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Efficient Carbon, Nitrogen and Phosphorus cycling in the European Agri-food System and related up- and down-stream processes to mitigate emissions

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Executive summary

Between 2012 and 2017, the EU-28 imported an average of 11.6 Gt of protein from South America, mainly Brazil, Argentina and Paraguay. Assuming that protein consists of 16 % N, 1.3 % P and 48 % C, these fluxes represent significant amounts of nutrients and carbon imported into the EU. At the same time, the EU-28 exported nearly 3.15 Gt of protein to Africa between 2012 and 2017, mainly in the form of cereal (wheat and barley, approx. 78 %). Livestock production is a key driver of protein imports, with 94% of protein imports related to animal feed purposes, while only 12% of exported proteins belong to categories related to animal products. 90% of protein imports during the studied period were in the form of soybeans or soybean cake, which are used to feed livestock. The increase in soybean cultivation in South America has therefore enabled a significant rise of the livestock sector in the EU. Soybean production is a major driver of land use change in South America and directly or indirectly causes large-scale conversion of primary forests, savannahs, and grassland into cropland for soy cultivation. The land use conversion for soybean production is having negative results on the regions biodiversity, soil and water and has grave implications for the global fight to slow climate change. International soybean trade between the EU and Brazil and Argentina was shown to result in a net benefit of $17.3 billion in 2008 including employment, labour relations, and the economic growth arising from trade However, soybean cultivation also presents indirect social negative effects on population health and the state of the local environment. In order to manage nutrients in a more sustainable way and reduce greenhouse gas emissions from agriculture, part of the focus needs to be placed on the wider context that enables our current crop and livestock systems to develop, such as trade of fodder and food products.

1 Preface

This report is part of the work conducted in work package 4 of the Circular Agronomics project (Grant Agreement no. 773649). Two of the key objectives of the H2020 Circular Agronomics project are:

- To increase our understanding of carbon, nitrogen and phosphorus flows and
- To contribute to the improvement of European Agricultural Policies by providing evidence based, farmer led and consumer led relevant recommendations for the agri-food chain.

Through the six case studies and several tasks focusing on farmers and consumers at the EU level, Circular Agronomics aims to provide recommendations on the potential to reduce environmental impacts of carbon and nutrient flows at the farm and regional levels. The project also aims to look beyond the EU´s borders and understand how fodder imports are contributing to current carbon and nutrient management challenges.

This report summarises the economic, environmental and social effects of international trade with fodder and food products. The document is divided into two main sections:

- The first part (section 2) estimates protein imports into the EU and, given that most of them are in the form of soya, the presentation of the flows is followed by a discussion on the environmental and social impacts of soya production based on scientific and grey literature.
- The second part (section 3) of the report presents the results of farmer workshops organised in East African countries to evaluate social, economic and environmental pressure by food exports. An analysis of carbon, nitrogen and phosphorus flows in terms of food exports from EU to Africa and the policy implications in the field of food exports is also included.

2 Protein imports into the EU

2.1 Nutrient flows (C, N, P) in terms of protein input from South America

The redistribution of nutrients is an emerging issue related to resource efficiency and closing nutrient loops. Mainly the product value chains and international trade of fertilising products, feed and food products are responsible for significant imbalances in local nutrient cycles. To assess the magnitude of the trade effect, an analysis of imported nutrients in the form of proteins to the European Union (EU) was conducted. Feed products for the European animal husbandry from South America (SA) in particular, but also from North America and Ukraine cause a significant reallocation of the key nutrients carbon (C), nitrogen (N) and phosphorus (P). Furthermore, the production of animal products and derivatives lead to atmospheric and terrestrial losses of nutrients and has an overall low nutrient efficiency.

To get a recent picture of the nutrient flows, the **analysed time period** of the last five years available (2013-2017) in the data source were applied to compute a yearly average. For computing all data frames and visualisations, R a Free Software and programming language was used. The main **data source** for this study is the Detailed Trade Matrix data frame provided by the United Nations Food and Agriculture Organization (FAO) [FAO, 2019], which contains international trade data on around 500 food products and derivatives. The information is on a yearly scale and includes:

- the origin and recipient nation,
- the volume of individual trade good and
- the monetary value of each trade good.

Complementary data was used to convert the weight of goods into protein contents, e.g. from the Nutritive Factors List [FAO, n.d.] by the statistics division of the FAO. The protein contents of missing items that were part of the European trade in the analysis period were manually added using the USDA Food Central database [USDA, n.d.] or deduced from FAO values of similar items.

To estimate the nutrient content of proteins, assumptions were used to simplify the calculation:

1. Independent from the origin, proteins maintain the similar molecular composition.
2. Nearly all of the nitrogen in the diet is present as amino acids in proteins, dietary carbohydrates and fats do not contain nitrogen [FAO, 2002].
3. The conversion factor between the average nitrogen mass into the protein content is Nx6.25 [FAO, 2002], which results in a N-content of 16 % (=1/6.25). Even though other conversion factors are proposed (especially for soy), the current factor of 6.25 is widely accepted and in use [FAO, 2016].
4. Derived from the estimated dietary intake of phosphorus, the P-content is 1.3 % [average P per gram of protein, D'Alessandro et al, 2015].
5. The mean weight share of carbon in amino acids is 48 %.

Figure 1: Member States of the EU-28

All in all, the conversion from mass of the traded good/product *m* into the respective nutrient mass m_i was calculated with the following equation:

$$m_i = m \cdot c_{Protein} \cdot f_i$$

with:

$f_N = 0.16$ (Jones' factor)

$f_P = 0.013$ (average dietary intake of P in terms of protein, amino acids don´t contain P)

$f_C = 0.48$ (average mass fraction of carbon in amino acids)

The FAO do not include all data in weight units. Hence, animal units (*head/1000 head*) were converted into metric weight by using the estimated mean weights for the traded animals. The lower bound of estimates for meat protein content were applied to convert animal mass into nutrient content. In total, inaccuracies in the related animal unit conversions are negligible because living animals only account for a small share of proteins in the total trade volume (< 1 %, see Table 1). The majority of proteins are plant-based or in dead animal products.

An overview of the global C, N and P imports in the form of proteins into the EU-28 (= exports to the EU-28) by continent is shown in Figure 2. The main share of imported proteins from 2013-2017 came from South America with approximately 51 % with more than 10,000 kt protein imports, followed by North America and North Asia (incl. countries on the European continent out of the EU-28).

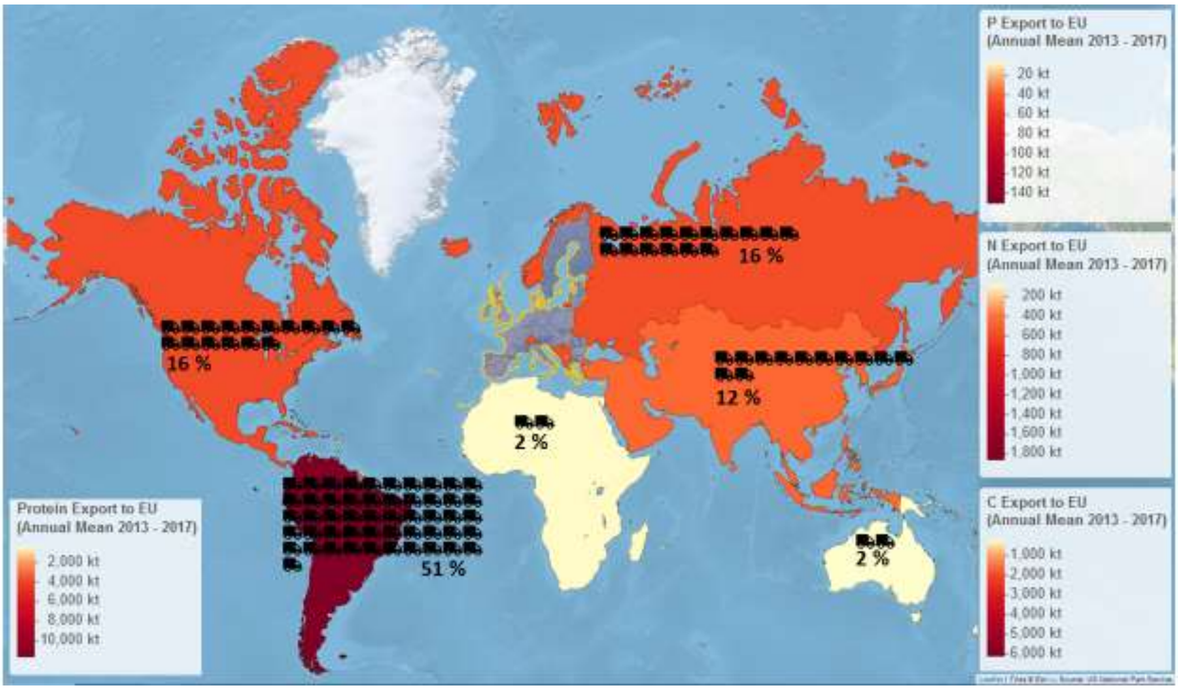

Figure 2: Share of continents in the protein exports and the included P, N and C contents to the EU-28 per year (source: own figure)

An overview of the calculated individual nutrient masses is given in Table 1. Between 2013 and 2017, the average of around 11 640 kt protein was shipped in more than 300 items types to Europe. The main imports from South America to the EU-28 consisted of soy cake and soy beans. The high protein content of the soy products resulted in a contribution of 10 460.7 kt protein mass, almost 90 % of the proteins and nutrients imported to the EU. Less significant amounts were other vegetable feed products not elsewhere specified (nes), maize and sunflower cake, which is also used as animal feed.

According to the assumptions, almost half of the protein consists of carbon (48 %), so that approximately 5 600 kt C were imported into the EU. The rest of the crucial nutrients have lower shares in proteins: 16 % N and 1.3 % P which actual resulted in imports into the EU of 1 862.5 kt N and 151.3 kt P.

Table 1: Imported food items from South America into the EU-28 (mean, 2013-2017)

Item	Mass [kt]	Protein mass [kt]	C mass [kt]	N mass [kt]	P mass [kt]
Cake, soybeans	16 717.6	7 690.1	3 691.2	1 230.4	100.0
Soybeans	7 291.1	2 770.6	1 329.9	443.3	36.0
Feed, vegetable products nes	1 443.7	231.0	110.9	37.0	3.0
Maize	2 318.7	220.3	105.7	35.2	2.9
Cake, sunflower	386.9	154.8	74.3	24.8	2.0
Groundnuts, shelled	368.1	94.6	45.4	15.1	1.2
Coffee, green	1 179.5	79.0	37.9	12.6	1.0
Meat, chicken, canned	174.0	37.9	18.2	6.1	0.5
Crude materials	204.6	30.7	14.7	4.9	0.4
Miscellaneous	10 951.4	331.7	159.2	53.1	4.3
Total	41 035.6	11 640.7	5 587.4	1 862.5	151.3

Overall, feed products were dominating the trade goods. In Table 2, the five FAO product groups are listed which have the biggest contribution to the imported proteins. More than 94 % were “Fodder crops and products” and “Bearing crops and derived products”, which include products suitable (or made) for feeding animals.

Table 2: Distribution of protein import of the EU-28 from South America over the FAO product groups (top 5)

Group	Mass [kt]	Protein mass [kt]	protein share [%]
Fodder crops and products	18 810.6	8 114.2	69.71
Bearing crops and derived products	7 786.9	2 885.0	24.78
Cereals and cereal products	3 013.3	281.2	2.42
Products from slaughtered animals	665.4	115.5	0.99
Stimulant crops and derived products	1 330.2	85.8	0.74

The trade between South America and the EU-28 is dominated by Argentina, Brazil and Paraguay (see Figure 3). The three countries exported 98 % of South American nutrient export to the EU-28 in the period under analysis. It is notable that these countries were also among the South American countries with the highest soy export compared to other products. The share of soy in the total export products exceeded 80 % or even 90 %. Uruguay still had an average soy export of around 200 kt annual.

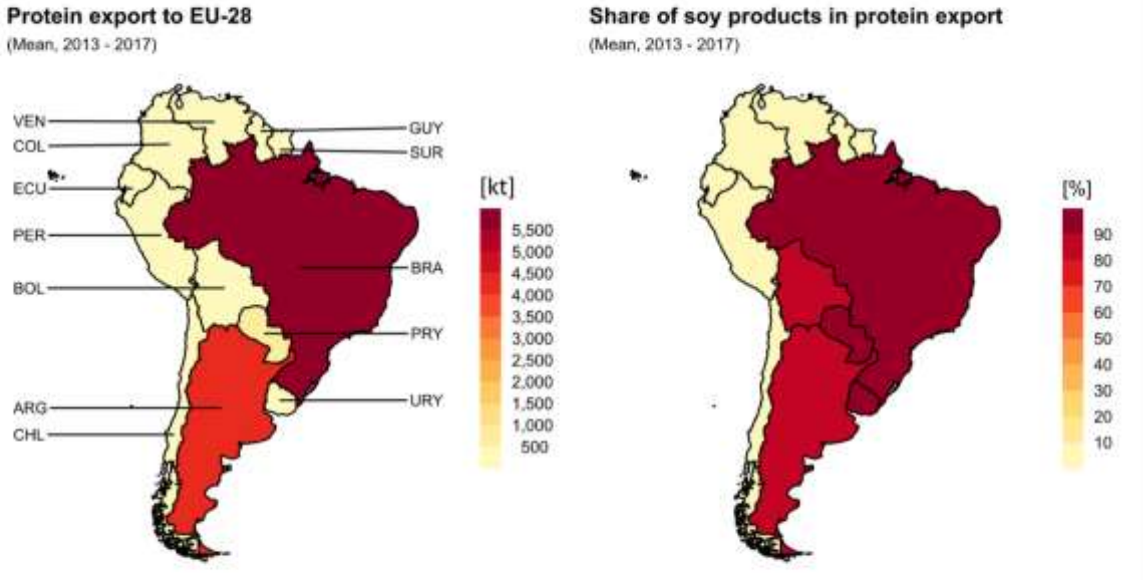

Figure 3: Protein exports to the EU-28 per South American country (left) and the share of soy protein (right) (source: own figure)

The export of soy seems to be an enabler for large-scale trade to the EU-28. This is underlined by Table 3 which breaks down the protein contributions of South American exports into soy and miscellaneous protein sources to compare the overall trade effect of soy products. From all South American countries other protein products were exported into the EU. Wherever soy was exported, the amounts of the related proteins significantly exceeded the other protein exports into the EU.

Table 3: Protein exports of South American countries split into soy and miscellaneous protein sources

Origin	Protein, soy [t]	Protein, other [t]
ARG	3 823 859	558 028
BOL	32 802	4 095
BRA	5 462 262	453 537
CHL	3	19 883
COL	1	23 996
ECU	0	19 492
GUY	0	19 566
PER	0	22 043
PRY	923 181	6 655
SUR	0	2 852
URY	201 293	21 761
VEN	0	143

2.2 Environmental impact of soybean production

2.2.1 Soybean production as a driver of deforestation in South America

Soybeans are one of the world's most traded agro-industrial commodities. As a crop they have a particularly high protein content, are suitable to large scale mechanised production systems and are non-perishable. These qualities, combined with the high value demand for the soybean oil, has resulted in a coupled increase with global livestock production, who feed mostly on the soybean cakes produced when extracting the oil. As seen in Figure 4, almost 90% of the global soy production is processed to produce cakes (81%) oil (19%). Almost all the soybean cake produced (99%) is used in the livestock sector.

Figure 4: An estimation of the uses of soybean and soybean derivatives by weight (Fraanje and Garnett ,2020).

For farmers in South America, the ever-growing demand for soybeans has pushed up the value of land leading to the large-scale conversion of uncultivated areas, including primary rain forest, into crop or grazing land. As the global population continues its trajectory to reach 11 billion by the end of the century, and the world's expanding middle class demands more livestock products, demand is unlikely to slow. It is estimated that global soybean production will increase on average by 2.2% per annum and as land availability becomes increasingly restricted this will increase the pressure on land conversion in South America (Tadayoshi and Goldsmith, 2009).

Soybean production has increased exponentially in the last 50 years. In South America alone, the amount of land used for soybean production increased more than 200 times, from 0.26 Mha in 1961 to over 57.08 Mha in 2017. According to the WWF, is the second most important driver of deforestation on the continent (after beef cattle ranching; World Wildlife Magazine, 2018). Prior to 2006 it was estimated that 30 percent of soy field expansion had occurred through deforestation (Gibbs et al., 2015), contributing to record deforestation rates during the period from the late 1970s to the early 2000s. Even today it has been estimated that 1/5 of all imported soybeans are linked to deforestation (Rajão et al., 2020).

Deforestation rates in the primary humid tropical forests of the Brazilian Amazon declined significantly in the early 2000s (Tyukavina et al., 2017), a result attributed to the Amazon Soy Moratorium (Greenpeace, 2020). Under this moratorium, signatory traders commit to not purchase soy grown on Brazilian Amazon land cleared after July 2018.

However, whilst historically most attention has been paid to deforestation in the Brazilian Amazon, there is increasing concern about land use change in other areas such as the Brazilian Cerrado and the Gran Chaco region in Argentina and Paraguay. While the savannas and woodlands of the Cerrado and Gran Chaco are less protected by legislation on deforestation, they too support high biodiversity levels, are major carbon sinks, and provide important ecosystem services (for example, the Cerrado and parts of the Gran Chaco are home to one of the largest aquifers on earth; Farm animal investment risk & return, 2022). In a paper by Lima et al in 2018, they labelled the Cerrado as the new frontier of soy production as buyers reposition themselves to get around the Soy Moratorium. This has led to a group of Brazilian NGOs calling for the Cerrado Manifesto in an attempt to extend the same restrictions to this species rich area (Farm animal investment risk & return, 2022).

The direct cause of the deforestation has also changed over the last two decades and maybe hiding the true extent of deforestation caused by land conversation for soy cultivation. Whilst in previous decades much of the land use change for new agricultural land was driven by the direct conversion to cropland, evidence has shown a shift in the primary direct cause of deforestation as large cattle ranches expand and take up new land for beef production (Kuschnig et al., 2019). According to a 2017 study on deforestation in the Amazon Basin, 63% of primary forest destruction between 2000 and 2013 was for grazing land for beef ranches, whilst only 9% of primary forest destruction was for crop land (Kuschnig et al. 2019). However, a new pattern of land use has been observed whereby cattle pastureland is being converted to soy production. This leads to a displacement of cattle grazing land which in turn drives the clearing of primary land for cattle ranching (Fraanje and Garnett, 2020). And so, whilst direct deforestation for soybeans in the Amazon declined significantly after the implementation of the Soy Moratorium, the overall acreage under soy production increased by 24 million ha between 2000 and 2010 (Fraanje and Garnett, 2020). Such a significant increase is therefore only possible through the conversion of pastureland and the conversion of new agricultural land outside the designated soy moratorium zone.

Recent developments in Brazil's politics have fuelled concern about both an expansion of land conversion in the Amazonian basin as well as the Cerrado area and other primary temperate forests and marshlands in Brazil. The government of Brazil has clearly stated its intention to further exploit the rainforest (Philips, 2019) and in 2019 the President cancelled a 10-year-old ban on sugarcane cultivation in the Amazon and Central wetlands, raising concerns that the Soy Moratorium will also soon be under threat (Teixeira, 2019). Indeed, figures released by the Brazilian Space Institute, INPE, in November 2020 showed at least 11,088 sq km of rainforest has been cleared between August 2019 and July 2020 – the highest figure since 2008. The devastating forest fires in 2019 have been linked to this recent rise in deforestation that some have said are as a result of the predevelopment policies of the current government (Escobar, 2019).

2.2.2 The environmental impact in the EU's main soya bean trading continent (South America)

It should be noted that this section of the report will only deal with the environmental impact of soy production in South America and will not deal with the social impacts, such as land requisition, intimidation and health impacts which will be dealt with in section 2.3.

The environmental impact of soy production in South America is twofold. In the first instance there is the impact of the clearance of uncultivated land, including savannas, forests and grasslands for agricultural land. Secondly there is the system of production itself – large scale intensive monocropping across 1000s of hectares. The deforestation and transformation of the forest and savanna land in South America has not solely been a result of soybean production. There are many factors at play, not least mining and logging, but also sugar cane crops and cattle ranching. However, as a primary driver of land use change in the region, soybean production is both directly and indirectly responsible for a significant part of the effects detailed here (Santibañez, F. and P. Santibáñez, 2007; Fehlenberg et al., 2017).

Biodiversity

The ecological impacts of this large-scale transformation of the landscape are significant. The eventual conversion of native forests and savannas to cropland directly reduces plant diversity, and indirectly reduces animal diversity by way of reduced habitat and disruptions to the balance of predator and prey species (Tabarelli et al., 2010). This is particularly impactful in South and Central America, a region which is the repository of the world's richest biodiversity, containing an estimated 40% of the Earth's plant and animal species (UNEP, 2002). Whilst only a fraction of Amazonia's ecosystems have been catalogued and studied, the area is believed to host 40,000 species of plants and trees, 2.5 million species of insects and 2000 species of mammals and birds (Butler 2021). The concentration of biodiversity is not only limited to the Amazon basin, the adjacent areas are as rich in biodiversity; the Cerrado area holds around 5% of world biodiversity and of its 11,000 plant species, nearly 50% are found nowhere else on earth (Fraanje and Garnett, 2020).

It is estimated that over the last 40 years, 18% of the forest in the legal Amazon region, 50% of the native vegetation in the Cerrado, Pampas and Caatinga and 88% of the native vegetation in the Atlantic Forest has been cleared primarily for agriculture (Ferreira, 2015). WWF's living plant index has calculated that species populations in South American tropical regions have fallen on average by 60% since 1970 (Fraanje and Garnett, 2020). According to the International Union for the Conservation of Nature (IUCN), about 137 living species are driven into extinction each day in Amazonia (Muller, 2020).

The reason for these dramatic figures is down to both the direct effect of the deforestation, the resulting effect of this deforestation on the remaining forest, and the subsequent fragmentation of forests by growing infrastructure. For example, many larger animals such as the ocelot *(Felis Paradalis*), or a number of primates, are unable to survive in the small remnant patches of forest. Remaining degraded forests become more vulnerable to drought and lose their resilience to induced or natural forest fires and serve as 'fire bridges' to primary forests nearby (Muller, 2020).

Recent modelling shows that by 2050, climate and deforestation combined could cause a decline of up to 58% in Amazon tree species richness (Gomes et al., 2019). According to the IUCN's Red List criteria, depletion of the Amazon's 14,000 species of trees may cause other species to lose an average of 65% of their 'original environmentally suitable area', threatening with extinction more than half of the region's animal and plant species (Muller, 2020).

<u>On Water</u>

Land conversion can have far-reaching effects on watershed hydrology, morphology and water quality. In the case of the affected forests in South America, the reduction in forest vegetation reduces evapotranspiration thereby affecting precipitation patterns. Forests create their own rain as leaves give off water vapour and this falls as rain further downwind. If large areas of rainforest are lost, rainfall levels in the region decline accordingly. In a study by Staal et al. (2020), the reduced level of "atmospheric moisture recycling" was simulated through computer modelling to estimate the effects that this would have on the region which led the authors to warn of a 'tipping point' that, combined with climate changes, could be only decades away. If such a tipping point were reached, large areas would start to lose trees and shift to a savannah-like mix of woodland and grassland and thus create a downward spiral effect (Staal et al., 2020).

When referring directly to soybean agriculture, Hayhoe et al (2011) estimated that that total water export can be three to four times higher in water sheds dominated by soy crop lands compared with forest (Hayhoe et al., 2011). Indeed, research shows that higher rainfall interception in soybean fields compared to tropical forests, combined with faster runoff due to soil compaction in these fields reduces the amount of water percolating into deeper soils and groundwater which can lead to reduced water availability in the long term (Base et al., 2012), while increasing the risks of floods downstream.

Water quality is another growing concern in the region, as both soil and agrochemical runoff cause pollution and change the ecological balance of water courses in the region. The scale of monoculture in soybean growing is vast, with very little diversity in crop lands or rotations. As with any large systems of production that cultivate single crops over large areas, soy monocultures minimise ecological services and become more dependent on chemical inputs to control pests (Tadayoshi and Goldsmith, 2009). Brazil currently uses 193 EU banned pesticides and it has been estimated that Brazil uses more than twice as much fertiliser on soyabeans on average than in the EU (34kg per tonne of soyabean compared with 13kg in the EU). Brazil's use has doubled since 1990 to 60kg per tonne in 2014 (Fuchs et al., 2020).

<u>On soil</u>

Soil erosion from a lack of soil cover from land clearance is compounded by a loss in organic matter, compaction and acidification in the area. The principal problems of soil degradation that affect the region of southern America include: water erosion, wind erosion, advancement of dunes, extraction of soil, salinization, drainage problems, loss of fertility, acidification, soil compaction, loss of soil structure, biological degradation, desiccation of fertile plains and valleys, landslides, and irreversible changes in soil use and pollution (Santibañez, F. and P. Santibáñez, 2007).

A number of studies have focused on estimating the loss of soil in the Cerrado region which has experienced a higher rate of deforestation in recent years. Life cycle analysis of soy production in the Cerrado found soil erosion losses of around 8 tonnes per ha per annum (Mattsson et al. 2000) and a 2015 study by Oliveira, Nearing, and Wendland (2015) found that the runoff coefficients of experimental plots increased from less than 1% under native Cerrado vegetation to approximately 20% when the vegetation was removed, while measured soil loss rates went from 0.1 to 12.4 Mg ha^{-1} yr^{-1} (Nearing and Wendland 2015).

Soil erosion has two major impacts. Firstly, eroded soil runs off into the water systems, silting up water courses and changing the delicate ecosystem balance of many biodiversity rich water courses, causing biodiversity loss, flooding, and hampering river transportation. Secondly, it eventually leads to land abandonment as agriculture becomes non-viable on eroded soils, which in turn accelerates expansion of the agricultural frontier onto new land.

On the climate

The Amazon plays a huge role in the earth's climate as a massive carbon store. Any destruction of the large swathes of forests in the area will affect GHG emissions both by removing the forest's capacity to absorb carbon, and through converting forest and savanna to cropland, releasing substantial amounts of carbon dioxide into the atmosphere, contributing to global warming. As an example, each hectare of Amazonian forest stores between 289 and 250Mg of CO_2 in the soil and above and below ground biomass, and each hectare of Cerrado savanna stores between 97 and 170 Mg of CO2 (Muller 2020) . In contrast, a hectare of land planted in soy in the Amazon or Cerrado returns only 0.9 Mg of CO_2 to the soil each year (Fargione, 2008).

Whilst the destruction of the Amazon Rainforest and its link to climate change is often discussed, the area of the Cerrado is referred to less, yet it is equally important in terms of carbon sequestration capacity and has been greatly affected by land use change in the last 10 years. The Cerrado area is also hugely important as a carbon sink due to its extensive and deep root systems with about 70% of the biomass of this 'upside down' forest underground. Recent studies suggest it may hold some 65 tonnes of carbon per hectare (De Castro, E. & Kauffman, J., 1998)

Whilst figures vary, it is estimated the Amazon rainforest alone absorbs a quarter of the 2.4 billion metric tons of carbon that global forests absorb each year. The ability of the rainforest to pull in more carbon than it releases is diminishing, weakened by changing weather patterns, deforestation and increasing tree mortality, among other factors. According to the European Union's Copernicus Climate Change Service, the 2019 fires have led to a clear spike in carbon monoxide emissions as well as planet-warming carbon dioxide emissions, posing a threat to human health and aggravating global warming (Freedman, 2019). A recently published study by Covey et al in 2021 estimates that due to the cumulative impact of land use in the Amazon rainforest, it is now most likely a net contributor to the warming of the planet (Kristofer, 2021).

Inevitably, this shift in the Amazon rainforest's role in both absorbing and emitting carbon will have a fundamental impact on the global efforts to keep climate change below 1.5C increase from preindustrial levels.

2.3 Social and welfare effects of soya production and trade

The EU has long been reliant on international trade to make up for the shortage of soybean in the domestic market, resulting in the establishment of soybean import routes primarily from such countries as the U.S., Argentina, and Brazil. While economic studies emphasize welfare gains generated from such trade relations around the world, they often disregard numerous social effects of soybean production on local communities in key crop producing areas of Latin America, reported in both academic and grey literature. These effects may include employment, labour relations, population health etc. It may be shown that locals can win in the short run at the expense of having more jobs or participating in trade but lose in the long run as the detrimental effects on environment and health accrue.

2.3.1 Summary of soybean imports to the EU

The EU countries have long been reliant on international trade to refill their soybean stocks. Figure 5 and Figure 6 show the state of imports of soybean products to the EU over the last twenty years. Brazil, the U.S., and Argentina remain the main importers of both soybeans and soybean by-products (flour and meal), with an aggregate share in imports fluctuating in the range between 49% and 85%. Brazil has long been the main importing country, but its dominant position has been recently challenged by the U.S. Figure 7 also shows that the three countries significantly increased their soybean cultivation areas in response to a strong international demand. Additionally, their productivity of soybean production, expressed in terms of amount harvested per ha, also grew (Figure 8).

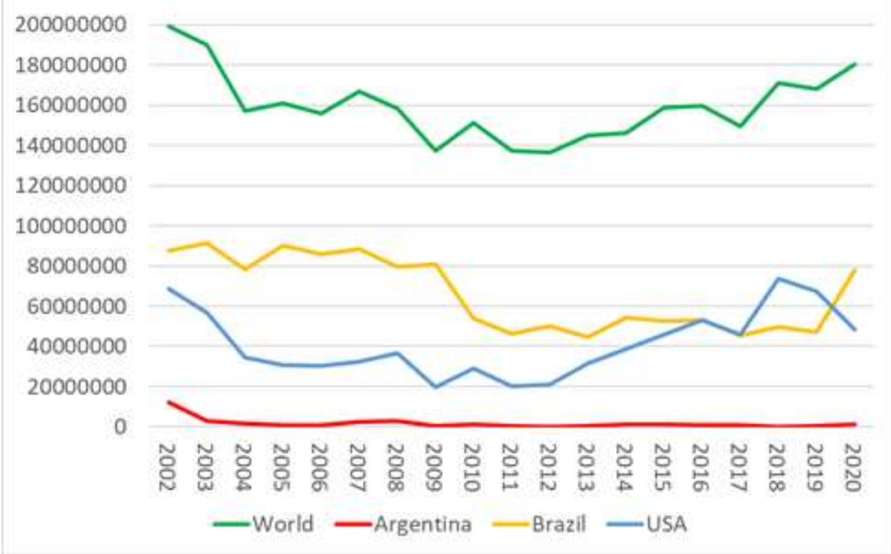

Figure 5: Total imports into EU-27:beans + flour & meal (Source: Eurostat)

Figure 6: Yearly share of ARG+BRA+USA in imports to EU-27(Source: Eurostat)

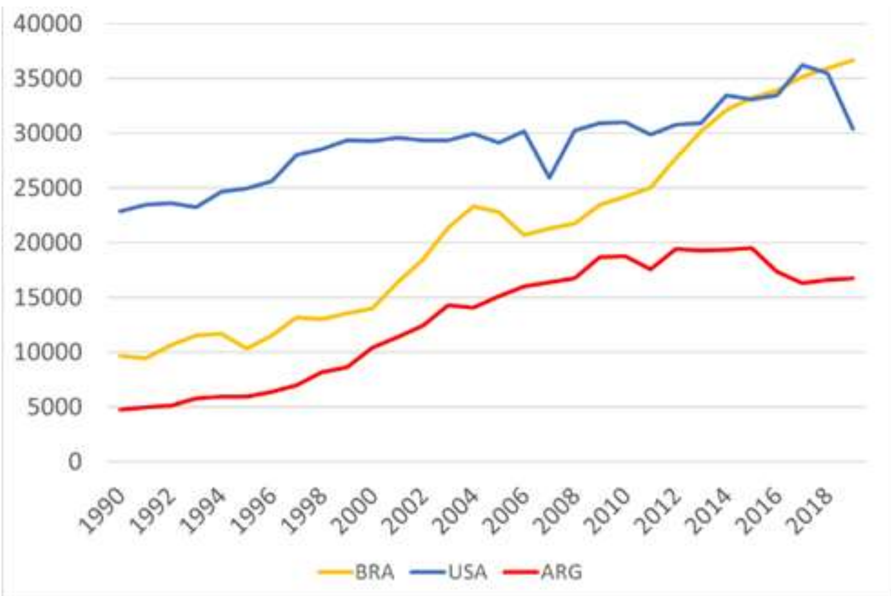

Figure 7: Area under soybean cultivation (Source: OECD)

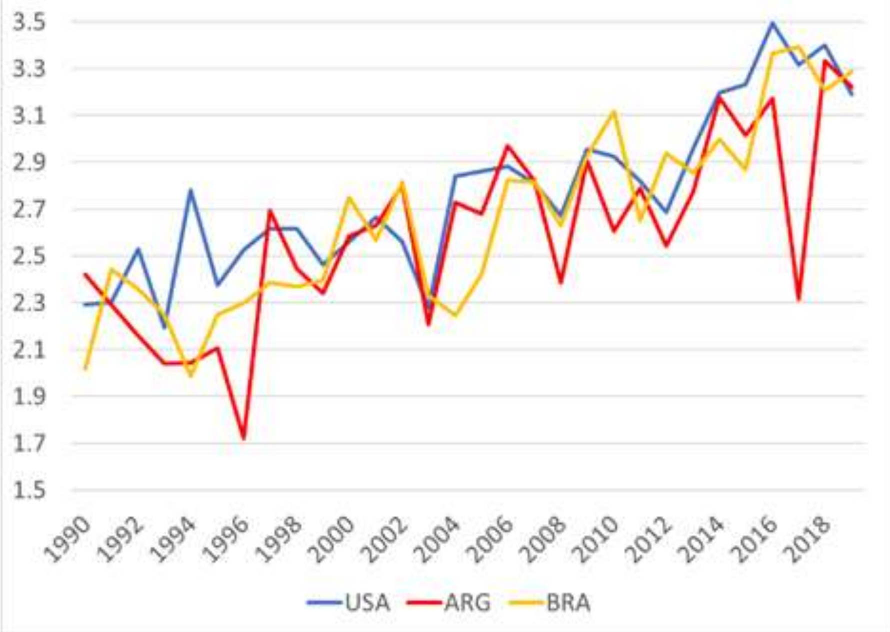

Figure 8: Soybean productivity (tons/ha) (Source: OECD)

2.3.2 Welfare effects of soybean trade

Several economic studies explored the effects of international soybean trade at an aggregated societal level, using such methods as cost-benefit analysis and welfare analysis. For example, Boerema et al. (2016) estimated a total monetary environmental and socio-economic impact of soybean trade between Brazil, Argentina, and the EU at $120 billion in 2008, which resulted in a net social benefit of $17.3 billion after deduction of several costs. Qaim and Traxler's (2003) results of welfare analysis of soybean production in Argentina, the U.S and the rest of the world showed that in 2001 society as a whole earned $1.2 billion as a result of implementing a genetically modified soybean technology, with consumers capturing 53% of this surplus. They also found that adoption of a genetically modified variety in Argentina resulted in an equal distribution of cost-reducing gains among both small-scale and large farms. In a similar study, Sobolevsky et al. (2005) estimated welfare gains from adoption of a gm-variety of soybeans in the U.S., Brazil, Argentina and the rest of the world, arriving at conclusion that both consumers and producers in all crop-growing areas increased their surplus when the cost of segregating gm-based and non-gm varieties of soybean is set to zero.

2.3.3 Social effects of soybean production

In general, social effects of soybean cultivation include primary or direct effects on labor and local communities, as well as secondary or indirect effects on human health and local communities mediated by changes in the local environment. On the one hand, local communities may increase their immediate prosperity and well-being through their direct involvement in cultivation and trade of soybeans. However, the long-term effects of large-scale soybean production may be detrimental to local environments due to, for example, increased use of chemicals or predatory re-cultivation practices, threatening both employment and health of locals.

Despite the growing significance of cross-continental soybean trade, the social effects of soybean production have received limited attention of researchers worldwide. Jia's et al. (2020) comprehensive review of international soybean supply chain management and sustainability, covering key crop-producing countries of Latin America, found that soybean production has been associated with such social issues as child labor or forced labor, poverty, land use conflicts, food security, and health impacts. Separately, Semino et al. (2009) identified a number of negative social effects associated with soybean cultivation in Argentina, including deterioration of human health resulting from increased herbicide use, as well as deforestation and depopulation of rural areas.

Several studies in Brazil explored the effects of soybean production on local employment and labor conditions in general. For example, Kamali et al. (2016) measured the employment index as working hours per ha per day for full-time, part-time, and casual labor involved in various soybean production systems. They found that organic system required more hours of employed labor compared to conventional production systems based on either genetically modified or non-gm cultures. Zortea et al. (2018) performed a life-cycle analysis of soya production using various environmental and social categories.

They found that both local employment and education and training of workers were among the worst affected dimensions of social sustainability, while the freedom of association and collective bargaining in addition to community engagement and supplier relationships all improved because of soybean production. van Berkum and Bindraban (2008) noted in their report that soybean cultivation practices in Brazil were historically associated with bad labor conditions, such as forced labor, but recent technological improvements reduced the demand for low-skilled labor, which also led to less labor abuse.

There are accounts of negative social effects of soybean production accumulated by non-governmental organizations too. For example, Yousefi's et al. (2018) investigation of soybean plantations in Argentina and Paraguay based on interviews with local farmers and community members showed the cases of negative external effects of extensive chemical application linked to soya production on both the quality of water and soil and on human health. Another investigation from Rainforest foundation Norway (2018) referenced the information from a local blog in Brazil linking extensive soya production practices to contamination of rivers supplying water to the indigenous communities. Also, this report collected multiple accounts of violent land grabbing, deforestation, forced labour, pesticide smuggling and increased instances of cancer in soya-producing areas. Similarly, Kuepper and Riemersma (2019) summarized findings from various sources such as media and non-governmental organizations showing the cases of land being forcibly expropriated from local communities to farm soy in Brazil and Argentina. While such activities are registered in soya-producing areas, they might be an indication of a broader institutional crisis affecting other crops too.

Sanginga's et al. (1999) comprehensive report of social impacts of soybean in Nigeria's Southern Guinea provides a rare look at how soybean cultivation practices affect lives of small-scale farmers in Africa. In general, it was found that adoption of soybeans had a positive impact on farmers' consumption and well-being. Specifically, an increase in income from soybean cultivation resulted in a higher index of material life, which is based on material purchases of such things as radios or bicycles. Simultaneously, it induced investments in human capital like schools or health services. Similarly, household consumption and production of soybeans were found to be associated with improved household food security and both the long-term and short-term nutritional status of children.

2.4 Protein export options with minimised environmental impact to African farmers

Agriculture faces new challenges such as feeding the world, meeting the demand for safe and nutritious food in line with rising world populations, increasing urbanization and growing incomes. Agriculture also generates jobs and supports the livelihoods of billions of rural people across the Earth, especially in developing countries.

60% of global arable land is in Africa. The continent has the potential to scale agricultural production capacity. To date, more than 200m people between ages of 15 & 24 years live in Africa and this is expected to double by 2045 – An opportunity for labour force and sustainability of the sector.

In line with the development of international trade, environmental concerns have arisen as a global problem. International trade has the potential to increase environmental externalities such as transboundary pollution, deforestation, transportation and production relocation avoiding environmental standards. Globalisation of food commodities is taking place at a large scale, disconnecting production and consumption. High income countries 'use' land abroad to 'virtually' increase their agricultural land, also referred to as 'virtual land use' or 'displaced land use. As a consequence, land and water resources needed for food production are displaced, virtually transferring the environmental impacts to the producing countries. The specific case is the trade in soybean, an important animal feed product, which in the recent past has exemplified the environmental and socio-economic impact of global markets and global agricultural policy.

This scoping study investigates the perception of farmers in Eastern Africa on matters related to increasing production of soybean in the exporting countries with related environmental consequences such as deforestation, grassland conversion. It attempts to highlight some options that take into account the needed balance between environmental and socio-economic impacts of an intercontinental market.

A systems analysis approach based on the perceptions of different farmer' stakeholder groups will be used to collect and analyze data. Using the study findings, EAFF will developed a position paper with recommendations as key building blocks to lobby policy makers and development partners in the whole of Eastern Africa region. This will ensure that there are appropriate support packages for farmers and their owned agribusinesses to guarantee that they are sustainable and create benefits for their families and respective economies at minimal environmental costs.

3 Food exports from the EU

3.1 Outcome of workshops in East African countries discussing social, environmental and economic pressures of food exports

The Eastern Africa Farmers' Federation (EAFF) is a regional farmers' organization whose membership consists of 23 national farmer federations, national co-operative organizations, and national commodity associations in ten countries in Eastern Africa: Burundi, Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, South Sudan, Tanzania, and Uganda. EAFF voices legitimate concerns and interests of farmers in the region, with the aim of enhancing regional cohesiveness and the social-economic status of farmers.

Since 2018, EAFF organized three workshops in selected East African countries with local farmers with the overall objective of discussing the role of farmer organizations in food systems transformation agenda. Specific issues raised during the discussions were improved farmers' understanding of sustainable agricultural production systems related to soil fertility and nutrient use efficiency, low productivity of African agriculture as compared to the one in EU, as well as the impact of climate change. The workshops' participants also gathered to discuss the needs of Eastern Africa farmers to effectively engage in action paths leading to equitable and sustainable food systems and opportunities presented by the United Nations Food Systems Summit 2021.

The three plenary sessions were complemented with the breakout sessions with farmers initially sharing their perspectives on the two issues: (i) Do EU food imports to Africa hinder African agricultural development and contribute to climate change? (ii) Do Africa's exports to the EU contribute to land grabbing and deforestation? Regarding the first question, participants observed that introduced under the CAP, subsidies depressed food prices worldwide, leading to detrimental effects on African farming economies. They also noted that in the recent past there has been progress in better aligning agriculture with international development goals. However, increasing international trade in agricultural products would not automatically lead to better outcomes as it could also damage the environment and lead to the displacements of local peoples among other negative outcomes. In terms of the second question, participants noted that while such developments are possible somewhere, they are not typical in the Eastern Africa region due to the small size of agricultural trade with the EU. There is, however, a potential interest in soya sourcing from the Democratic Republic of Congo and Uganda from the EU.

Eventually, participants were asked to discuss six questions focusing on key aspects of how to transform food systems in the Eastern Africa: agricultural policy, access to inputs and means of production, resilience, agricultural land, agricultural finance, and inclusion. In relation to policies affecting agriculture, members noted that some of the constraints facing farmers include limited understanding of the existing agricultural policies as well as the contradictory nature of those policies. On the subject of access to inputs and means of production, it was noted by participants that agricultural inputs remain underused in Africa due to their low affordability and incompatibility with local agri-ecological conditions. Regarding resilience and the ability to confront weather conditions, farmers pointed to low resilience levels among the farmers in the area due to lack of both storage facilities and climate-resilient varieties of cultures. Speaking of the issue of agricultural land, participants mentioned that in most countries land policies aren't favourable to farmers while other problems such as cultural barriers and prohibitive taxes hinder farmers from accessing land. In terms of agricultural finance, participants remarked that unfavourable loan prepayment schedules, lack of collateral insurance, and lack of proper financial policy are main constrains to securing funding. Finally, speaking of inclusion, farmers noted low rates of participation among women and youths in farming and suggested the local governments to reconsider their policies to make it easier for minorities to access land.

3.2 C, N, P flows in terms of food exports from EU to Africa

The nutrient flows from the EU-28 to Africa were equally calculated like the imports from South America into the EU (see method and assumptions in Chapter 2.1). The export of European food items to Africa was shaped by an excessive amount of >2 100 kt wheat, which were approximately 69 % of the protein exported from the EU-28 to Africa in 2013-2017 (see Table 4). In total, the EU exported 1 511 kt of carbon, 504 kt of nitrogen and 41 kt of phosphorus.

Table 4: Exported food items from the EU-28 to Africa (mean, 2013-2017)

Item	Mass [kt]	Protein mass [kt]	C mass [kt]	N mass [kt]	P mass [kt]
Wheat	17 897.2	2 183.5	1 048.1	349.4	28.4
Barley	1 472.7	176.7	84.8	28.3	2.3
Malt	764.1	100.1	48.0	16.0	1.3
Milk, skimmed dried	215.6	78.0	37.5	12.5	1.0
Meat, chicken	498.9	73.3	35.2	11.7	1.0
Broad beans, horse beans, dry	292.9	68.5	32.9	11.0	0.9
Maize	715.6	68.0	32.6	10.9	0.9
Flour, wheat	601.4	65.6	31.5	10.5	0.9
Food wastes	301.4	52.7	25.3	8.4	0.7
Milk, whole dried	156.6	41.2	19.8	6.6	0.5
Cake, sunflower	73.1	29.2	14.0	4.7	0.4
Cattle	214.8	25.8	12.4	4.1	0.3
Miscellaneous	8 371.9	186.1	89.3	29.8	2.4
Total	31 576.1	3 148.7	1 511.4	503.8	40.9

In contrast to the imports from South America, the traded items were more related to animal products in the European export product range. Around 12 % of products belong to categories related to animals: almost 4 % were dried milk products, 3 % were chicken meat and cattle. Table 5 gives an overview of the main seven FAO categories. The significant majority of protein exports of 78 % to Africa were “cereals and cereal products”, followed by “fodder crops and products” and animal products.

Table 5: Distribution of protein exports of the EU-28 to Africa over the FAO product groups (top 7)

Group	Mass [kt]	Protein mass [kt]	Protein share [%]
Cereals and cereal products	22 350.2	2 670.5	77.94
Fodder crops and products	851.1	217.5	6.35
Products from live animals	895.7	162.5	4.74
Products from slaughtered animals	973.9	149.0	4.35
Pulses and derived products	330.6	76.9	2.24
Livestock	514.7	61.8	1.8
Tobacco and rubber and other crops	465.6	24.2	0.71

Figure 9 shows the recipient African countries individually. The main destinations inside Africa for European protein export were Algeria, Egypt and Morocco. Algeria (DZA) imported 837.6 kt proteins or one in four of the proteins exported from the EU, which seems unreasonable high. Analysing the data, there are no indications that Algeria does function as a proxy country for the export of goods to Africa. No further distribution to other African countries are included in the FAO data. Egypt imported 485.7 kt proteins and Morocco 417.9 kt which represented both >10 % of the exported proteins from the EU to Africa, followed by Libya (approximately 6%) (See Annex Table 6)

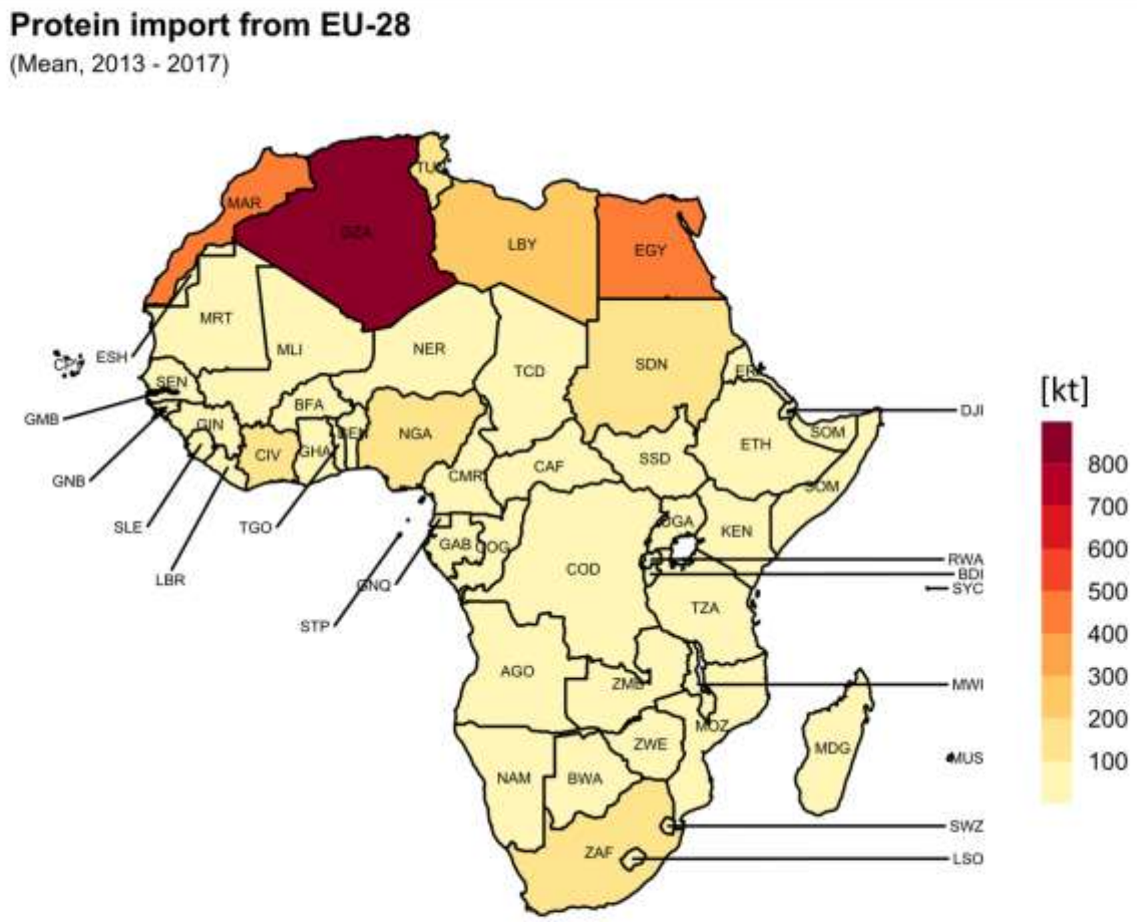

Figure 9: Main importing countries of European nutrients through food trade in Africa (mean, 2013 – 2017)

3.3 The impact that policy and market measures for food trade have on nutrient flows to and from Europe

Nutrient flows to and from Europe cover an extremely wide range of products, and related policies, and include all food and drink exports and imports, fertilisers, waste contracts, biomass in the form of timber and other products, natural fibres for clothing, and so on. In this section of the report, we will specifically focus on the area of most concern to the Circular Agronomics project: livestock.

The Circular Agronomics project focuses on improving the efficiency of nutrient cycling within EU agriculture; both to reduce resource use and promote better reuse of nutrients and carbon, and to reduce emissions into the air, water and soils. The technologies and practices being tested and developed within the project are crucial in helping the European Union to meet its environmental and climate targets and will likely play an important role in contributing to reducing the impact of the agricultural sector. But whilst it is evident that such innovations will be imperative in reducing the impacts of the sector, many question whether they will go far enough when we consider the scale of the nutrient flows into and out of Europe and their resulting effects. Notably because a substantial percentage of these flows relate to livestock production (Sutton et al., 2013).

The European livestock sector has increased significantly since the mid-20th century; its rapid expansion being enabled by significant technological and structural change in livestock farming systems. This has been marked by a greater concentration of livestock production in certain areas of Europe, and a move away from pasture-based feeding to more scientifically formulated and nutrient dense crops and oilseed cake (Buckwell and Nadeu, 2018).

In 2017, the EU Produced 47 million tonnes of meat, making it the second largest meat producer in the world, accounting for 14% of global production (Eurostat 2013). The greatest growth area has been intensive feed-based livestock systems, especially monogastrics (pigs and poultry; Buckwell and Nadeu, 2018). Indeed, Europe remains the largest exporter of pig meat globally, closely followed by dairy products (European Commission, 2020).

Such a vast livestock sector needs inputs, and currently it is estimated that the animals farmed in Europe consume 57% of the cereals grown in the EU. 70% of the protein-rich feed derives from cereals (40%) and soyabean meal (29%) (FEFAC, 2017). But whilst the EU is 91% self-sufficient in cereal production for feed, it is only 5% self-sufficient for soyabean meal. 60% of the protein meals used in the EU come mostly from imported soya meal and soybean and with some from palm products (European Commission, 2017). Consequently, the EU is one of the largest soya importers in the world (although the demand from China is rapidly growing).

This growth has had substantial global effects. In South America, as shown section 2.2, the coupled expansion of the soybean production had directly contributed to large scale deforestation, a loss of carbon sequestration and growth in GHG emissions, loss of biodiversity, disruption of climatic systems, soil erosion and pollution. Equally, the resulting inflow of nutrients into Europe to support the extensive 'landless' livestock sector is also having detrimental effects on the environment and climate. The sector is still an important emitter of GHG emissions, mostly methane and nitrous oxide, from animals, their manure, and from the production of their feeds. In addition, the leakage of nutrients such as nitrogen and phosphorus and their compounds cause serious water pollution, eutrophication, and air pollution.

Inevitably this resource intensive form of production has come under growing scrutiny and there are many that have advocated that the European Union address their policies, including trade agreements, to reduce the import of soybeans and move towards a smaller pasture and food waste system of production. Any reduction in soybean imports from South America would reduce land use pressure and its effects in South America (and other soy producing countries). In Europe it could reduce the size of some sectors of European livestock production, most notably pigs and poultry (Karlsson et al. 2021) which would in turn bring down emissions to water, soil and air (as long as Europe maintained its strict environmental regulations).

The Green Deal is the EU's flagship climate and environmental strategy. It is the EU's plan to make the EU's economy sustainable, '*by turning climate and environmental challenges into opportunities, and making the transition just and inclusive for all'* (European Commission, 2022). It short, its aims to make Europe climate neutral by 2050, boosting the economy through green technology, creating sustainable industry and transport, and cutting pollution (European Commission, 2019). The associated Farm to Fork and Biodiversity strategies include targets to increase land for biodiversity, increase the percentage of European agricultural land that is farmed organically to 25%, reduce nutrient losses (and thereby fertiliser application) and increase agroforestry. This will increase pressures on current land use in Europe. As mentioned above, the livestock sector within Europe accounts for 57% of cereals gown in the EU, a significant area of land which is further added to through soy products covering hundreds of thousands of hectares in Brazil. It has been argued that if Europe is to move towards a lower input method of production (with potentially lower yields) and dedicate more land to carbon sequestration and biodiversity, at a time of a growing global population, it seems unlikely that this can be done with the current livestock numbers and densities (Buckwell et al., 2020). The Netherlands, an EU member state with high livestock densities, has already started taking steps in this direction (Levitt, 2021).

In addition, the structure and size of the livestock system is likely to considerably slow agriculture's contribution to the reduction of GHG emissions in order to meet the European Climate Law legally binding target of net zero greenhouse gas emissions by 2050. Agriculture is currently responsible for 10.3% of the EU's GHG emissions and nearly 70% of those come from the animal sector (EEA, 2019).

The management of livestock manure is another source of concern that could be tackled by reducing the size of the livestock sector. Current livestock systems, often concentrated in certain EU regions and under high densities, produce large amounts of manure that need to be managed. In densely populated livestock areas, there is often not enough agricultural land to recycle the manure and alternatives need to be found to avoid further pollution of waters. Meeting the targets of the Water Framework Directive and the Nitrates Directive is challenging for some EU member states often leading them to fail to meet the objectives of the targets.

Going back to the large-scale import of animal feed proteins, it has long been recognised by the European Union as a concern, both for the reliance of Europe on the production of other countries, but also for its environmental impact overseas. In the Farm to Fork strategy, the EC states that it "*will examine EU rules to reduce the dependency on critical feed materials (e.g. soybean grown on deforested land) by fostering EU-grown plant proteins as well as alternative feed* *materials such as insects, marine feed stocks (e.g. algae) and by-products from the bio-economy (e.g. fish waste)"(European Commission 2022)*.

In an analysis of the strategy by the European Environmental Bureau they argue that '*the ambition is not proportional to the scale of nutrients pollution in the EU. To achieve truly circular nutrients management and end pollution, all new inputs of nutrients must be drastically reduced and nutrients in the system must be better recycled. This means phasing out synthetic fertilisers and livestock feed imports, and halving food waste across the whole supply chain, areas where the Strategy is rather weak*' (European Environmental Bureau, 2019).

Restriction of soybean imports may be problematic vis a vis previously agreed upon trade policy. In 2018 the then Commission President Jean Claude Juncker, used soybeans in a negotiation with President Trump to allay the tariff dispute on steel and aluminium, pledging to buy more soybean from the United States (Valero, 2018).

One way that harmful soy production could be reduced would be through environmental regulations on all imports. However, EU trade agreements do not require imports to be produced sustainably. Instead, a patchwork of rules, some mandatory, some voluntary, govern the sustainability of agricultural imports into the EU. The 2018 Revised Renewable Energy Directive stipulates that oilseed such as soyabeans should not be sourced from recently deforested land (European Parliament 2022) but such requirements are often limited in scope and poorly enforced (Fuchs et al., 2020). Indeed a 2018 study found that only 14% of all soy companies could trace their goods back to the farm of origin (Haupt et al. 2020). Signatories to the EU Mercosur pact for example, only agree to strive to improve their environmental and labour protection laws (Fuchs et al., 2020) and an analysis by the Greens in the European Parliament has predicted that the agreement's abolition of export duties will lead to a reduction in the cost to export soybeans and soy meal to the EU, making them more competitive (especially vis a vis European produced soy) and therefore lead to probable increase in production (Ghiotto and Echaide, 2019).

In 2018 the European Commission published its Protein Plan (European Commission, 2018) to look at ways for the EU to produce more of its own plant proteins. Through the plan the Commission aims to support farmers growing plant proteins via the proposed future CAP, by including them in national CAP strategic plans, in particular through rewarding the benefits of legumes for environment and climate objectives through eco-schemes and environmental/climate management commitments under rural development programmes; mobilising rural development support e.g. to stimulate investments and cooperation along the food chain and coupled income support(European Commission, 2018). However even if the EU plans to support plant protein production in the EU through a series of measures, producers will still have to follow the EU's strict environmental regulations and may fail to compete on price against soy bean imports, especially in light of the Mercosur Trade agreement. A solution will need to be found to address these challenges.

The Farm to Fork is an important strategy in that it recognises the detrimental effect of the enormous nutrient flows as a result of the livestock sector, and importantly aims to tackle the issue at all stages of the food chain, including consumption. Yet it only addresses the consumption and production of meat, dairy and eggs in the EU and fails to propose parallel targets to govern the impact of external trade putting the F2F into jeopardy, potentially limiting the EU's ability to meet its own targets, but also expanding its land use outside its own borders leading to greater environmental and climatic effects. According to a recent paper in Nature, the European Union must streamline and align environmental standards for imports and domestic production and enforce them with customs checks. Because although the EU cannot enforce standards of production elsewhere, it can require that good entering the European market meet its own regulations (Fuchs et al., 2020).

Addressing the size of the livestock sector in Europe could contribute to solving some of these issues. The European livestock sector is currently operating far outside its safe operating space (Buckwell and Nadeu, 2018) (as determined in part by its GHG emissions and nutrient use) and actions on both innovation *and* a constriction of the sector will be required in order to return it to its safe operating space. Certainly, the size of the sector may in part be affected by any reduction of soy imports and price increase, and European policies such as the implementation of environmental directives, the Climate Law, the revised LULUCF and the work on reducing consumption will be critical. But to show that the European Union is signed up to reducing the global impacts of the nutrient flows associated with livestock production, the Common Agriculture Policy will need to be aligned to the F2F objectives, not least moving away from a system that makes it more financially advantageous to move away from regionally dispersed pasture/waste systems of production towards highly efficient yet centralised feed dependant units.

4 Conclusions

The import of goods from South America to the EU-28 is characterized by the high proportion of protein rich animal feed products, mainly soybeans and soybean cake. In the analysed timespan, protein made up 28.3 % of the total imported mass of the products included in the FAO data with soybean cake and soybeans contributing to approximately 90 % of the nutrients in proteins, totalling an average of 11.6 Gt a^{-1}. It can be concluded that the European animal industry is a key enabler for the South American export economy. Vice versa the high contribution of soy products to the total trade volume indicates, that soy export is an indispensable driver in the economic structure of the main exporting countries Brazil, Argentina and Paraguay.

In contrast to the import from South America, the mean protein content of goods exported from the EU-28 to Africa in the timespan from 2012 to 2017 is merely 10 %. Most of the nutrients in proteins in the export volume come from cereals like wheat and barley (77.9 %), while fodder crops only make up 6.4 % of the exported protein related nutrients. The target countries of export are mainly Algeria, Morocco and Egypt (51 % of nutrients in proteins), while the remainder is exported to the other states of the continent. Animal products (e.g. skimmed milk and chicken meat) have an increased importance in the EU-28 export compared to the import from South America, totalling around 12 % of the exported protein. As expected, the European animal industry that is co-driven by protein imports has a higher significance in the European export.

Soybean production is a major driver of land use change in South America and directly or indirectly causes large scale conversion of primary forests, savannahs and grassland into cropland for soy cultivation. Whilst efforts have been made to slow the deforestation of the Amazon rainforest through the Soy Moratorium, this has resulted in accelerated land use conversion elsewhere, and the Moratorium itself may also be under threat under the current Brazilian administration. The land use conversion reaps catastrophic results on the regions biodiversity, soil and water and has grave implications for the global fight to slow climate change. The European Union, as the second largest importer of soybean from South America, is itself a direct driver of this unsustainable market.

While the international soybean trade may lead to increased welfare gains and create employment opportunities, it is also important to remember about the long-term detrimental effects on the environment and health of local communities in major crop producing countries. More sustainable trade relations between the EU and key importers of soybean should be established to minimize the odds of land grabbing, labour abuse, and environmental degradation.

The European livestock sector has increased substantially since the mid-20th century, enabled by significant technological and structural changes in farming systems, and a move away from pasture-based feeding to processed feeds developed from oil seed. Most of this growth has occurred in feed-based livestock systems and has led to the EU becoming the number one driver of the soybean trade globally. As discussed in section 2.2., this massive trade of nutrients in the form of soybean trade is directly driving up climate and nutrient emissions both in South America and in Europe, and leading to damaging environmental impacts on both continents, thereby creating a major barrier to the European Union reaching its climate and environmental targets. Therefore, compulsory and verified environmental conditions on soy production would have to be integrated into trade deals, such as Mercosur Second, steps need to be taken to reduce the impact of the livestock sector on climate change and nutrient fluxes. Whilst major innovations are ongoing to reduce the impact of the sector, some EU member states have already started questioning whether current objectives in the Green Deal and Fit for 55 can be met without a reduction in the overall size of their livestock sector.

This report has shown that in order to manage nutrients in a more sustainable way and reduce greenhouse gas emissions from agriculture, part of the focus needs to be placed on the wider context that enables our current crop and livestock systems to develop, such as trade of fodder and food products. We have placed particular emphasis on soybean imports from South America and looked at the economic, environmental and social effects of its international trade.

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Annex

Table 6: Protein mass import of African states from EU-28 (mean, 2013 – 2017), overview

Country	Protein mass [kt]	Country	Protein mass [kt]
AGO	78.1	MDG	6.6
BDI	2.6	MLI	33.5
BEN	28.9	MOZ	26.3
BFA	15.5	MRT	42.0
BWA	1.9	MUS	16.6
CAF	2.3	MWI	4.0
CIV	95.6	NAM	10.7
CMR	61.4	NER	4.1
COD	40.5	NGA	118.7
COG	28.5	RWA	3.2
CPV	9.0	SDN	71.2
DJI	30.3	SEN	62.2
DZA	837.6	SLE	3.1
EGY	485.7	SOM	5.7
ERI	4.4	SSD	0.2
ETH	51.2	STP	2.8
GAB	28.2	SWZ	0.7
GHA	49.7	SYC	1.0
GIN	29.3	TCD	5.3
GMB	8.0	TGO	13.9
GNB	1.9	TUN	193.6
GNQ	6.6	TZA	24.7
KEN	59.1	UGA	14.1
LBR	7.7	ZAF	160.5
LBY	210.7	ZMB	2.8
LSO	0.5	ZWE	6.0
MAR	417.9		