E-Forum on Full Cost Accounting of Food Wastage:
Week 4, 11 November – 17 November
Land Occupation and Degradation

Week four of the E-Forum addresses food wastage impacts on land occupation and land degradation.

Food wastage impacts on land occupation and degradation

Land occupation

Phase I of the Food Wastage Footprint (FWF) project (FAO, 2013) estimated that land occupation due to food wastage amounted to almost 1.4 billion ha, which is about 30% of the total global agricultural area. About 0.9 billion ha are grasslands wasted through the wastage of animal products, and 0.5 billion ha are arable lands. These calculations have been further refined in Phase II by:

- including land occupation by food commodities that were not covered in Phase I (e.g. sugar, coffee, alcoholic beverages);
- further refining the herd structure models of cattle, pigs and chicken and thus the corresponding feed and related area requirements;
- including additional forage and fodder crops (e.g. alfalfa and beets) besides forage maize and triticale as animal feed.

Following these changes, the revised total land use due to food wastage is only slightly increased to about 1.5 billion ha. Further refinements in the SOL-model will be undertaken, which will eventually affect final results. For example, grassland productivity data, and animal productivity data in relation to different feeding rations will be refined, which will affect the land use per kg of meat or milk.

Land degradation

Land degradation has been captured in Phase I of the FWF project by the Biophysical Status and Land Degradation Indices (BSI and BLDI) provided by GLADIS (FAO, 2011). Results show that about 45% of food wastage at the production stage origin from regions[1] with good land status but medium to strong degradation, and about 55% origin from regions with bad land status and medium to strong degradation. This indicator is not crop-specific and covers the production impact (as this is the most impacting stage of the life cycle for land) of wastage arising along the whole value chain. Land use for wastage occurring at higher levels of the value chain has been calculated as if the wasted quantities would have been produced in the country where the wastage occurs.

For Phase II, a different indicator for land degradation is used to allow a more detailed analysis regarding crops grown. It consists in a rough qualitative crop-specific indicator for the soil erosion potential. Each crop was assigned a value of 0.3, 1 or 2, in reference to how long soils are left bare during the cropping period. For a first assessment, permanent grasslands were assigned a value of 0.3, crops with short periods of bare soil received 1, and crops with longer periods of bare soil received 2 (e.g. maize or beets).[2] Intact grasslands have a very low erosion potential ("0" in the scale used above), but the reality shows huge areas of already degraded grasslands, where the erosion potential is higher. We derived the value of 0.3 for a first, gross average grassland erosion potential based on Pimentel, Harvey *et al.* (1995). We used their average soil loss numbers of grassland in relation to arable land, namely 6 t/ha/y and 17t/ha/y, respectively, and combined this with gross estimates on the share of degraded grasslands in each country to estimate the erosion potential on grasslands. Expert interviews on these assignments resulted in very similar outcomes and we consider this indicator as a quite robust measure for non-site-specific assessment of erosion. This has subsequently been aggregated to crop groups and national or regional levels. Results show that 10% of food wastage stem from areas with erosion potential 2, while 25% and 65% stem from those with potential 1 and from grasslands respectively.

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[1] FWF regions are mainly supra-national, at the sub-continent level cf http://www.fao.org/docrep/018/i3347e/i3347e.pdf

[2] We use the "area harvested" to calculate the land use for crops, which accounts for the cropping intensity on the areas as two harvests from the same plot are taken into account with a correspondingly higher erosion potential.

This approach, looking at crop-specific erosion potential on country level, complements the Phase I approach focusing on the land-cover based erosion potential on a supra-national regional level. We use those two approaches in combination further down, where we provide some first illustration for land use cost from food wastage calculations.

Societal costs of food wastage impacts on land use and land degradation

Land occupation

Land is an input to many different activities and has various utilizations; its valuation heavily depends on those. Figure 1 below presents examples for the different aspects of land valuation in the Total Economic Value (TEV) Framework, depending on the type of economic activity happening on the land or its utilization.

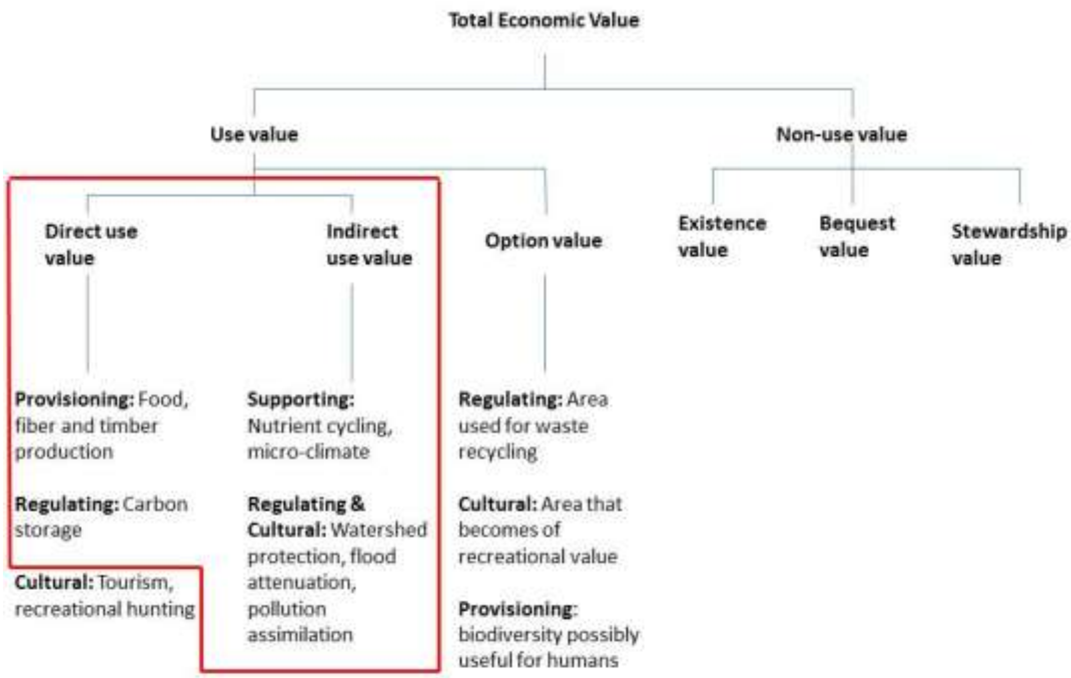

Figure 1: TEV for land-based activities and utilization

When assessing the value of land, we can differentiate between the value under constant management (e.g. for agricultural production) and the value or costs due to land use change (e.g. if natural forest is converted to pasture land). For full cost accounting, results from the valuation of land under constant management and from land use change should be added.

For *land used under constant management*, using opportunity costs is one option to quantify the costs of food wastage impacts. Another option would be land rental prices. However, opportunity costs and rental prices for agricultural land use are difficult to obtain and to generalize, due to the highly local organisation of land markets and price determinants. One proxy would be the use of an average potential agricultural production value on those lands. This however assumes that such alternative output could fully be sold, which is a strong assumption on demand for agricultural products. Specific production alternatives could be investigated, such as source crops for biomaterials or for biofuels, where assumptions on existing demand in the long run may be less problematic. Alternative uses outside agriculture clearly also could be considered, covering the whole range from land use for buildings to land use for conservation areas but numbers for the related opportunity costs will greatly vary and are also very local and lack the potential for generalization. Considering these uncertainties, we refrain from providing an estimate of these costs of land occupation due to food wastage but rather take this up as a key question on how to best monetize this aspect.

To address the costs of *land subject to land use change,* another approach should be followed. Trucost (2013) suggests to value land use change via the value of ecosystem services provided by the land and lost together with the land use change, based on the valuation of ecosystem services from Van der Ploeg and de Groot (2010). Using this approach focusing on ecosystem services, it has to be carefully assured that no double counting occurs with other cost categories that refer to ecosystem services losses in other parts of the Full Cost Accounting Framework.

Land degradation

For the cost of land degradation, we use valuation data coming from studies on the costs of soil erosion (e.g.FAO (1994), Pimentel, Harvey *et al.* (1995), Pretty, Brett *et al.* (2000), Stocking (2001), Berry, Olson *et al.* (2003), Hein (2007)). They are based on the different on and off-site damages incurred due to soil erosion. Table 1 presents what can be considered as on-site and off-site damages.

Table 1: On and Off-site damages categories of erosion adapted from Telles, Dechen *et al.* (2013) & *Pimentel, Harvey et al.* (1995)

On-site damages from water and wind erosion	Off-site damages from water and wind erosion
Nutrient loss	Sedimentation
Lost yield	Flooding
Drop in land values	Water treatment
Biological losses	Electricity Power Generation
	Repairing Public & Private Property (Roads, cars, ...)
	Global Warming
	Health
	Cost to business
	Cost to irrigation and conservation districts
	Biological impacts
	Navigation

The studies provide average values for the total costs of land degradation (on and off-site damages) for single countries. For some estimates, average per ha values can be derived, which then can be used in other countries by means of benefit transfer (e.g. Pimentel, Harvey *et al.* (1995)). To assess the degradation costs of food wastage, these cost values are weighted with a factor indicating how much of the erosion damages are due to agriculture. These cost estimates, being average numbers, need to be weighted with some degradation impact indicator for different crops to account for the different erosion potential of those. For a first assessment, we suggest to employ the gross degradation impact indicator used above (assuming that the value 1 used for most crops corresponds to the average erosion situation, reflected by the average erosion costs reported in these studies). Finally, these weighted cost estimates are assigned to the land occupation numbers of food wastage of different crops.

Draft approach to the monetization of land degradation

Land occupation

As explained above, for the moment we are focusing on the land use change data for valuation. The relevant data for the cost estimates used in Trucost (2013) is not publicly available, but we provide a gross and preliminary estimate based on the available data. Summing the costs from land use due to agriculture in the 19 regions with the highest cost estimates results in about USD 1000 billion. Combining those estimates with regional commodity group waste shares as reported in (FAO, 2013) results in about USD 200 billion. This number thus can be taken as a lower estimate of the costs of ecosystem services losses due to land use change caused by the production of the food that is wasted or lost.

Land degradation

We illustrate the cost estimate described above with the values from the USA provided in Pimentel, Harvey *et al.* (1995), as this is one of the most encompassing assessments of soil degradation costs, even if the estimates are a bit old. The total costs amount to USD70 billion which leads to an average per ha cost estimate of land degradation of about USD 300 in 2012 terms, accounting for different erosion rates on croplands and grasslands. This estimate covers a wide range of categories, such as the costs of nutrient losses to the farmers, damages to infrastructure, health costs, cleaning costs for drinking water, loss of recreational value, etc. To account for the crop specific erosion potential, which differentiates cropland into two categories (with the values 1 and 2, cf. above), the average value was adjusted for the two erosion levels on croplands. This results in per ha costs of USD 260 for crops with degradation potential of 1.

For comparison, we also refer to the value from the UK from Pretty, Brett *et al.* (2000) which covers only real financial costs (i.e. treatment, prevention, administration and monitoring costs) from agriculture to the society (and not private costs to farmers due to nutrient losses, for example). This covers phosphate and soil particle removal costs from drinking water (USD 130 million, also accounting for the share of agriculture) and damage to infrastructure and roads (USD 35 million). This comprises much less damage categories than Pimentel, Harvey *et al. (*1995). This leads to costs of USD 13/ha in 2012 terms, including weighting according to the erosion potential of crops and grassland.

Given that almost 100% of food wastage stems from regions with medium to strong land degradation (FAO, 2013), we conservatively assume that an average crop leads to an average erosion on the areas where the wasted agricultural products are produced (and not less). Thus, we multiply the land areas that correspond to the quantities lost due to food wastage with per ha costs for average erosion levels reported above, transferred to other countries with benefit transfer[3]. We then multiply these costs with the index capturing the crop-specific erosion potential to account for the cultures that lead to more or less erosion than average. This leads to total costs from land use due to food wastage of about USD 10 to 130 billion.

Questions for Discussion

- We suggest addressing the costs of food wastage on land use in two steps: 1) assessing the foregone revenues due to the land being used for unnecessary agricultural production, 2) assessing the costs of land use change due to this unnecessary agricultural production. Does this approach make sense? Which alternatives and refinements are possible?
- When looking at valuing the misuse of land due to food wastage, several opportunities are possible: opportunity cost, rental cost, possible production value etc... Which of these options should we pursue?
- We tried to estimate land degradation potential. To do so, we used gross estimates for the land degradation potential of different areas and for the land degradation potential of different crops. Which other approaches can be used to assess land degradation impacts of food wastage?
- When assessing costs related to ecosystem degradation and loss, double counting becomes an issue. Indeed, for example, when calculating the costs from greenhouse gas emissions, ecosystem losses are included, so they should not be accounted for again under the land use change calculation. How to best avoid double counting when assessing the costs of food wastage?

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[3] The benefit transfer undertaken here, consists in that the reported costs in the US and UK, respectively, are transferred to the other countries with corrections for differences in per capita GDP levels and purchasing power.

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