country-specific. For example, the protein content of the "Apple and apple products" are different from one country to another. It is also necessary to point out that some food items like soybeans have 0 "Food" and "Protein supply quantity" for some countries. The reason for this is soybeans are processed into soybean oil and soybean cake where cakes are only used for feed purpose and soybean oil is registered under another food category. In case of such items, we can not calculate the protein content using the aforementioned approach and parameters. Instead, the regional average protein content of soybean were used to represent the country one. If the regional average is as well not available, we used the global average instead. Based on the protein content of the food items, the protein mass contained by the FLW can be calculated.

The country-wise protein intake requirement was calculated by multiplying the recommended protein intake per-kg bodyweight by WHO to the average bodyweight of the referred country [7]. The data show that the average protein intake requirement at the global level is 56 g/day. This is consistent to the finding in [8] that the daily protein requirement of an average global citizen falls between 50 to 60 g. By comparing the real daily protein intake per capita in each country with the suggested amount of daily protein need, the countries with protein intake deficits and the magnitudes of the gaps were identified. To close (or narrow) the gap, two potential pathways were investigated: 1) prevention of the FLW so that more food is available with more proteins and 2) convert the FLW proteins to proteins in animal meat through animal feed application. For the later pathway, chickens were as the target animals to convert the proteins from FLW. The reason for this selection is chickens have the highest protein conversion ratio (21%) compared to pigs (9%) and cattle (3%) [9] and lower the environmental and religious concerns than beef and pork.

## III. Key findings of this study

The key findings of this study are listed as follows:

- In general, there are enough proteins to ensure the WHO-recommended protein intakes to be met at the global and continental levels
- At the country level, there are only 14 countries which do have the protein gaps. The large majority are low & middle-income countries with Slovakia as an exception (Figure 1).
- The protein gaps can be closed in the 14 countries if all the FLW in those countries are avoided (prevention strategy) (Table 1).
- 5 out of the 14 countries' protein gaps can be filled following the "chicken feed" valorization strategy (Table 2).
- The prevention strategy seems to be better off than the valorization strategy in terms of protein gap fulfilment efficiency because of the protein conversion losses for feed applications. It is also due to the assumption that the animal-product wastes can not be used for feed applications. However, since not all the FLW are avoidable, feed application still has its value when human can not use the unavoidable FLW directly.

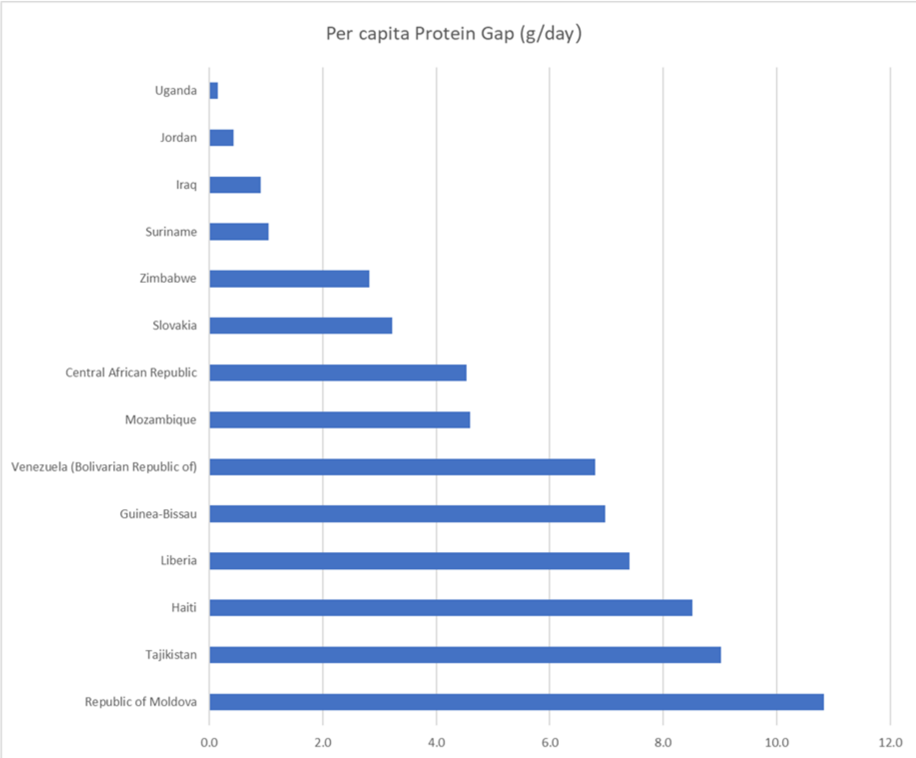


*Figure 1. The 14 countries with the protein intake gaps.*

*Table 1 Protein gap analysis for the prevention strategy*

| Region | Area | Population | Protein available per person (g/day) | Protein requirements per person (g/day) | Per capita Protein Gap (g/day) | Total_protein_per_year (Ton) | Total_protein_per_year_required (Ton) | Protein Gap (Ton) | FLW_protein (Ton) | FLW_protein/Protrein gap | Mitigated FLW-related GHG emissions (Ton) when protein gap is (partially) filled by FLW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Saharan Africa | Uganda | 42,729,000 | 46.3 | 46.4 | 0.1 | 721,914 | 724,154 | 2,240 | 261,013 | 11654% | 102,193 |
| North Africa, West & Central Asia | Jordan | 9,965,000 | 63.4 | 63.8 | 0.4 | 230,673 | 232,214 | 1,541 | 48,985 | 3179% | 51,090 |
| Latin America | Suriname | 576,000 | 57.2 | 58.2 | 1.0 | 12,026 | 12,244 | 218 | 3,748 | 1718% | 9,730 |
| North Africa, West & Central Asia | Iraq | 32,965,000 | 59.6 | 60.5 | 0.9 | 716,861 | 727,726 | 10,865 | 160,751 | 1480% | 128,918 |
| Europe | Slovakia | 5,453,000 | 60.5 | 63.7 | 3.2 | 120,419 | 126,832 | 6,413 | 78,689 | 1227% | 94,038 |
| Sub-Saharan Africa | Zimbabwe | 14,439,000 | 43.6 | 46.4 | 2.8 | 229,857 | 244,706 | 14,849 | 62,983 | 424% | 650,867 |
| Sub-Saharan Africa | Central African Republic | 4,666,000 | 43.9 | 48.4 | 4.5 | 74,689 | 82,418 | 7,729 | 32,506 | 421% | 462,107 |
| Sub-Saharan Africa | Guinea-Bissau | 1,874,000 | 42.8 | 49.8 | 7.0 | 29,262 | 34,032 | 4,770 | 16,228 | 340% | 178,407 |
| Sub-Saharan Africa | Mozambique | 29,496,000 | 41.8 | 46.4 | 4.6 | 450,418 | 499,886 | 49,468 | 129,019 | 261% | 2,104,205 |
| Europe | Republic of Moldova | 4,052,000 | 51.3 | 62.2 | 10.8 | 75,920 | 91,937 | 16,017 | 40,101 | 250% | 297,292 |
| Sub-Saharan Africa | Liberia | 4,819,000 | 42.3 | 49.8 | 7.4 | 74,479 | 87,514 | 13,035 | 31,584 | 242% | 362,332 |
| Latin America | Venezuela (Bolivarian Republic of) | 28,887,000 | 51.0 | 57.8 | 6.8 | 537,729 | 609,424 | 71,695 | 142,306 | 198% | 3,781,441 |
| North Africa, West & Central Asia | Tajikistan | 9,101,000 | 49.1 | 58.1 | 9.0 | 163,101 | 193,066 | 29,965 | 54,277 | 181% | 836,035 |
| Latin America | Haiti | 11,123,000 | 47.2 | 55.8 | 8.5 | 191,802 | 226,372 | 34,570 | 39,328 | 114% | 931,736 |

*Table 2 Protein gap analysis for the chicken feed application strategy*

| Region | Area | Population | Protein available per person (g/day) | Protein requirements per person (g/day) | Per capita Protein Gap (g/day) | Total_protein_per_year (Ton) | Total_protein_per_year_required (Ton) | Protein Gap (Ton) | Converted_chicken_protein (Ton) | Converted_chicken_protein/Protein Gap | Mitigated FLW-related GHG emissions (Ton) when protein gap is (partially) filled by FLW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub-Saharan Africa | Uganda | 42,729,000 | 46.3 | 46.4 | 0.1 | 721,914 | 724,154 | 2,240 | 42,062 | 1878% | 56,407 |
| North Africa, West & Central Asia | Jordan | 9,965,000 | 63.4 | 63.8 | 0.4 | 230,673 | 232,214 | 1,541 | 6,809 | 442% | 31,619 |
| North Africa, West & Central Asia | Iraq | 32,965,000 | 59.6 | 60.5 | 0.9 | 716,861 | 727,726 | 10,865 | 27,429 | 252% | 68,408 |
| Latin America | Suriname | 576,000 | 57.2 | 58.2 | 1.0 | 12,026 | 12,244 | 218 | 533 | 245% | 9,973 |
| Europe | Slovakia | 5,453,000 | 60.5 | 63.7 | 3.2 | 120,419 | 126,832 | 6,413 | 14,014 | 219% | 55,808 |
| Sub-Saharan Africa | Zimbabwe | 14,439,000 | 43.6 | 46.4 | 2.8 | 229,857 | 244,706 | 14,849 | 9,924 | 67% | 951,948 |
| Sub-Saharan Africa | Central African Republic | 4,666,000 | 43.9 | 48.4 | 4.5 | 74,689 | 82,418 | 7,729 | 5,034 | 65% | 704,635 |
| Sub-Saharan Africa | Guinea-Bissau | 1,874,000 | 42.8 | 49.8 | 7.0 | 29,262 | 34,032 | 4,770 | 3,071 | 64% | 443,499 |
| Sub-Saharan Africa | Liberia | 4,819,000 | 42.3 | 49.8 | 7.4 | 74,479 | 87,514 | 13,035 | 5,926 | 45% | 721,348 |
| Europe | Republic of Moldova | 4,052,000 | 51.3 | 62.2 | 10.8 | 75,920 | 91,937 | 16,017 | 6,819 | 43% | 469,925 |
| Sub-Saharan Africa | Mozambique | 29,496,000 | 41.8 | 46.4 | 4.6 | 450,418 | 499,886 | 49,468 | 20,553 | 42% | 3,180,508 |
| North Africa, West & Central Asia | Tajikistan | 9,101,000 | 49.1 | 58.1 | 9.0 | 163,101 | 193,066 | 29,965 | 9,598 | 32% | 652,050 |
| Latin America | Venezuela (Bolivarian Republic of) | 28,887,000 | 51.0 | 57.8 | 6.8 | 537,729 | 609,424 | 71,695 | 18,986 | 26% | 2,401,315 |
| Latin America | Haiti | 11,123,000 | 47.2 | 55.8 | 8.5 | 191,802 | 226,372 | 34,570 | 6,866 | 20% | 628,437 |

## IV. Policy advice based on this study

Based on the work done by WUR the following policy advice can be given to the policy makers:

1. The policy makers should target at the 14 countries listed in Figure 1 for protein gap interventions.
2. The results that Republic of Moldova and Slovakia have the protein intake gaps are conflicting with the common notion derived from the previous study. In this study, we have used the FAO food balance sheets (2018) as the data source to derive the protein intake numbers per country. Since FAO has changed the methodology of food balance sheets calculation since 2014, there could be a gap caused by the methodological change. Anyhow, based on the new FAO food balance sheets data, Republic of Moldova and Slovakia fall in the countries with protein intake gaps which desire the policy attention. However, policy makers should use this piece of information in a more careful way and more validation on this point should be conducted.
3. When possible, FLW prevention is preferred because feed application has low protein conversion ratio and animal production is not favorable from a climate change perspective.
4. For the non-avoidable FLW, the chicken feed application strategy could be applied.
5. Moreover, it is necessary to point out that there are FLW that may not be edible even for chicken. We also acknowledge that there are other practical restrictions that affect the efficiency of FLW valorization. In this sense, the results of this research should be considered as a theoretical upper bound for the protein potentials instead of practical guideline for policy making.

6. Finally, the intake standards presented in Figure 1 and Table 1 & 2 are actually the minimum requirements suggested by WHO. To ensure the protein intakes to be met especially in the abnormal period such as period of the COV-19 outbreak, a buffer should actually be added to the minimum requirements. In this research, we have also calculated the resilient scenarios with the "buffers". In the resilient scenarios, more countries are added to the picture because they have the protein intake gaps when taking the buffers into account.

## V. Acknowledgements and contact person

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