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# ENVIRONMENTAL–ECONOMIC ACCOUNTING

## Land-use of food products 2008 – 2015

2018

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mn = Million

ha = Hectare

kg = Kilogram

g = Gramm

t = tons

$m^2$ = Square meter

Kcal = Kilocalorie

% = Percentage

X = Entry blocked, because statement not plausible.

FAO = Food and Agricultural Organization of the United Nations

# Introduction

Worldwide agricultural land is increasingly becoming a scarce resource. The main reasons are:

- Rapid global population growth resulting in higher demand for food.
- Increased energy crop cultivation requiring more agricultural land.
- Changes in nutritional habits increasing the consumption of luxury foods such as coffee and chocolate, fast food with high land use.
- A growing dietary share of animal proteins and fats requires a higher land use than a plant-based diet.

Industrial farming in Germany is leading to increased land use in foreign countries. On the one hand rising exports of agricultural goods and food products cause a higher demand for imported agricultural raw materials, which are used to produce these exports. This particularly concerns exports of animal products, especially meat, milk and dairy products. On the other hand domestic fattening farms and dairy farms use increasingly imported protein to feed the livestock.

Increased exports also require more domestic land. In addition more and more land is used to cultivate energy crop, leaving less land available for growing domestically consumed food products. This "gap" was partly compensated by increased land-use abroad.

Cultivating agricultural raw materials like oil seeds and fruits abroad often has high environmental impacts, such as slash-and-burn practices and high pesticide and industrial fertilizers use. Slash-and-burn-practices produce large volumes of harmful greenhouse gases. Additionally, they cause a high loss of species in the rain forest. Besides these environmental impacts the focus on export-oriented agriculture results in severe social problems such as the marginalization of small farmers.

# 1 Land-use for food of plant and animal origin

## 1.1 Agricultural land – domestic and abroad

### Increasing land-use of imports and exports of food of plant and animal origin

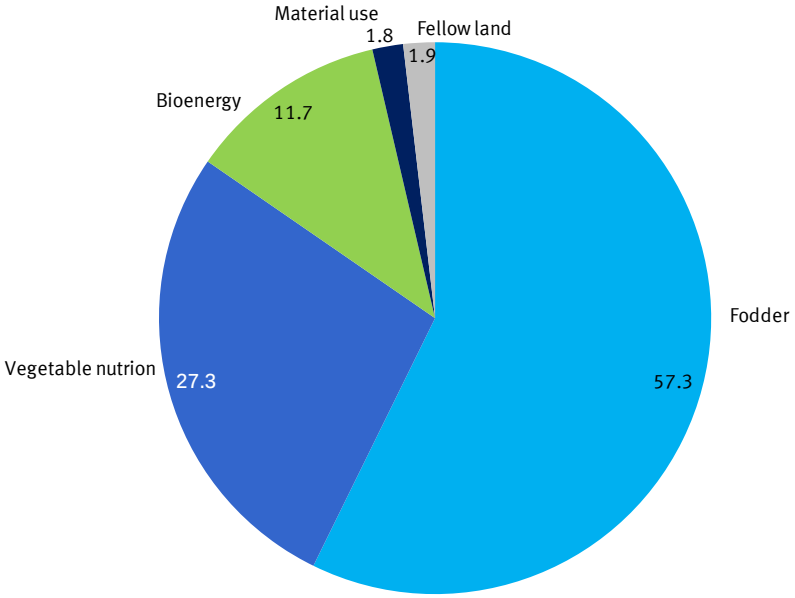
Agricultural land is used for growing food products and other agricultural raw materials like energy crops. Land for food products can be divided in „land used for products of animal origin“ and „land used for products of plant origin”.

The basis for calculating land-use of imports and exports of food products is the foreign trade statistics, which collects data on the volume of imports and exports. In a computational model data on the land used for agricultural raw materials is determined. In this model imports and exports of fodder are allocated to the category „animal origin“.

In 2015, agricultural land in Germany totaled to 16.7 million ha (cf. table 1), of which 14.2 million ha were used for nutritional purposes: 9.6 million ha for growing fodder and 4.6 million ha for plant based food products. In 2008 land used for nutritional purposes was 14.9 million ha. This corresponds to a decrease of 5.1 %. This decrease affects both land used for plant based food crops (– 8.7 %) as well as land used for fodder crops (– 3.3 %).

In 2015 57.3% of total domestic land area was used for growing fodder plants, 27.3 % for cultivating vegetable based food crops and 11.7% for growing energy plants. (cf. figure 1).

Figure 1 Domestic agricultural land by type of use in 2015
%



Among the 16.7 million ha (2015) of agricultural land, 11.8 million ha were arable land, 4.7 million ha were permanent cropland. The remainder is used for tree nurseries, orchards, christmas tree nurseries and domestic gardens and vegetables plots.

Between 2008 and 2015 land used abroad for imports increased by 10.6 %; for products of animal origin by 8.2 % and for plant based products by 11.4 %.

Table 1 Land-use – domestic and abroad – for food products of plant and animal origin

| Categories | 2008 | 2012 | 2015 | 2015 to 2008 |
|---|---|---|---|---|
| | in 1,000 ha | | | % |
| Domestic | | | | |
| Land-use for agriculture [1] | 16,926 | 16,667 | 16,731 | – ***1.2*** |
| Thereof: | | | | |
| Fodder [2] | 9,903 | 9,883 | 9,580 | *– 3.3* |
| Plant based nutrition | 5,009 | 4,355 | 4,575 | *– 8.7* |
| Energy plants [3] | 1,380 | 1,910 | 1,965 | *42.4* |
| Industrial use [4] | 323 | 304 | 300 | *– 7.3* |
| Fallow land, land set-aside | 310 | 215 | 310 | *0.2* |
| Exports [5] | | | | |
| Plant origin | 5,509 | 6,233 | 6,884 | *25.0* |
| Animal origin [7] | 5,027 | 5,423 | 5,229 | *4.0* |
| Total | 10,536 | 11,656 | 12,113 | ***15.0*** |
| Thereof imports | 3,735 | 4,519 | 4,871 | *30.4* |
| Plant origin | 2,713 | 3,306 | 3,667 | *35.2* |
| Animal origin | 1,022 | 1,213 | 1,204 | *17.8* |
| Imports [5] [6] | | | | |
| Total | 16,886 | 17,875 | 18,673 | ***10.6*** |
| Animal origin [7] | 4,159 | 4,440 | 4,501 | *8.2* |
| Plant origin | 12,726 | 13,435 | 14,172 | *11.4* |
| Thereof for domestic use | 10,014 | 10,129 | 10,505 | *4.9* |
| Thereof: | | | | |
| Fodder | 2,582 | 2,822 | 2,880 | *11.5* |
| Industrial use, energy use | 1,152 | 1,178 | 1,406 | *22.1* |
| Nutrition | 8,993 | 9,435 | 9,886 | *9.9* |
| Domestic consumption of food products | 20,141 | 19,329 | 19,411 | – ***3.6*** |
| Plant origin [7] | 9,399 | 8,534 | 8,634 | *– 8.1* |
| Animal origin [8] | 10,741 | 10,795 | 10,777 | *0.3* |

1 Federal Statistical Office, Subject matter Series 3, Land- und Forstwirtschaft, Fischerei; Series 3.1.2 Landwirtschaftliche Bodennutzung, various years.
2 Roughage and other preparations of fodder.
3 Excl. wood and other plant-based waste.
4 Incl. Christmas tree plantations etc.
5 Excl. re-exports.
6 Regarding cropland multiple counts of areas possible due to crop-rotation.
7 Excl. fodder.
8 Incl. fodder.

In particular, land used for producing exported goods rose substantially: it in-creased by 25% for plant based products and by 4% for products of animal origin.

## 1.2 Land-use of domestic consumption

### Less domestic land for food production, more land for energy crops and exports

When calculating domestic consumption of food products, crops used for energy or industrial purposes are excluded. Fodder is reclassified to the category „animal origin“. This makes it easier to estimate the total area required for domestic production and consumption of products of animal origin.

In 2015, the total area required for domestic food consumption was 19.4 million ha (cf. Table 1). It therefore exceeds the domestic area used for nutritional purposes by 5.3 million ha. Germany records an import surplus – in other words a “land deficit”. This import surplus corresponds with the balance of imports and exports.

Between 2008 and 2015 land used for domestic consumption of food products has declined by 3.6 %. Thereof land used for food products of animal origin remained almost constant, land used for plant based products fell by 8.1 %. The proportion of land used for products of plant origin was close to 45 % in 2015 and that for products of animal origin at 55 %. Since 2008 these shares have not changed substantially.

Domestic consumption of food products includes food products from domestic production and imports. Between 2008 and 2015 the import ratio of domestic consumption rose from 59.7 % to 64.4 %. Consequently more than half of the land used for growing food products is located abroad. There are big differences between products of plant origin and animal origin. The import ratio of domestic consumption of products of animal origin increased only slightly from 47.9 % to 50.8 % in the period 2008 – 2015.

The import ratio of domestic consumption for products of vegetable origin was substantially higher. In 2008 the import ratio was already 73.2 %. Until 2015 it increased up to 81.4 %. Therefore in 2015 only a fifth of the land required for domestic consumption was used domestically.

Table 2 Land-use for nutritional purposes, exports and domestic consumption

| Categories | 2008 | 2012 | 2015 | 2015 to 2008 |
|---|---|---|---|---|
| | 1,000 ha | | | % |
| Land-use of agriculture (domestic territory) . . . | 16,926 | 16,667 | 16,731 | *– 1.2* |
| Land used for nutrition . . . . . | 14,913 | 14,238 | 14,155 | *– 5.1* |
| Thereof: | | | | |
| Land use of exports . . . . . | 6,801 | 7,137 | 7,243 | *6.5* |
| Land-use of domestic consumption . . . . . | 8,112 | 7,101 | 6,913 | *– 14.8* |

Compared to 2008 domestic land-use of exports of food products has risen by 6.5 % in 2015, whereas the land-use of domestic consumption declined by 14.8 % (cf. table 2). In 2008 land used for domestic consumption exceeded land-use of exports by 1.3 million ha. In contrast in 2015 land-use of exports was 0.3 million ha higher than land-use of domestic production. Thereby in 2015 51.2 % of total land-use can be allocated to the production of exports, 48.8 % to the production of food products for domestic consumption.

# 2 Land-use of products of animal origin

## 2.1 Land-use of fodder crops

### Fattening pigs and fowl consume proportionately less fodder, but require more land for fodder production

Producing food of animal origin (meat, dairy products, eggs) requires the cultivation of fodder crops. This feed is grown both in Germany and abroad. Accordingly, this results in a use of domestic and foreign land areas. To calculate the land used for domestic consumption of products of animal origin, the land used for producing exports is subtracted and the land for imports is added.

Table 3 shows the animal feed consumed in 2015 ascribed to the type of livestock and the corresponding land use for producing these quantities in Germany and abroad. Of the total feed consumed (131.8 million tons) almost 40 % is allocated to dairy cows and other female cattle, about 26 % to beef cattle, followed by about 12 % for pigs and another 12 % for calves.

Table 3 Feed consumption by livestock and related land-use in 2015

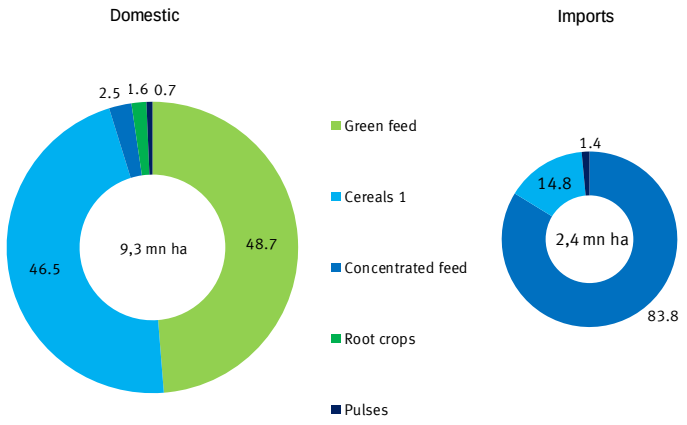
| Type of livestock | Fodder | Land-use | Fodder | Land-use |
|---|---|---|---|---|
| | 1,000 tons | 1,000 ha | in % of total | |
| Beef cattle | 34,488 | 2,579 | *26.2* | *22.0* |
| Cows and female cattle | 51,904 | 4,128 | *39.4* | *35.2* |
| Calves | 15,671 | 1,000 | *11.9* | *8.5* |
| Feeding pigs | 15,835 | 2,142 | *12.0* | *18.2* |
| Fowl | 11,030 | 1,636 | *8.4* | *13.9* |
| Sheep/Goats | 1,220 | 100 | *0.9* | *0.9* |
| Horses | 1,683 | 156 | *1.3* | *1.3* |
| Total | 131,831 | 11,740 | ***100*** | ***100*** |

The land used for producing feed shows a similar distribution to feed consumption. However, the share of land required to produce the feed for cattle is slightly smaller than their share of feed consumption. With pigs and fowl the opposite is the case. This is related to the fact that green fodder used for cattle is grown exclusively within the country, whereas feed for other animals (e.g. pigs or fowl) is increasingly imported. Imported feed has a higher requirement for land area than domestic feed because of the more extensive forms of farming found abroad.

### Green fodder from domestic land, concentrated feed from abroad

Figure 2 shows the land used for fodder crops subdivided into domestic production and imports in the year 2015. Land-use for the domestic production of feed amounted to 9.3 million ha in 2015; land use abroad for imported feed to Germany amounted to 2.4 million ha. Domestically 48.7 % of land was used for green fodder, 46.5 % for cereals and 2.5 % for concentrated feed. For imports, 83.8 % of land abroad was used for concentrated feed, followed by cereals at 14.8 %.

Figure 2 Land used for domestically produced fodder and for imported feed 2015
%




1 Incl. silage maize.

### Increased fodder and land-use 4 shows feed of livestock

Table 4 shows feed consumption of livestock according to feed origin as well as the land area used for its cultivation. In 2008 92.4 % of fodder had a domestic origin, 7.6 % were produced abroad. In 2015 the share of fodder produced abroad was 8.7 %, the share of fodder of domestic origin was 91.3 %. Land-use abroad has a higher share than the respective feed consumption since more extensive forms of agriculture are used abroad and yields per hectare are lower. In 2015 80 % of land was used domestically and 20 % abroad. Compared to 2008 the share of land used abroad increased by 1.8 percentage points.

Table 4 Fodder and land-use by region of origin

| Year | Domestic origin | Imports | Total |
|---|---|---|---|
| | Fodder consumption | | |
| | in 1,000 tons | | |
| 2008 | 126,413 | 10,458 | 136,871 |
| 2015 | 120,338 | 11,493 | 131,831 |
| | in % of total | | |
| 2008 | *92.4* | *7.6* | *100* |
| 2015 | *91.3* | *8.7* | *100* |
| | Land-use | | |
| | in 1,000 ha | | |
| 2008 | 9,601 | 2,205 | 11,806 |
| 2015 | 9,331 | 2,409 | 11,740 |
| | in % of total | | |
| 2008 | *81.3* | *18.7* | *100* |
| 2015 | *79.5* | *20.5* | *100* |

## 2.2 Land-use of products of animal origin

### Meat occupies one third of the land for domestic production, but more than half of the land for exports

Table 5 shows the use of land by different types of products of animal origin for domestic production, imports and exports and domestic consumption. The land-use for meat accounts for 32 % of domestic production. For imports and exports, the percentages are much higher: at 53 % and 60 %. For sausage products, the share of domestic production is 28 %, with 10.7 % and 6.8 % for exports and imports respectively. For dairy products, the land-use of domestic production as well as for imports and exports are between 35 % and 37 %.

Table 5 Land-use of products of animal origin for domestic production, imports, exports and domestic consumption 2015

| Categories | Meat | Sausage | Dairy products | Eggs | Total |
|---|---|---|---|---|---|
| | in 1,000 ha | | | | |
| Domestic production [1] | 3,716 | 3,228 | 4,372 | 375 | 11,690 |
| Imports | 2,692 | 305 | 1,292 | 212 | 4,501 |
| Exports | 2,786 | 558 | 1,814 | 71 | 5,229 |
| Domestic consumption | 3,622 | 2,975 | 3,850 | 515 | 10,962 |
| | in % of total | | | | |
| Domestic production [1] | *31.8* | *27.6* | *37.4* | *3.2* | *100* |
| Imports | *59.8* | *6.8* | *28.7* | *4.7* | *100* |
| Exports | *53.3* | *10.7* | *34.7* | *1.4* | *100* |
| Domestic consumption | ***33.0*** | ***27.1*** | ***35.1*** | ***4.7*** | ***100*** |

1 These results slightly differ from the results in table 3, since the calculations in this table cover several periods, whereas table3 is based on a year-specific calculation.

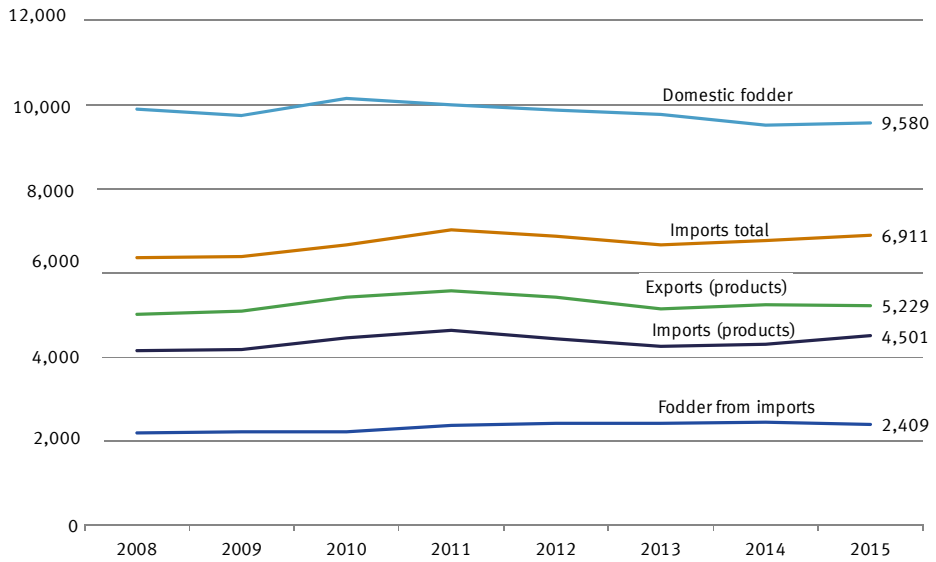
## 2.3 Land-use of domestic production, imports and exports

### Decrease in land-use of domestic fodder and moderate increase in land-use of imports and exports of products of animal origin

Figure 3 shows the changes in land-use of animal feed and products of animal origin with regard to imports and exports for the years 2008 – 2015.

Between 2008 and 2015 land-use of fodder has decreased on domestic territory by 3.3 %, whereas land-use abroad has grown by 9.3 %. Land use of imported products of animal origin also increased by 8.2 %, land-use of exports by 4.0 %.

Figure 3 Land-use of domestic production and imports of fodder and imports and exports of food products of animal origin
1,000 ha




## 2.4 Land-use per capita

### Domestic food consumption: highest land-use for dairy products

Based on the land used for domestic consumption, it is possible to determine the land-use per capita (cf. table 6). In 2015, it amounted to 1,438 square meters/capita and therefore has decreased by 2.3 % compared to 2008 (1,380 square meters/ capita). For meat it increased by 10.2%, for dairy products numbers dropped by 10.6 %.

Table 6 Land-use in m² per capita for products of animal origin – domestic consumption

| Products of animal origin | 2008 | 2015 | 2008 to 2015 |
|---|---|---|---|
| | m²/per capita | | in % |
| Meat | 408 | 450 | *10.2* |
| Sausage | 393 | 364 | *– 7.4* |
| Dairy products | 527 | 471 | *– 10.6* |
| Eggs | 51 | 63 | *23.4* |
| Total | 1,380 | 1,348 | ***– 2.3*** |

In 2015, 35 % of land was used for the domestic consumption of dairy products, 33 % for meat, 27 % for sausage products and just about 5 % for eggs..

# 3 Land-use of plant products

## 3.1 Methodology

For the calculation of land-use linked to domestic consumption of plant products not only domestic production and agricultural land used within the national territory need to be considered. Since Germany also imports plant products and food products from abroad, a certain part of agricultural land abroad has also to be assigned to domestic consumption. In contrast, there is domestic agricultural land which must not be attributed to domestic consumption because it is used to produce export goods. Hereinafter the methods used to calculate land-use of imports and exports of plant origin are presented [1].

The calculations are based on a coefficient approach. Import and export volumes of agricultural raw materials are linked to data on harvest yields of the crop-producing countries and the required cropland is determined. For processed products this simple approach could not be used. Instead the volume of raw materials included in the processed products needs to be specified. Furthermore, countries supplying imports are not necessarily the ones growing these raw materials. Therefore in many cases it is necessary to look closer at the supply chain of the traded goods.

The advantage of the coefficient approach is that by using a comprehensive commodity level a detailed calculation and presentation of results is feasible. Within the calculations only the land required for cultivating crops is taken into account. Land use during processing, transport routes etc. is not included.

Calculations are based on the detailed data from trade statistics on a commodity level as well as data for import and export volumes and data on re-exports. Country-specific land-coefficients and production volumes are taken from the database of United Nations Food and Agricultural Organization (FAO). For converting processed crops into their original raw materials several sources are used and completed by own estimates. The FAO's "Technical Conversions Factors for Agricultural Commodities" are particularly important here. For tracking supply chains back the United Nations COMTRADE database is used.

1 In the following imports and exports are not differentiated by their designated use at first, viz. the commodities include food products as well as feedstuff and products for technical or industrial use.

## 3.2 Imports

### Increasing crop imports

The volume of imported agricultural commodities and food products of plant origin increased by 14 % from 47.5 million tons (2008) to 54.1 million tons (2015) (cf. table 7). "Cereals" (+ 36 %), "Cocoa and cocoa preparations" (+ 34 %) and "Oil seeds" (+ 29 %) showed a particularly significant growth. In absolute numbers cereals (19 %) and oil seeds (18 %) were the most important import commodities in 2015.

Table 7 Import volumes of crop products according chapters of trade statistics

| WA [1] | Products | 2008 | 2015 | | 2015 to 2008 |
|---|---|---|---|---|---|
| | | 1,000 t | | % | |
| 07 | Vegetables | 4,449 | 4,697 | *8.7* | *5.6* |
| 08 | Fruits and nuts | 5,847 | 6,164 | *11.4* | *5.4* |
| 09 | Coffee, tea, spices etc. | 1,269 | 1,321 | *2.4* | *4.2* |
| 10 | Cereals | 7,592 | 10,310 | *19.0* | *35.8* |
| 11 | Products of the milling industry | 887 | 998 | *1.8* | *12.6* |
| 12 | Oil seeds and oleaginous fruits | 7,552 | 9,712 | *17.9* | *28.6* |
| 15 | Animal and vegetable fats and oils | 3,274 | 3,213 | *5.9* | *– 1.8* |
| 17 | Sugar and sugar confectionary | 1,885 | 2,010 | *3.7* | *6.6* |
| 18 | Cocoa and cocoa preparations | 821 | 1,103 | *2.0* | *34.4* |
| 19 | Preparations of cereals | 1,305 | 1,692 | *3.1* | *29.6* |
| 20 | Preparations of vegetables, fruits etc. | 3,561 | 3,351 | *6.2* | *– 5.9* |
| 21 | Misc. edible preparations | 725 | 833 | *1.5* | *15.0* |
| 22 | Beverages, spirits | 3,076 | 3,294 | *6.1* | *7.1* |
| 23 | Waste from food industry, prep. of fodder | 5,233 | 5,448 | *10.1* | *4.1* |
| | Total | 47,476 | 54,147 | ***100*** | ***14.1*** |

1 According the classification of foreign trade statistics.

When producing import commodities agricultural land is occupied in the respective cultivating country [2]. Total land-use of imports increased by 13 % between 2008 and 2015 – from 13.5 million ha to 15.3 million ha (c.f. table 8). The growth in land-use reflects more or less the growth in import volume. For that reason the growth of the import volume should not be assigned – at least not solely – to an increase of yields per hectare. In accordance with the increase in volume, land-use particularly increases for the items "Cocoa and cocoa preparations" (+ 36 %), "Cereals" (+ 34 %) and "Oilseeds and oleaginous fruits" (+ 28 %). In 2015 land-use of these three items added up to 51 % of total land-use of imports.

2 For arable land multiple accounting of land-use is possible due to multi-harvesting and crop rotation.

Table 8 Land-use of imported crop products according to trade statistic chapters

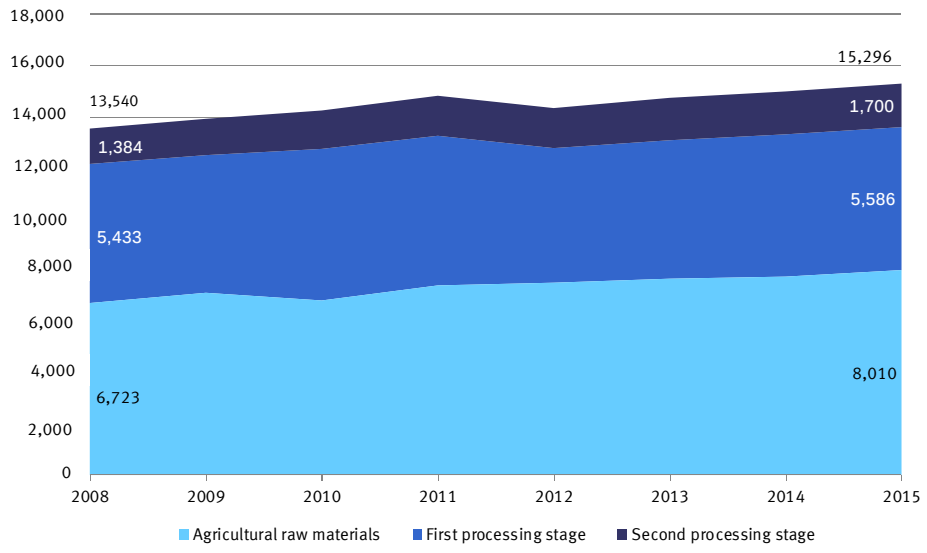
| WA [1] | Products | 2008 | 2015 | 2015 to 2008 | |
|---|---|---|---|---|---|
| | | 1,000 ha | | % | |
| 07 | Vegetables | 208 | 237 | *1.6* | *14.2* |
| 08 | Fruits and nuts | 745 | 912 | *6.0* | *22.5* |
| 09 | Coffee, tea, spices etc. | 1,435 | 1,244 | *8.1* | *– 13.3* |
| 10 | Cereals | 1,530 | 2,055 | *13.4* | *34.3* |
| 11 | Products of the milling industry | 197 | 217 | *1.4* | *10.0* |
| 12 | Oil seeds and oleaginous fruits | 2,853 | 3,652 | *23.9* | *28.0* |
| 15 | Animal and vegetable fats and oils | 2,024 | 1,850 | *12.1* | *– 8.6* |
| 17 | Sugar and sugar confectionary | 204 | 247 | *1.6* | *21.0* |
| 18 | Cocoa and cocoa preparations | 1,536 | 2,086 | *13.6* | *35.8* |
| 19 | Preparations of cereals | 296 | 367 | *2.4* | *24.3* |
| 20 | Preparations of vegetables, fruits etc. | 689 | 641 | *4.2* | *– 6.9* |
| 21 | Misc. edible preparations | 98 | 140 | *0.9* | *42.7* |
| 22 | Beverages, spirits | 515 | 522 | *3.4* | *1.3* |
| 23 | Waste from food industry, prep. of fodder | 1,211 | 1,126 | *7.4* | *– 7.0* |
| | Total | 13,540 | 15,296 | ***100*** | ***13.0*** |

1 According the classification of foreign trade statistics.

## Germany imports relatively few manufactured food products of plant origin

About 52 % of land-use for imported plant-based goods accounts for agricultural raw materials (c.f. figure 4). Another 37 % account for first-stage processed goods. These products are directly produced from the crop. This includes semi-finished products like cocoa paste or fruit concentrates.

Figure 4 Land-use of imported crop products by processing stages
1,000 ha

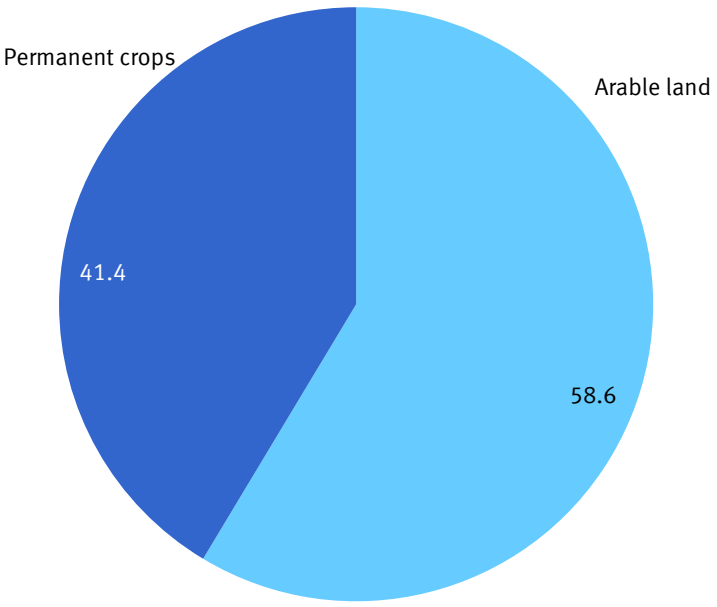


Between 2008 and 2015 the growth of land-use of imports mostly resulted from increased raw material imports. The volume of finished products remained almost unchanged.

### Particularly high land-use abroad for permanent crops

In 2015 about 59 % of land-use abroad for imports was arable land, 41 % were permanent crops (c.f. figure 5). This ratio remained stable during the whole period 2008 to 2015 despite an absolute growth in land-use.

Figure 5 Land-use of imports by land categories 2015
%




### Important countries of origin

In 2015 the most important importing countries[3] in terms of volume were the Netherlands (13.5 %), Poland (9.9 %) and France (9.3 %) (c.f. table 9). These three countries alone contributed to more than 30 % of total imports. The Netherlands particularly import “vegetables”, “oilseeds and oleaginous fruits” and “food industry waste”, for Poland it is especially “cereals”. From France mostly “Oilseeds and oleaginous fruits” and “Cereals” are imported to Germany. In the period 2008 to 2015 imports from Poland (+ 166 %) and the Czech Republic (+ 112 %) increased sharply.

3 The trade statistics’ import data is based on the principle of “country of origin”.

Table 9 Import volume of crop products by supplying country

| Supplying country | 2008 | 2015 | | 2015 to 2008 |
|---|---|---|---|---|
| | 1,000 t | | % | |
| Netherlands | 6,495 | 7,305 | *13.5* | *12.5* |
| Poland | 2,025 | 5,379 | *9.9* | *165.6* |
| France | 5,669 | 5,017 | *9.3* | *–11.5* |
| Brazil | 5,045 | 4,068 | *7.5* | *–19.4* |
| Czech Republic | 1,785 | 3,786 | *7.0* | *112.1* |
| Spain | 2,832 | 3,623 | *6.7* | *27.9* |
| Italy | 3,572 | 3,447 | *6.4* | *– 3.5* |
| Belgium | 1,609 | 2,038 | *3.8* | *26.7* |
| United States | 1,816 | 2,003 | *3.7* | *10.3* |
| Hungary | 1,522 | 1,556 | *2.9* | *2.2* |
| Other countries | 15,107 | 15,927 | *29.4* | *5.4* |
| Total | 47,476 | 54,147 | ***100*** | ***14.1*** |

Although the data from trade statistics that was used for the calculations is based on the "country of origin"-principle of, this does not automatically guarantee that the imported crop is also cultivated in that country. The trade statistics data includes agricultural raw materials like coffee beans from the Netherlands which are not cultivated in that country. Therefore in these cases, but only for the member states of the European Union and for Serbia and Suisse, the origin of the raw material was determined by analyzing the supply chains. This is also necessary for manufactured products, for which the original growing country of the raw materials had also to be determined. In the calculation model this is only done if the raw material is not cultivated at all in the supplying country. For certain products, particularly those made from oilseeds and cereals, intensive trade relations exist in Europe. Sometimes this could result in an inconsistent determination of the growing country. In these cases the growing country is registered in a special category "non-assignable countries".

The importance of the neighboring countries Poland and France is also evident when looking at the land-use of imports. Overall, land-use is less concentrated than import volumes. Thus, when looking at volumes, the top 10 countries account for 71 % of import volumes, but only 56 % of land use. Particularly the share of Brazil (10.5 %) and the Ivory Coast (5.4 %) is quite high when looking at land-use. For Brazil this is due to a high share of oilseed-based products, which are relatively land-intensive. Germany imports substantial amounts of cocoa bean-based products from the Ivory Coast. This crop also needs very large cultivation areas.

Table 10 Land-use of crop products by growing countries

| Growing country | 2008 | 2015 | | 2015 to 2008 |
|---|---|---|---|---|
| | 1,000 ha | | % | |
| Brazil | 1,935 | 1,599 | *10.5* | *– 17.3* |
| Poland | 492 | 1,167 | *7.6* | *137.4* |
| France | 1,013 | 989 | *6.5* | *– 2.3* |
| Non-allocable countries | 736 | 934 | *6.1* | *26.9* |
| Ivory Coast | 544 | 831 | *5.4* | *52.7* |
| United States | 740 | 773 | *5.1* | *4.4* |
| Czech Republic | 380 | 745 | *4.9* | *95.9* |
| Italy | 601 | 644 | *4.2* | *7.1* |
| Hungary | 449 | 500 | *3.3* | *11.5* |
| Indonesia | 540 | 443 | *2.9* | *– 18.0* |
| Other countries | 6,111 | 6,671 | *43.6* | *9.2* |
| Total | 13,540 | 15,296 | ***100*** | ***13.0*** |

## Product families

In the following chapter so-called “product families” are analyzed instead of using the tariff-based trade statistics classification. To generate product families, individual items from trade statistics are allocated to groups of specific raw materials.

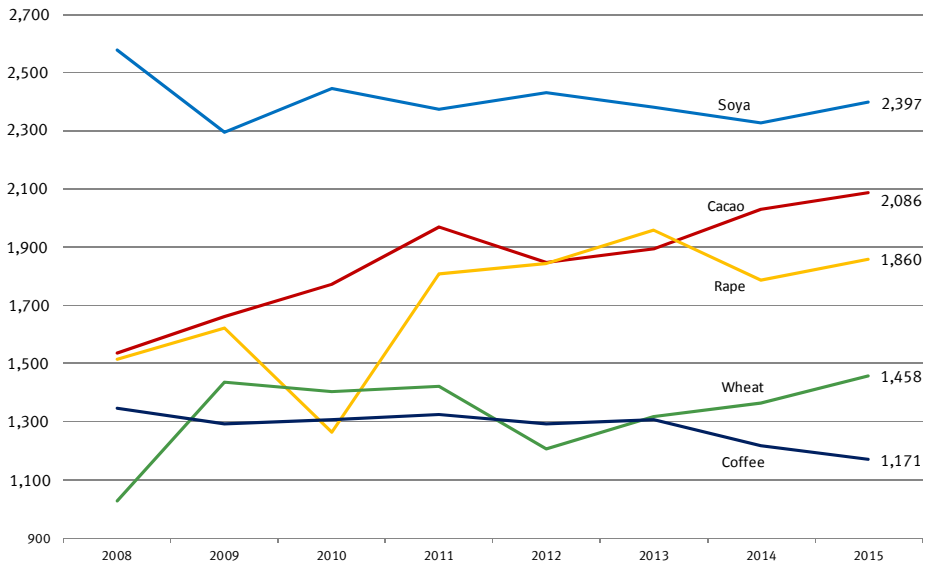
The imports show a significant concentration on a few product families. In 2015 the five most important groups caused 60 % of total land-use. The most important groups are products based on soya (16 %), cocoa (14 %) and rape (12 %). Whereas the combined share of products made from cocoa and coffee only account for 4.2 % of import volumes, land-use of these two product families amounts to 21%. Conversely less land is required for other vegetables and fruits and crops. These are cultivated intensively on a relatively small area.

Table 11 Land-use of crop products by product families 2015

| Product family | Volume | | Land use | |
|---|---|---|---|---|
| | 1,000 t | % | 1,000 ha | % |
| Soya | 7,329 | *13,5* | 2,397 | *15.7* |
| Cacao | 1,103 | *2,0* | 2,086 | *13.6* |
| Rape | 5,594 | *10,3* | 1,860 | *12.2* |
| Wheat | 7,582 | *14,0* | 1,458 | *9.5* |
| Coffee | 1,217 | *2,2* | 1,171 | *7.7* |
| Nuts | 961 | *1,8* | 1,170 | *7.6* |
| Oil palm | 2,449 | *4,5* | 628 | *4.1* |
| Maize | 3,831 | *7,1* | 587 | *3.8* |
| Other oil seeds | 402 | *0,7* | 560 | *3.7* |
| Sunflower seeds | 1,044 | *1,9* | 538 | *3.5* |
| Other corn | 1,531 | *2,8* | 444 | *2.9* |
| Barley | 2,539 | *4,7* | 398 | *2.6* |
| Wine | 2,178 | *4,0* | 381 | *2.5* |
| Exotic fruits | 4,135 | *7,6* | 281 | *1.8* |
| Fruit | 2,742 | *5,1* | 263 | *1.7* |
| Other | 9,510 | *17,6* | 1,074 | *7.0* |
| Total | 54,147 | ***100*** | 15,296 | ***100*** |

Since 2008 particularly rape and cocoa gained significance (cf. figure 6). In contrast imports of soya products slightly declined. This is due to increased use of rape as animal feed.

Figure 6 Land-use of imported products of plant origin by product families
1,000 ha



## 3.3 Exports

### Significant growth of plant product exports

The volume of exported agricultural raw materials and of food products of plant origin increased by 27 % from 32.5 million tons (2008) to 41.2 million tons (2015) (cf. table 12). Especially “Cereals” showed a particularly high increase of 4.2 million tons (+ 41 %). The two most important export commodities were “Cereals” (35 %) and “Waste from food industry” (15 %).

Table 12 Exports of plant products by trade statistics chapters

| WA [1] | Products | 2008 | 2015 | | 2015 to 2008 |
|---|---|---|---|---|---|
| | | 1,000 t | | % | |
| 07 | Vegetables | 2,204 | 2,361 | *5.7* | *7.1* |
| 08 | Fruits and nuts | 1,015 | 935 | *2.3* | *– 7.9* |
| 09 | Coffee, tea, spices etc. | 542 | 583 | *1.4* | *7.5* |
| 10 | Cereals | 10,377 | 14,589 | *35.4* | *40.6* |
| 11 | Products of the milling industry | 1,708 | 2,648 | *6.4* | *55.0* |
| 12 | Oil seeds and oleaginous fruits | 682 | 509 | *1.2* | *– 25.4* |
| 15 | Animal and vegetable fats and oils | 1,600 | 2,533 | *6.2* | *58.3* |
| 17 | Sugar and sugar confectionary | 1,312 | 1,764 | *4.3* | *34.4* |
| 18 | Cocoa and cocoa preparations | 741 | 1,101 | *2.7* | *48.5* |
| 19 | Preparations of cereals | 1,919 | 2,357 | *5.7* | *22.9* |
| 20 | Preparations of vegetables, fruits etc. | 1,911 | 1,957 | *4.8* | *2.4* |
| 21 | Misc. edible preparations | 1,103 | 1,276 | *3.1* | *15.7* |
| 22 | Beverages, spirits | 2,346 | 2,560 | *6.2* | *9.1* |
| 23 | Waste from food industry, prep. of fodder | 5,010 | 6,006 | *14.6* | *19.9* |
| | Total | 32,471 | 41,179 | ***100*** | ***26.8*** |

1 According the foreign trade statistics classification.

The growth in export volumes is also reflected in land use figures of exported products (cf. table 13). Land-use increased from 6.3 million ha (2008) to 8.0 million ha (2015), viz. by 27 %. The largest share is used for cereals (23 %). When it comes to land-use items like “Cocoa and cocoa preparations” (18 %) and “Waste from food industry” (17 %) gain importance in comparison to their export volume.

Table 13 Land-use of plant product exports by trade statistics chapters

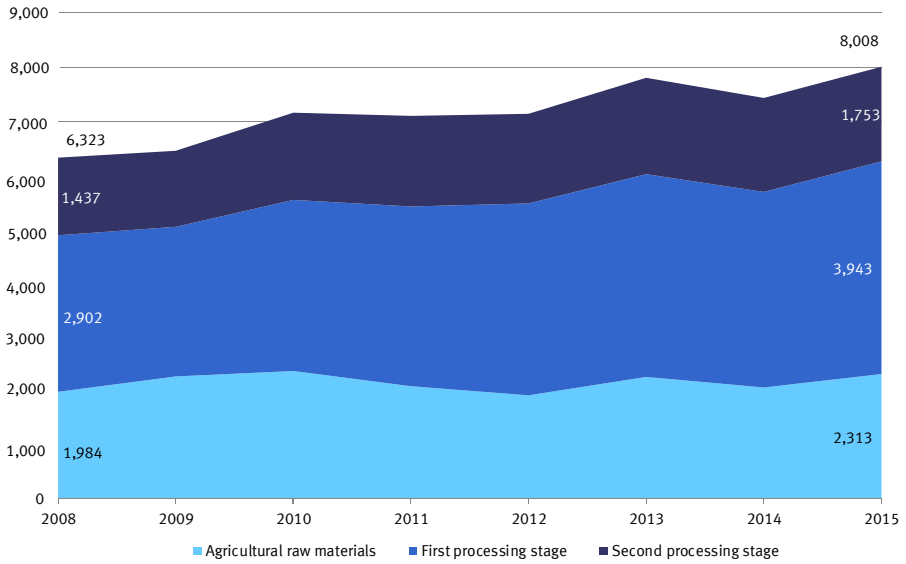
| WA [1] | Products | 2008 | 2015 | | 2015 to 2008 |
|---|---|---|---|---|---|
| | | 1,000 ha | | % | |
| 07 | Vegetables | 79 | 79 | 1.0 | 0.7 |
| 08 | Fruits and nuts | 118 | 170 | 2.1 | 44.2 |
| 09 | Coffee, tea, spices etc. | 650 | 593 | 7.4 | – 8.8 |
| 10 | Cereal | 1,416 | 1,821 | 22.7 | 28.6 |
| 11 | Products of the milling industry | 293 | 447 | 5.6 | 52.2 |
| 12 | Oil seeds and oleaginous fruits | 222 | 170 | 2.1 | – 23.3 |
| 15 | Animal and vegetable fats and oils | 882 | 1,362 | 17.0 | 54.5 |
| 17 | Sugar and sugar confectionary | 137 | 151 | 1.9 | 10.2 |
| 18 | Cocoa and cocoa preparations | 852 | 1,416 | 17.7 | 66.2 |
| 19 | Preparations of cereals | 303 | 376 | 4.7 | 23.8 |
| 20 | Preparations of vegetables, fruits etc. | 235 | 201 | 2.5 | – 14.3 |
| 21 | Misc. edible preparations | 141 | 156 | 1.9 | 10.2 |
| 22 | Beverages, spirits | 185 | 206 | 2.6 | 11.2 |
| 23 | Waste from food industry, prep. of fodder | 809 | 861 | 10.8 | 6.4 |
| | Total | 6,323 | 8,008 | **100** | **26.7** |

1 According the foreign trade statistics classification.

## Germany exports more processed products than raw materials

Whereas raw materials dominate imports (52 %), with 29 % their share is far less significant when it comes to exports. Therefore Germany primary imports plant-based raw materials whereas exports mainly comprise processed products.

Figure 7 Land-use of exports by processing stages
1,000 ha



## Countries of destination

Data on the countries of export destination shows the great importance of the European Single Market (cf. table 14). The most important countries of destination are the neighboring countries the Netherlands (22.8 %), France (6.5 %) and Belgium (6.4 %). Among the top 10 countries of destination only Saudi-Arabia (5.5 %) and the Islamic Republic Iran (3.2 %) are non-European countries. To both countries mainly cereals are exported. Cereals and waste from the food industry have the largest share of exports to the Netherlands.

Table 14 Export volume of crop products by countries of destination

| Country of destination | 2008 | 2015 | | 2015 to 2008 |
|---|---|---|---|---|
| | 1,000 t | | % | |
| Netherlands | 7,830 | 9,370 | *22.8* | *19.7* |
| France | 2,466 | 2,665 | *6.5* | *8.1* |
| Belgium | 2,053 | 2,639 | *6.4* | *28.5* |
| Saudi-Arabia | 540 | 2,280 | *5.5* | *322.5* |
| Italy | 2,105 | 2,053 | *5.0* | *– 2.4* |
| Poland | 1,672 | 2,018 | *4.9* | *20.7* |
| United Kingdom | 1,824 | 1,672 | *4.1* | *– 8.3* |
| Denmark | 1,617 | 1,640 | *4.0* | *1.4* |
| Austria | 1,560 | 1,468 | *3.6* | *– 5.9* |
| Iran | 829 | 1,323 | *3.2* | *59.6* |
| Other countries | 9,977 | 14,052 | *34.1* | *40.8* |
| Total | 32,471 | 41,179 | ***100*** | ***26.8*** |

## Product families

Wheat-based products are of great significance for the German export industry (cf. table 15). In 2015 these products made up for 24 % of total land-use of exports. Looking at the export volumes the share is even higher. It accounted for 36 %. It is especially noticeable that there are many important raw materials like cocoa (18 %), soya (12 %) and coffee (7 %) which are not cultivated at all in Germany or only in small volumes. This demonstrates the high competitiveness of the German export industry on international markets.

Table 15 Land-use of exported crop products by product family 2015

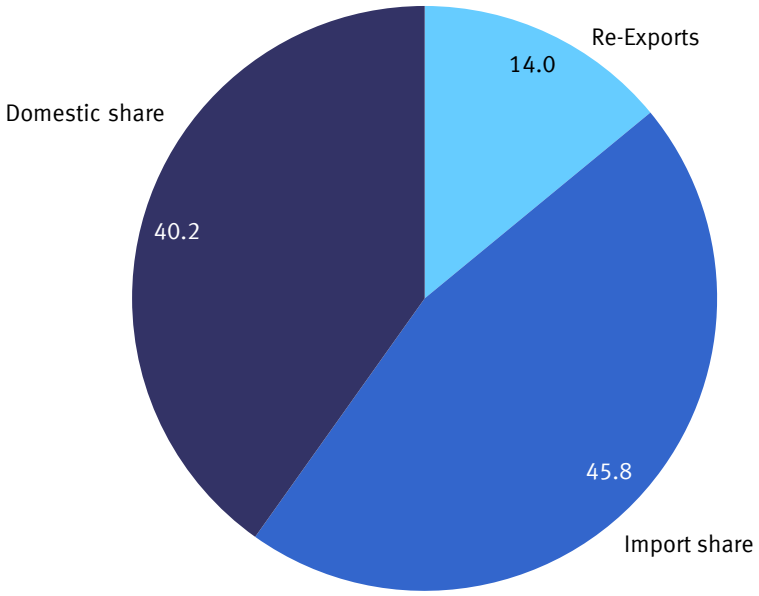
| Product family | Volume | | Land | |
|---|---|---|---|---|
| | 1,000 t | % | 1,000 ha | % |
| Wheat | 14,929 | *36.3* | 1,922 | *24.0* |
| Cacao | 1,101 | *2.7* | 1,416 | *17.7* |
| Soya | 3,295 | *8.0* | 980 | *12.2* |
| Rape | 3,001 | *7.3* | 712 | *8.9* |
| Coffee | 604 | *1.5* | 579 | *7.2* |
| Barley | 5,384 | *13.1* | 573 | *7.2* |
| Oil palm | 798 | *1.9* | 265 | *3.3* |
| Nuts | 192 | *0.5* | 237 | *3.0* |
| Other oil seeds | 145 | *0.4* | 225 | *2.8* |
| Other corn | 777 | *1.9* | 166 | *2.1* |
| Sunflower seeds | 279 | *0.7* | 162 | *2.0* |
| Sugar beet/-cane | 1,919 | *4.7* | 148 | *1.8* |
| Maize | 953 | *2.3* | 113 | *1.4* |
| Potatoes | 3,644 | *8.8* | 94 | *1.2* |
| Fruit | 1,035 | *2.5* | 74 | *0.9* |
| Other | 3,125 | *7.6* | 343 | *4.3* |
| Total | 41,179 | ***100*** | 8,008 | ***100*** |

## 3.4 Import share of exports

**To produce exports a lot of imported agricultural raw materials are needed**

In 2015 only 40 % of land used for exports was provided domestically (cf. fig. 8). The predominant share (46 %) is attributable to processed products, whose raw materials are cultivated abroad and imported to Germany.

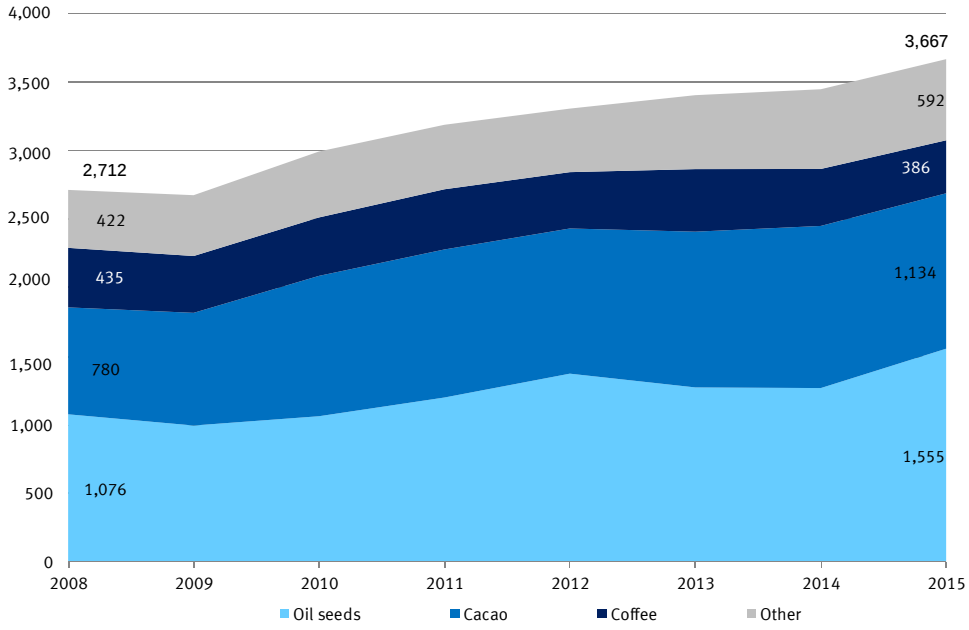
Figure 8 Land-use of exports of plant based food products 2015
%




Between 2008 and 2015 the import share of exports increased significantly. Whereas in 2008 only 2.7 million ha land were allocated abroad for products intended for the production of German exports, land-use increased to 3.7 million ha in 2015. Both land-use linked to imports and to exports have to be examined independently from domestic use. Land-use of imports increases rather because the German export industry for processed food products is growing. Within the period 2008 to 2015 only 28 % of increasing land-use of imports can be domestic use. 72 % can be attributed to increased German exports.

The increased import share of exports is mainly caused the product families “Cocoa and cocoa products” as well as “Oil seeds” (cf. figure 9). This indicates, that particularly those raw materials, which are not cultivated in Germany at all or only in small amounts have gained significance for plant-based exports.

Figure 9 Import share of exports
1,000 ha



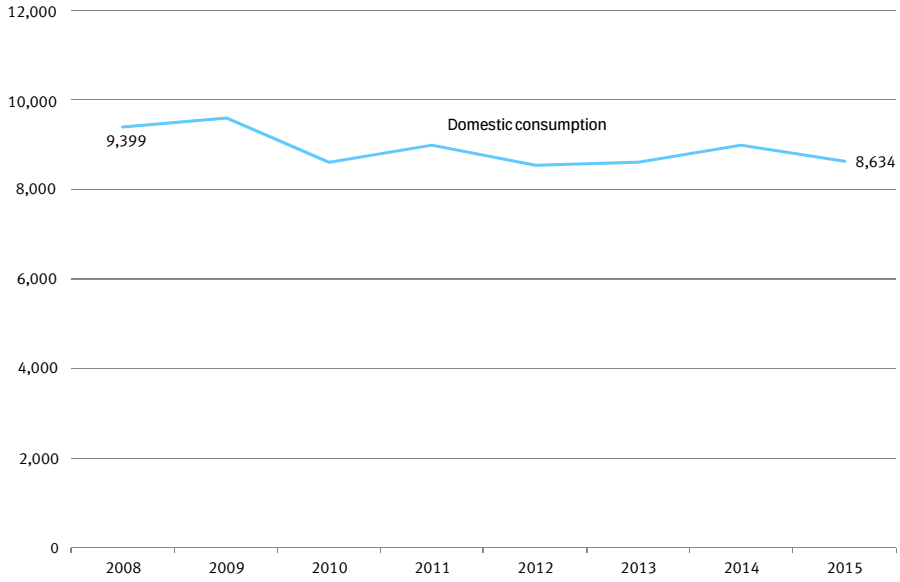

## 3.5 Domestic use of plant-based food products

### A high share of land-use for domestic consumption of luxury goods

To determine land-use of domestic consumption imports have to be added to land-use on national territory, while exports need to be subtracted. Furthermore designated use of cultivated crop or processed products must be determined. Land-use of goods which are intended for feed, for energetic purposes or for industrial use has to be subtracted. [4]

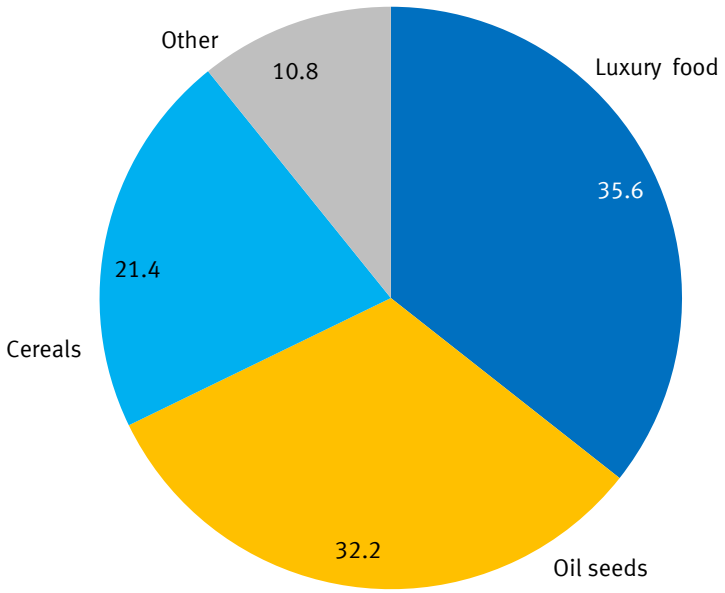
4 The designated use is not identified for all exported goods. For instance, exported wheat could be used abroad as feed or for nutrition purposes. To determine land-use of domestic consumption, first domestic consumption has to be determined independently from the designated use. Then the part of domestic consumption which is not related to nutrition purposes has to be subtracted.

Figure 10 Land-use of domestic consumption of food products
in 1,000 ha




The results show a relatively constant course of land-use of domestic consumption of plant products (cf. figure 10). The rise of land-use of imports is not due to an increased domestic consumption, but predominantly the result of rising raw material demands for German exports. At the same time an increased part of the domestic agricultural land is used for energetic purposes.

Figure 11 Land-use of imports intended for domestic use by food categories 2015
%




Looking at the import share of domestic consumption there is a remarkable high share of luxury products (cf. figure 11). In 2015 luxury food products made up for 36 % of total land- use. The reason is high land-use of cocoa products and coffee.

## 3.6 Analysis of selected products

### Significant differences in land-use of certain products

In the following land-use of four selected products is illustrated.

Table 16 Area-coefficients of selected products

| Product | Unit | Agricultural commodity | Area in $m^2$ |
|---|---|---|---|
| Roasted coffee | 100 g | Coffee bean | 0.82 |
| Wheat flour | 100 g | Wheat | 0.15 |
| Chocolate | 100 g | Cacao bean | 1.62 |
| | | Sugar beet | 0.03 |
| Beer | 1 Liter | Barley | 0.31 |
| | | Hop | 0.02 |

A chocolate bar of 100 g dark chocolate needs a cultivation area of 1.65 $m^2$. The major part of land-use takes place abroad, because the cocoa bean has a higher land requirement per unit of weight than sugar beet (which is also cultivated domestically). Coffee has a significantly lower land requirement of 0.82 $m^2$ per 100 g. However, coffee is still cultivated land-intensively. For 100 g of wheat flour for example an area of only 0.15 $m^2$ is needed. To produce one liter of beer one needs about 210 g barley and 4 g hop. This requires a cultivation area of 0.33 $m^2$.

Back to the chocolate example: the detailed calculation shows that the large cultivation area needed is not due to ingredients like sugar, but to the low yield-coefficient of the cocoa bean.

Table 17 Area coefficient of chocolate

| Ingredients of chocolate | Share in % | Agricultural commodity | Raw material equivalent | Area in $m^2$ per 100g |
|---|---|---|---|---|
| Cocoa mass/cocoa butter . . | *60.0* | Cacao bean | 74.94 | 1.62 |
| Sugar . . . . . | *35.0* | Sugar bean | 217.04 | 0.03 |
| Non-vegetarian (e.g. milk [1]) . | *5.0* | – | – | – |

1 Land-use of non-plant products is not taken into account here.

A 100 g chocolate bar of dark chocolate consists of 60 g cocoa mass and cocoa butter, 35 g sugar and 5 g of non-vegetarian ingredients like milk. This corresponds to about 75 g of cocoa beans and 217 g of sugar beets needed for the production of the chocolate. Although a relatively high amount of sugar is needed, the cultivation area needed to produce the sugar (0.03 $m^2$) is relatively small. In contrast the cultivation of 75 g of cocoa bean required an area of 1.62 $m^2$.