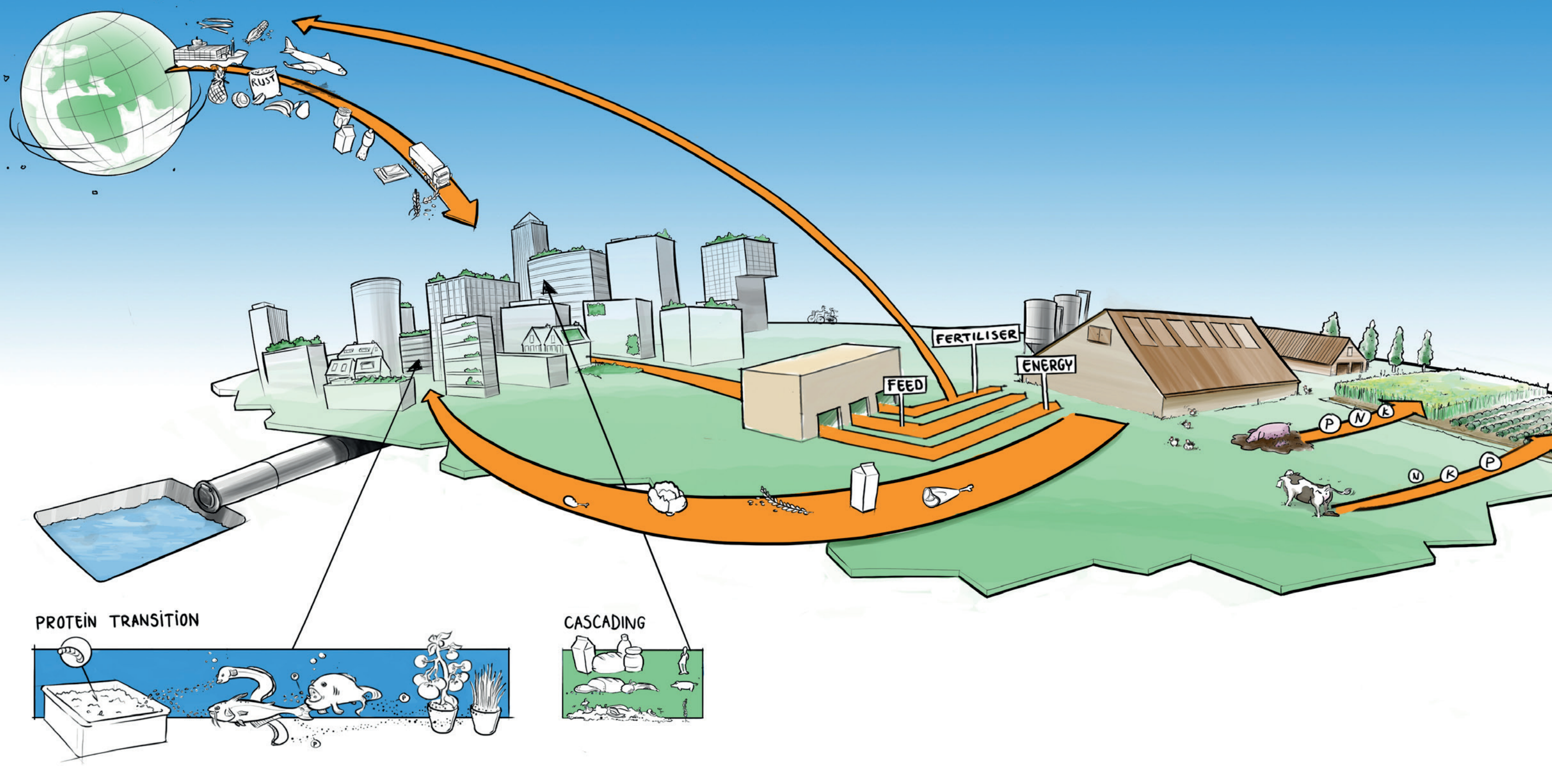

Food related land requirement and phosphorus balance of The Netherlands

Appendix of report *Closing the life cycle of phosphorus in an urban food system: the case Almere (NL) report WPR-725*

J.G. Conijn[1] & W. van Dijk[2]

1 Wageningen University & Research, Agrosysteemkunde
2 Wageningen University & Research, Praktijkonderzoek AGV

This study was carried out by the Wageningen Research Foundation (WR) and was commissioned and financed the Dutch Ministry of Economic Affairs within the context of the KB research program Metropolitan Solutions, research theme KB-25-006-003 and the KB-research program A Global One Health, research theme KB-31-001-006
WR is part of Wageningen University & Research, the collaboration of Wageningen University and Wageningen

Wageningen, February 2018

WAGENINGEN
UNIVERSITY & RESEARCH

Food related land requirement and phosphorus balance of The Netherlands

Appendix of report *Closing the life cycle of phosphorus in an urban food system: the case Almere (NL) (report WPR – 725)*

J.G. Conijn[1] & W. van Dijk[2]

1 Wageningen University & Research, Agrosysteemkunde

2 Wageningen University & Research, Praktijkonderzoek AGV

This study was carried out by the Wageningen Research Foundation (WR) and was commissioned and financed the Dutch Ministry of Economic Affairs within the context of the KB research program Metropolitan Solutions, research theme KB-25-006-003 and the KB-research program A Global One Health, research theme KB-31-001-006

WR is part of Wageningen University & Research, the collaboration of Wageningen University and Wageningen

Wageningen, February 2018

Report WPR-757

Conijn, J.G. & W. van Dijk, 2018. Food related land requirement and phosphorus balance of The Netherlands; Wageningen Research, Report WPR-757. 18 pp.; 4 fig.; 6 tab.; 7 ref.

This report can be downloaded for free at https://doi.org/10.18174/441272

This study compares two approaches for calculating area demand and associated phosphorus flows for food production in the Netherlands. The assumptions and the results of the two approaches are compared and differences are discussed.

Keywords: food system, land requirement, phosphorus balance

Report WPR- 757

Contents

Summary

Recently, two studies were done that focussed on global and urban phosphorus (P) flows in the food chain and land demand for food production: 1) a study aimed at exploring the possibilities of a local food system and its effect on the phosphorus cycle for the urban region Almere and 2) a study in which the state of the global food system in 2010 was modelled with respect to land use, GHG emission, nitrogen and phosphorus cycling using the model BIOSPACS (Balancing Inputs and Outputs for the Sustainable Production of Agricultural CommoditieS).

In a separate study both models have now been applied to the Netherlands while focussing on phosphorus flows and land demand for the situation in which the Netherlands produces its own food (i.e. self-sufficient, except for exotic food products). In this report the assumptions and the results of the two new studies for the Netherlands are compared. We refer to these new studies by, respectively, Almere_NLD and BIOSPACS.

Basis of the calculations for both approaches is the food intake and food supply (including food wastage) to households. From that point the area demand for food production and associated P flows are calculated based on crop and animal production data.

For BIOSPACS the food intake and food supply data are derived from FAOSTAT (originating from CBS) and for Almere_NLD the food intake is based on data from the Dutch national food consumption survey and, subsequently, food supply to households is calculated by assuming a wastage of 20%. Generally, in the analysis with BIOSPACS higher food supply rates are used for feeding the Dutch population and more P needs to be ‘provided’, relative to Almere_NLD (average values for food: +27% and for P: +23%).

Except for cereals and oil crops, the assumed crop yields used in Almere_NLD are higher than those derived from BIOSPACS, especially for potatoes (+21%), pulses (+19%) and fruits (+59%). For the animal production the feed requirement per unit animal product (FRR, feed requirement ratio) together with the crop yields determine the area and phosphorus demand. The FRR-values for pig meat, poultry meat and egg production are comparable. For bovine meat and milk production the FRR-values calibrated in BIOSPACS are lower by using less roughages and concentrates.

Despite different assumptions and data sources, the overall results are more or less comparable for the two studies. This applies to the required area for agricultural production as well as the main P flows. However, considerable differences in crop area demand between individual crops are calculated, and explained by differences in input values. BIOSPACS calculates a higher area demand for food crops while Almere-NLD calculates a higher area demand for animal production, resulting in a total agricultural area demand that is comparable for the two studies. For a self-sufficient situation more agricultural land would be needed compared to the amount currently in use for food production in the Netherlands.

P flows in waste and P flows entering and leaving the city (households, retail, food processing industry) were quite similar for both approaches. In agriculture larger differences are found due to different assumptions in the studies of BIOSPACS and Almere_NLD. In the latter most waste flows have been assumed to be recycled towards agriculture, which has not been done for BIOSPACS. Furthermore, Almere_NLD assumes no P losses nor any accumulation of P in agricultural soils (crop P demand equals crop P offtake), contrary to the situation in BIOSPACS. However, when these two conditions were also assumed for BIOSPACS, the required amounts of P fertiliser were more or less comparable.

1 Introduction

Recently, two studies were done that focussed on global and urban phosphorus flows in the food chain and land demand for food production. The study of Van Dijk et al. (2017) aimed at exploring the possibilities of a local food system and its effect on the phosphorus cycle. For the urban region Almere different scenarios were compared ranging from the current situation with limited local food production to a self-sufficient scenario in which all food products were produced locally except for exotic products (e.g. tropical fruits, coffee, tea). In the global study the state of the food system in 2010 was modelled with respect to land use, GHG emission, N and P cycling (Conijn et al., 2018). This model, BIOSPACS (Balancing Inputs and Outputs for the Sustainable Production of Agricultural CommoditieS), was also used to explore the possibilities to meet food demand at the global level in 2050 within planetary boundaries.

Both models have now been applied to the Netherlands while focussing on phosphorus flows and land demand for the situation in which the Netherlands produces its own food (i.e. self-sufficient, except for exotic food products). In this document the assumptions and the results of the two new studies for the Netherlands are compared and differences are discussed, and we refer to these new studies by respectively Almere_NLD and BIOSPACS.

2 Methodology

2.1 General description used models

2.1.1 Almere_NLD

Starting point is the intake of food, from that point stepwise the area demand and P flows are calculated (Fig. 1). The food intake was derived from national data for the intake of food per gender and per age group in the period 2007-2010 (Van Rossum et al., 2011) and the population structure of the Netherlands (CBS). For each food product group representative model products were chosen (e.g. bread for cereal products, milk and cheese for dairy products) and these model products were linked to primary products that are produced on farms (e.g. bread linked to wheat, cheese to milk). Subsequently, for each food product group the needed amount of primary product can be calculated assuming a ratio primary product versus model product and a total wastage of 30% throughout the chain from farm gate to households. Based on crop yield and animal production data the area demand was derived. For the crop yields we took national values based on KWIN Akkerbouw 2015 (average of clay and sandy soils). The required amount of phosphorus for crop growth was set equal to the phosphorus removal with harvested product. The required P supply was covered with manure and recycled P from waste.

For the chosen model products per food product group and the used ratio primary product versus model product, we refer to Van Dijk et al. (2017).

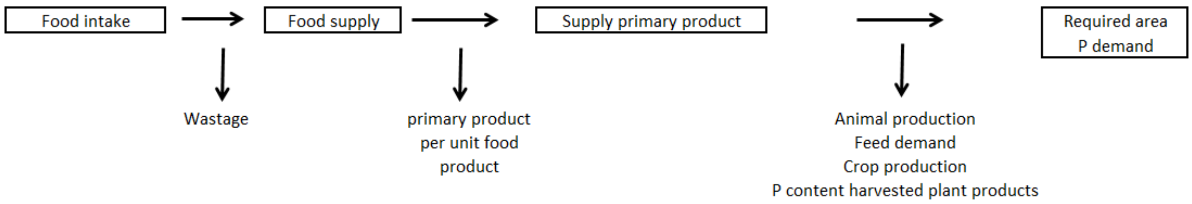

Figure 1. Schematic outline of the methodology of the calculation of the area demand for food production and quantification of the P flows in Van Dijk et al (2017).

2.1.2 BIOSPACS

BIOSPACS quantifies N and P flows between five interacting components in the food system and those across the system's boundary as a function of food demand (see example of global P flows in Fig. 2). Related agricultural land requirements and GHG emissions from agricultural production are also calculated. The five components are: (1) human *population* consuming food items, (2) the *food balance* supplying (non-)food items, (3) *livestock* producing animal-based products, (4) *organic fertilizer* consisting mainly of excreted manure from livestock and (5) *agricultural land* comprising arable land and permanent grassland for the production of food crops and feed for livestock. N and P stock changes are determined for agricultural land, the food balance and the population. Non-agricultural land areas, aquatic systems and the atmosphere are not described in BIOSPACS, except for those flows that cross the food system boundary. Requirements for non-food demands such as non-food crops like cotton, and non-feed use of residues like straw for bedding, are not taken into account. Extra food crop demand due to other use of food crops such as for biofuels, is included.

Statistical data from FAOSTAT and additional information from other sources are used to derive quantitative input–output relations of each component in the food system. These relations are then used to calculate the output as function of the food demand, e.g. required land and mineral fertilizer and related losses. The "Food Balance Sheets" of the FAO are used to describe the human diet by the supply rates of the underlying food commodities that are part of the agricultural production domain, such as cereals (e.g. wheat, maize, rice, etc.), vegetables, various meat types, milk, eggs, etc. Twenty main food groups are distinguished and a dominant crop for each food crop group can be selected in BIOSPACS, based on production quantity and/or harvested area share, such as wheat for cereals and potato for starchy roots. Food products at household level, such as spaghetti, biscuits, quark, mayonnaise, sandwich meat, etc. are not specified. Next to food crops, also the requirement of grassland and fodder crops for our food demand is calculated.

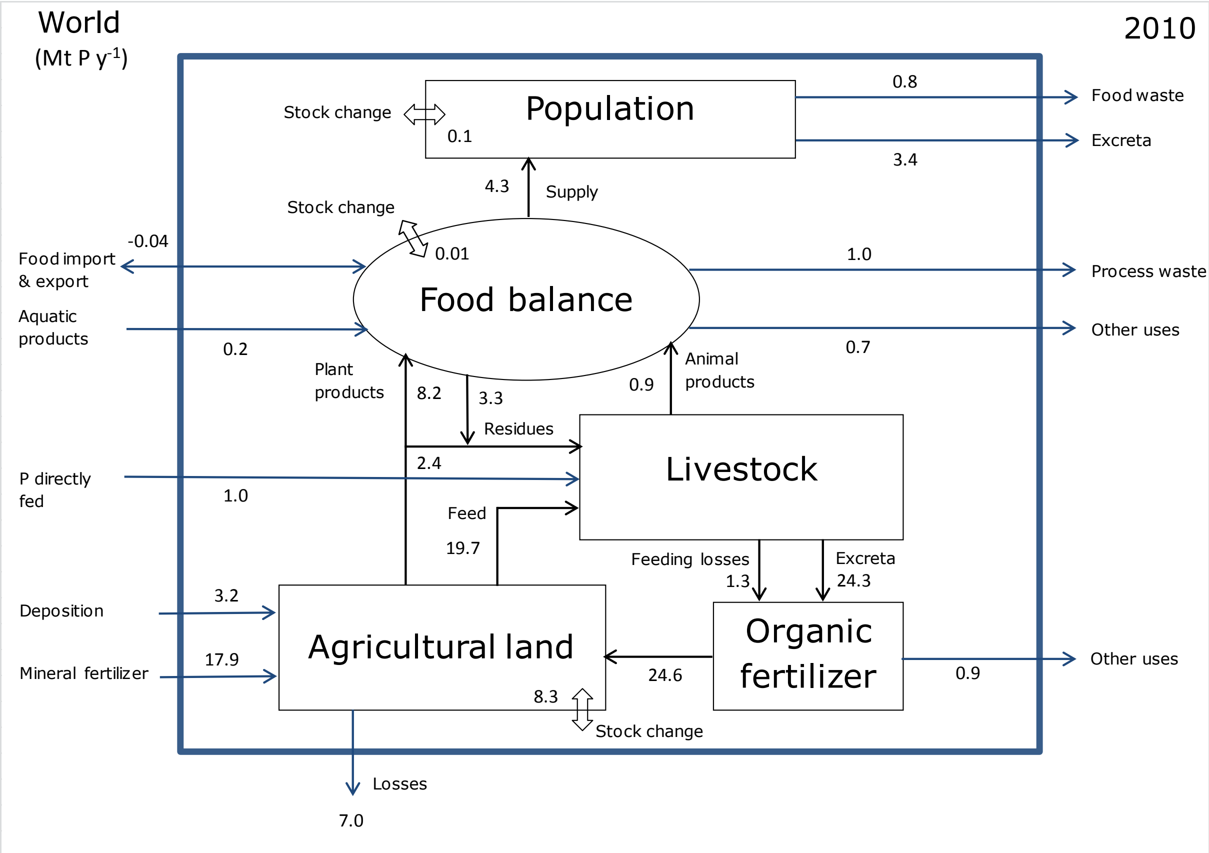

Figure 2. Phosphorus flows of the global food system for 2010 (Conijn et al., 2018).

BIOSPACS v1.0 has been used for the global study, and v2.0 was developed for the Netherlands and is used for the analysis described in this report. One of the main differences between the two versions relates to the impact of food import and export on the food system, which is nil for the global analysis (see Figure 2) and quite substantial for the Netherlands. To simulate the self-sufficient situation these import and export flows were set to zero, as well as the use of food crops for non-food purposes.

2.2 Inputs

2.2.1 Food intake and supply

In Table 1 the food supply, food intake and P intake are given for both studies. The difference between food supply and intake refers to wastage of food products at the household level. For Almere_NLD a value of 20% wastage in the households was taken for all food products. For the analysis with BIOSPACS data of wastage in households were estimated based on Gustavsson *et al.* (2011). Different values are used for different food groups, ranging from 13% to 33%, and an average of 21% was calculated for the total diet excluding non-alcoholic beverages.

The total food intake, P intake and food supply excluding non-alcoholic beverages are about 20% lower in Almere_NLD as compared to the data in BIOSPACS. The basis of BIOSPACS for describing the human diet is FAOSTAT in which data for the Netherlands originally come from Dutch organizations, such as CBS (“National Statistics Office”). These data of the human diet refer to annual rates of supply to households and intake is estimated by using the above-mentioned household wastage percentages per food group. In the national food consumption survey, which is the basis of the Almere_NLD study, the intake is monitored per age class and gender by questionnaires. For food products with a relatively low intake, this regularly results in a 'zero'-registration per gender-age-class for the average intake while for the total population there is a certain intake. However, in the food survey no integration over age-gender-classes is made. This may underestimate the total food intake in Almere_NLD and may partly be the reason for the lower total intake. But also between food products there are some considerable differences. They are discussed hereunder.

In FAOSTAT/BIOSPACS, the intake of starchy roots (mainly potatoes) is almost twice as high as in Almere_NLD and this is also the situation for the supply and P intake. In the national food consumption survey the intake probably concerns the direct consumption of potatoes which is about half of the total consumption. The latter also includes potatoes processed in e.g. chips and other snacks. This may explain the observed difference in intake.

The sugar intake in Almere_NLD is based on Sluik et al. (2014) who calculated the sugar consumption based on the food intake as given in the national food consumption survey. This applies to direct consumption and sugars added to food products (e.g. drinks, cakes, confectionary). The sugar supply to households is derived from the sugar consumption and the above mentioned wastage in households. So, for the food product groups that contain added sugar (e.g. sugar and confectionary, cakes, non-alcoholic beverages) the sugar (and sugar beet area) demand is calculated via the value for sugar consumption in Table 1. In BIOSPACS human sugar consumption represents sugars from sugar crops and other sweeteners that are used in food products. In 2010 sugar intake and supply in BIOSPACS are 45% higher as compared to Almere_NLD.

The vegetable and fruit intake and supply are higher in BIOSPACS than in Almere_NLD. For vegetables as well as fruits the relative difference between the data in BIOSPACS and Almere_NLD is higher for the P intake than for the food intake due to additional differences in P content between both studies (see also Table 2). This may partly be due to the difference in the selected crops that represent vegetables and fruits in both studies.

The fat & oil consumption is about twice as high in BIOSPACS than in Almere_NLD. This will partly be due to the fact that oils and fats in processed foods are not taken into account in Almere_NLD. Large differences in intake were found for fish and alcoholic beverages being roughly 6 and 3 times higher in BIOSPACS, respectively.

For land use and P flows especially the animal product supply is important. Total meat supply is 40% higher in the analysis with BIOSPACS than in Almere_NLD, while the milk supply is more or less comparable. The supply of eggs is about 25% higher in the BIOSPACS data set.

Generally, in the analysis with BIOSPACS higher food supply rates are used for feeding the Dutch population and more P needs to be 'provided', relative to Almere_NLD (average values for food: +27% and for P: +23%). This will affect the land requirement and associated P flows which are both modelled as function of these consumption patterns.

Table 1. Diet of the human population in the Netherlands according to data obtained from FAOSTAT (BIOSPACS) and according to the Dutch national food consumption survey (Van Rossum et al., 2011) and additional calculations to come to primary product intake (van Dijk et al., 2017). Data of BIOSPACS refer to 2010 and those of van Rossum et al. (2011) to the period 2007-2010.

	BIOSPACS			Almere_NLD		
Diet	Food supply[1] kg/cap/y	Food intake kg/cap/y	P intake g/cap/y	Food supply[1] kg/cap/y	Food intake kg/cap/y	P intake g/cap/y
Cereals[2]	91.7	61.9	157.5	77.7	62.2	178.9
Starchy roots	78.2	58.4	26.6	37.3	29.8	14.3
Sugar	47.1	38.1	0.1	32.5	26.0	0
Pulses	1.4	1.2	5.2			
Tree nuts	4.1	3.5	4.7			
Oil crops	3.9	3.3	5.4			
Vegetables	78.4	57.1	21.2	50.1	40.1	10.4
Fruits[3]	116.2	84.7	18.3	89.1	71.4	8.5
Meat	78.4	62.8	94.3	55.9	44.7	66.5
Offals, edible	0.6	0.4	0.7			
Milk - excluding butter	340.5	285.0	262.7	357.4	285.9	200.1
Eggs	13.9	11.7	21.1	11.1	8.9	16.0
Fish, seafood	23.4	18.7	22.8	4.1	3.2	8.4
Vegetable oils[4]	16.3	14.1	0.0	10.6	8.5	0
Animal fats[4]	5.4	4.3	0.3			
Non-alcoholic beverages[5]				578.0	462.4	21.0
Alcoholic beverages[5]	85.3	69.1	15.1	25.9	20.7	4.9
Sugar & confectionary[6]				17.1	13.7	28.9
Condiments & sauces[6]				10.1	8.1	4.0
Stimulants[6]	4.3	3.5	5.4			
Spices[6]	1.8	1.4	3.0			
Total, primary products	*877*	*686*	*640*	*715*	*572*	*503*
Fats & oils[4]	*21.7*	*18.4*	*0.3*	*10.6*	*8.5*	*0*
Alcoholic beverages[5]	*85.3*	*69.1*	*15.1*	*25.9*	*20.7*	*4.9*
Other products[7]	*6.7*	*5.3*	*9.1*	*27.3*	*21.8*	*32.9*
Total, excl. non-alcoholic beverages	*991*	*779*	*664*	*779*	*623*	*541*

[1] Food supply refers to food entering households; they are expressed in primary equivalents, where carcass weight is used for meat.

[2] Including cereal demand for cakes, but excluding cereal demand for beer

[3] Including fruit demand for non-alcoholic beverages, but excluding fruit demand for wine

[4] Amount of oil and fat (no primary product)

[5] Amount of drinks (no primary product)

[6] Amount of product (no primary product in Almere_NLD; in BIOSPACS this refers to imported food items, e.g. coffee, cocoa, tea, pepper, etc.)

[7] Edible offals, spices, stimulants, condiments and sauces, sugar and confectionary

2.2.2 Crop yields

Table 2 shows the crop yields that are used to calculate the area demand for the production of the primary products. The data refer to net crop production harvested from the land. Except for cereals and oil crops, the yields used in Almere_NLD are higher than those derived from BIOSPACS, especially for potatoes (+21%), pulses (+19%) and fruits (+59%). This may partly be due to the fact that data in the analysis with BIOSPACS refer to 2010 while data of Almere_NLD refer to 2015.
Generally, the differences in P yield reflect the differences in crop yield except for vegetables and fruits. For these crop groups the used P content of the products is higher in BIOSPACS whereas for the other crops the P content is similar.

Table 2. Net grassland and crop yields as used in both studies.

	BIOSPACS		Almere_NLD	
Crops	Yield t FW/ha/y	P yield kg/ha/y	Yield t FW/ha/y	P yield kg/ha/y
Cereals	8.6	29.3	8.4	28.6
Starchy Roots	43.6	21.8	52.8	25.4
Sugar Crops	74.8	29.9	79.8	31.4
Pulses	3.7	16.9	4.4	20.5
Oil crops	4.4	28.9	3.7	24.1
Vegetables	53.2	18.2	57.9	14.3
Fruits	31.5	4.9	50	5.0
Grassland[1,2]	9.9	36.8	10.5	42.0
Silage maize[1]	15.5	31.0	15.6	31.1

[1] Grassland and maize yields are expressed in t DM per ha per year.

[2] Yields refer to both permanent and temporary grasslands.

2.2.3 Animal production

In order to calculate the area demand for feed, production data are needed for animal production (e.g. milk and meat production per animal) and the feed demand of animals. Table 3 gives the feed requirement ratios (FRR, feed demand/unit animal product) as used in both studies. There is a difference in the basis of the calculation. Almere_NLD starts with the human diet and uses FRR-values, derived from KWIN Veehouderij (2015), to calculate the feed demand. BIOSPACS first calibrates the FRR values by combining FAO data for animal production and feed production, and, subsequently, uses these FRR values to calculate the feed demand as function of the human diet. Combined with the yield data of feed crops the area demand can be calculated.

The FRR-values for pig, poultry and egg production are comparable. For bovine and milk production the FRR-values used in BIOSPACS are lower. For milk as well as bovine meat production BIOSPACS uses less roughages and concentrates.

Table 3. Feed requirement ratios (kg feed per kg animal product; meat in carcass weight, roughages and concentrates in dry weight) as used in the two studies. Feed requirement ratios refer to feed that is corrected for feeding losses, but not for conservation losses.

	Roughages		Concentrates		Total	
	Almere_NLD	BIOSPACS[1]	Almere_NLD	BIOSPACS[1]	Almere_NLD	BIOSPACS[1]
Pig meat			3.1	3.2		
Poultry meat			3.7	3.4		
Bovine meat	8.5	7.5	4.2	3.2	12.7	10.7
Milk	1.0	0.78	0.23	0.08	1.2	0.85
Eggs			1.4	1.3		
Sheep/goat meat		18.2		4.2		23.3

1 final values after calibration are given.

3 Results

For the comparison of the two studies, we selected the scenario Self-sufficient in van Dijk et al. (2017) in which all food and feed was locally produced except for food products that cannot be grown in the Netherlands (e.g. exotic fruits, coffee, tea). The analysis was restricted to production for human intake (not for e.g. biofuels). This means that the following flows in BIOSPACS are set to zero: import, export, stock variation and other uses. Other uses refers to the use of biomass suitable for food, such as food crops or animal products, for non-food purposes, e.g. for the production of biofuel.

3.1 Area demand

The calculated area demand is shown in Table 4. The subtotal for food crops differs substantially by 120,000 ha, mainly due to differences in land requirements for cereals, starchy roots and fruits. These differences can be explained by the differences in food demand (cereals, starchy roots: Table 1) and in case of fruits the difference is also caused by the situation that in Almere_NLD citrus/exotic fruits are imported whereas in the analysis with BIOSPACS it is assumed that all fruits are produced locally (which means that the consumption of citrus/exotic fruits is replaced by consumption of fruit grown in the Netherlands, notably apples and pears).

The total area required for animal production (grassland, fodder and feed crop production) is about 185,000 ha higher for Almere_NLD than for BIOSPACS. This is mainly caused by two aspects. (1) Almere_NLD uses a higher feed requirement for roughages to produce milk and bovine meat (Table 3) which leads to circa +70,000 ha of required grassland (partly compensated by the higher grass yields in Almere_NLD); (2) seed legumes supply a larger share in the animal ration of Almere_NLD, while in BIOSPACS this requirement is mostly covered by cereals. Roughly, one ha of seed legumes is equivalent to 0.5 ha of cereals (based on dry matter yields), and the lower cereal area required for feed in Almere_NLD (-100,000 ha) is “compensated” by the higher seed legume area (+200,000 ha). As a consequence the area requirement for feed crops (excl. grassland) is almost 100,000 ha higher in Almere_NLD.

Despite the differences in required area for food crops and animal production, the total area needed for food production is more or less comparable. In the Almere_NLD study a higher requirement of circa 65,000 ha is calculated, which equals 3% of the average value for total area requirement, obtained from both studies (i.e. 2.4 million ha).

Table 4. Land use requirements for plant and animal food products in the diet and for the total diet. Land use of imported food[3] has not been included.

	Land use (1000 ha)	
Crops	BIOSPACS	Almere_NLD
Plant food products		
Cereals	225	190
Starchy Roots	39	14
Sugar Crops	43	50
Pulses	6.9	
Oil crops[1]		
Vegetables	29	13
Fruits	67	25
Subtotal food crops	*409*	*291*
Animal food products		
Perm. and temp. grassland	615	687
Forage (silage maize)	142	130
Cereals	551	444
Oil seed rape	666	686
Seed legume crops[2]	8.9	225
Starchy Roots	4.9	
Vegetables	0.6	
Subtotal fodder and feed crops, excl. grassland	*1373*	*1485*
Subtotal grassland, fodder and feed crops	*1988*	*2172*
Total food, fodder and feed crops, excl. grassland	*1783*	*1776*
Grand total agricultural land[3]	*2397*	*2463*

1 area demand included in animal food production

2 mix of lupine, peas and field beans

3 it is assumed that stimulants, spices and tree nuts are imported (BIOSPACS) and in Almere_NLD total import also includes citrus/exotic fruits

3.2 P flows

Results of P flows are illustrated in Figure 3 (BIOSPACS) and Figure 4 (Almere_NLD) and summarized in Table 5.

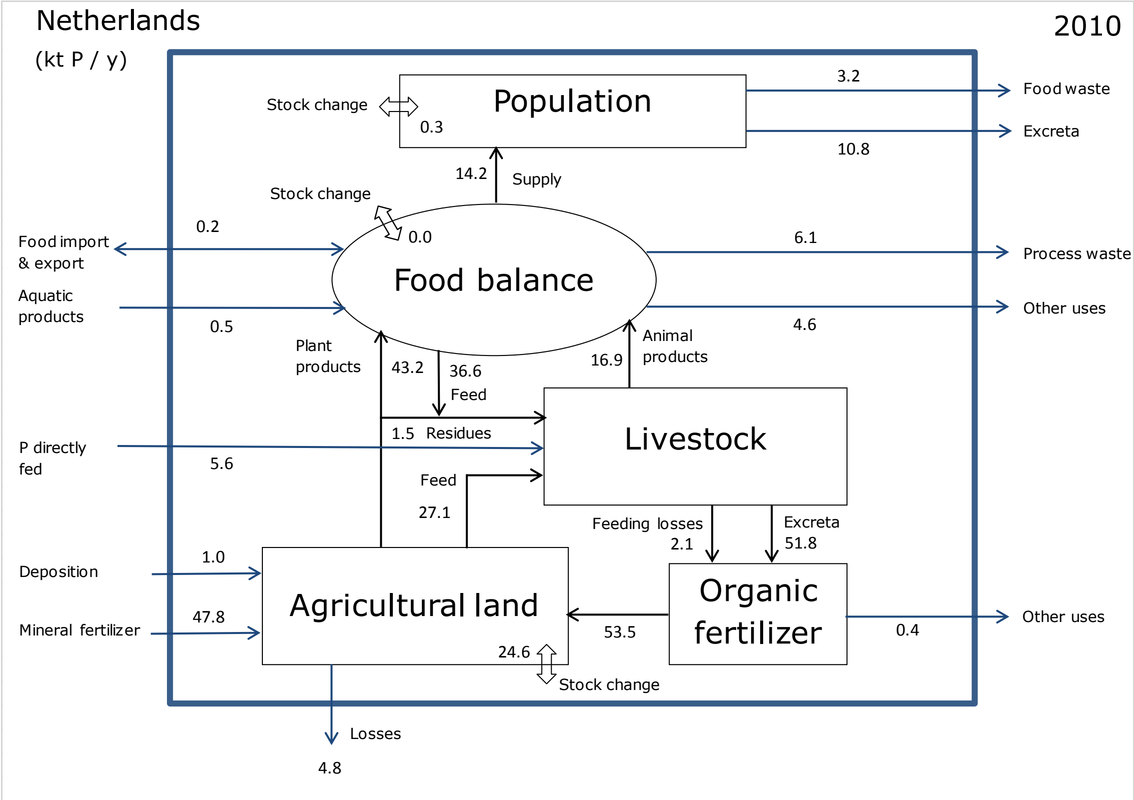

Figure 3. *Phosphorus flows of the food production and consumption system in the Netherlands for 2010 in a scenario of self-sufficiency, calculated with BIOSPACS (note: in the diagram above, the P flow of "Other uses" contains part of the P in slaughter waste).*

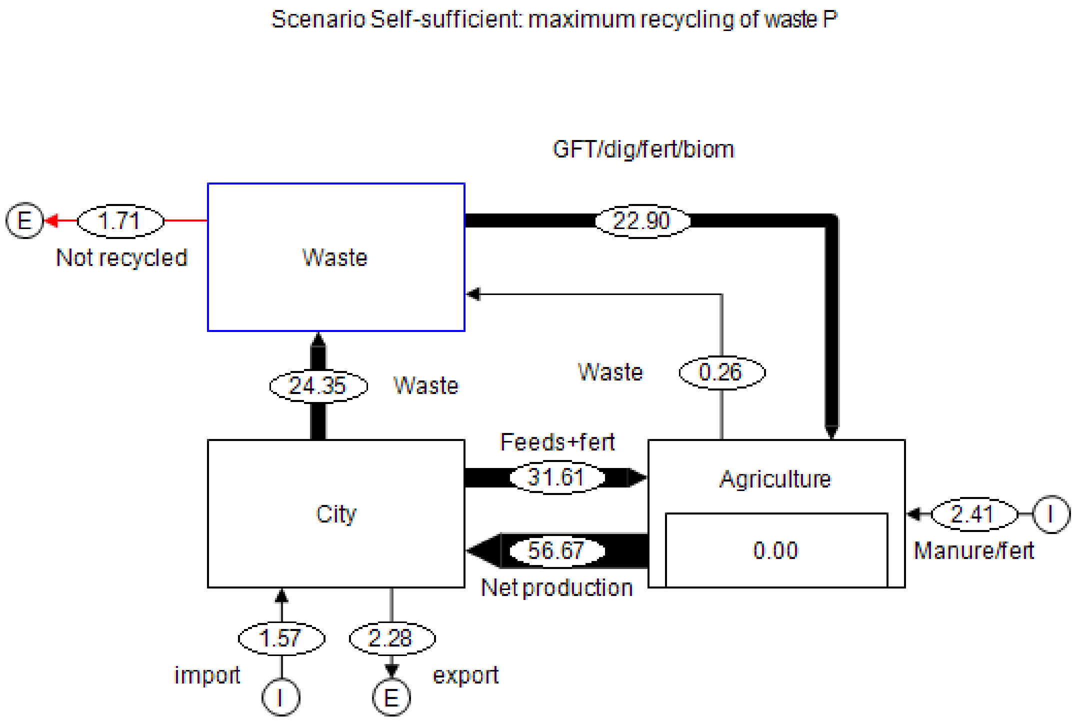

Figure 4. P flows (kt P) of the national food system for scenario Self-Sufficient with maximal recycling of waste P (via GFT, digestate, fertilisers, food or feed biomass) in Almere_NLD in 2015.

To compare the two studies the compartments of BIOSPACS have been grouped into the three main compartments of Almere_NLD: all flows at the right hand side of the diagram in Figure 3 refer to "*Waste*" in Figure 4; compartments "Food Balance" and "Population" represent the "*City*" and "Livestock", "Organic fertilizer" and "Agricultural land" together equal "*Agriculture*" in Figure 4.

Total calculated P waste flows are almost identical (compare 25.1 with 24.6 kt P/y in Table 5). In Almere_NLD most of this waste is returned to agriculture, as result of the assumption of maximal recycling, which was not the case in the calculations with BIOSPACS. The latter study has not made explicit assumptions on the final destination of the P waste flows on the right hand side of the diagram (Figure 3).

For the *City* the main input and outputs of both approaches are similar: total net production of 60 vs. 57, total feed of 37 vs. 32 and total waste of 25 vs. 24 kt P/y. BIOSPACS calculates a slightly higher net production of 6%, and "returns" approximately the same amount via the feed flow from *City* to *Agriculture*.

In *Agriculture* larger differences are found due to different assumptions in the studies of BIOSPACS and Almere_NLD. In the latter most waste flows have been assumed to be recycled towards agriculture, which has not been done for BIOSPACS (see flow 22.9 in Table 5). Almere_NLD assumes no P losses nor any accumulation of P in agricultural soils (crop P demand equals crop P offtake). BIOSPACS has used the flows of 2010 to estimate P losses and P accumulation, and relationships have been derived from that situation for the distribution of available P in the soil among crop uptake, loss and accumulation. If P accumulation is set to zero and the recycling of all P waste as fertilizer at a level of 85%, the requirement for P fertilizer would decrease from 47.8 to 1.9 kt P/y which is close to the value of Almere_NLD (2.4 in Table 5). However, in the study of BIOSPACS this should be added to the other imports of 5.6 kt P via feed additives and 1.0 kt P via deposition, which are not explicitly calculated by Almere_NLD, as well as the loss of P from agricultural soils (4.8 kt P/y).

Table 5. Summary of annual P flows (kt P) of both studies.

		BIOSPACS		Almere_NLD	
		In	Out	In	Out
Waste		25.1	25.1	24.6	22.9
					1.7
	Total	*25.1*	*25.1*	*24.6*	*24.6*
City		60.1	36.6	56.7	31.6
		0.7	24.7	1.6	24.4
					2.3
	Total	*60.8*	*61.3*	*58.3*	*58.3*
Agriculture			0.4	22.9	0.3
		36.6	60.1	31.6	56.7
		54.4	29.4	2.4	
	Total	*91.0*	*89.9*	*56.9*	*57.0*

4 Discussion and conclusions

4.1 Discussion

Agricultural land use: self-sufficient versus current

Compared to the current agricultural area used in 2010, the required area for grassland is 30-35% lower in the self-sufficient situation (Table 6), whereas the required area for arable land is more than double as high. A large share of this arable land would be needed for feed production (75-85%). For a self-sufficient situation this would mean that with the current diet, population density and cropping systems in the Netherlands there is not enough agricultural land.

Table 6. Agricultural land use in the self-sufficient scenario (BIOSPACS and Almere_NLD) and in the current situation (FAOSTAT, 2010).

The Netherlands	Self sufficient		"Current"	Self-suff vs. current	
Land requirement (*1000 ha)	BIOSPACS	Almere_NLD	FAOSTAT (2010)	BIOSPACS/ current	Almere_NLD /current
Perm. and temp. grassland	615	687	955[1]	64%	72%
Arable land for fodder & feed	1373	1485			
Total arable land, incl. feed	1783	1776	797	224%	223%
Total agricultural land	2397	2463	1751[1]	137%	141%

[1] it is assumed that 5% of total permanent grassland is not in use for food production.

P accumulation in the soil

As shown in Figure 3 in 2010 there is a considerable P accumulation in the soil (approx. 50% of P fertilizer input). In 2011 and later years, P fertilizer input decreased strongly in the Netherlands and would in BIOSPACS have led to an equally strong reduction in the accumulation of soil P because the other flows (notably manure P input and crop P offtake) remained more or less the same in these years.

Loss of P from the soil and accumulation of P in the soil were among the main differences in the overall P balances of the two studies. Whether assuming them to be zero, as in Almere_NLD, or significantly larger, as in BIOSPACS, determines for a large part the required amount of P fertilizer input, next to the possibility of recycling P from the various waste flows as fertilizer.

4.2 Conclusions

Despite different assumptions and data sources, the overall results are more or less comparable for the two studies (BIOSPACS and Almere_NLD). This applies to the required area for agricultural production as well as the main P flows.

The substantial differences in food supply and intake between FAOSTAT (originating from CBS) and the Dutch national food consumption survey are remarkable and require further investigation.

Considerable differences in crop area demand between individual crops are calculated, and explained by differences in input values. BIOSPACS calculates a higher area demand for food crops while Almere-NLD calculates a higher area demand for animal production, resulting in a total agricultural area demand that is comparable for the two studies.

Notably, soil P accumulation seems variable and uncertain, and its relation with P input as well as P loss should be studied in more depth.

References

Conijn, J.G., P.S. Bindraban, J.J. Schröder, R.E.E. Jongschaap (2018). Can our global food system meet food demand within planetary boundaries? Agriculture, Ecosystems and Environment 251, p. 244-256.

Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R., Meybeck, A., 2011. Global Food Losses and Food Waste: Extent, Causes and Prevention. FAO, Rome, Italy (38p).

Kwantitatieve Informatie Akkerbouw, 2015. Praktijkonderzoek Plant en Omgeving, publicatie nr. 643, 200 pp.

Kwantitatieve Informatie Veehouderij, 2015. Wageningen UR – Livestock Research

Sluik, D., L. Van Lee & E. J.M. Feskens, 2014. Consumptie van toegevoegde suikers in Nederland. Resultaten uit de Nederlandse Voedselconsumptiepeiling 2007-2010. Wageningen University, humane voeding, The Netherlands

Van Dijk, W., J.E. Jansma, W. Sukkel, H. van Reuler, T. Vermeulen & A.J. Visser (2017). Closing the life cycle of phosphorus in an urban food system: the case Almere (NL). Wageningen University & Research, WPR-report 725, 44 pp.

Van Rossum, C.T.M., E.J.M. Buurma-Rethans, F.B.C. Vennemann, M. Beukers, H.A.M. Brants, E.J. de Boer & M.C. Ocké, 2016. The diet of the Dutch: Results of the first two years of the Dutch National Food Consumption Survey 2012-2016. RIVM Letter report 2016-0082, Bilthoven, The Netherlands.

To explore the potential of nature to improve the quality of life

Wageningen University & Research
Praktijkonderzoek AGV
Edelhertweg 1
Postbus 430
8200 AK Lelystad
T | (+31)320 29 11 11 1
www.wur.nl/agv

Rapport 757

De missie van Wageningen University & Research is 'To explore the potential of nature to improve the quality of life'. Binnen Wageningen University & Research bundelen 9 gespecialiseerde onderzoeksinstituten van stichting DLO en Wageningen University hun krachten om bij te dragen aan de oplossing van belangrijke vragen in het domein van gezonde voeding en leefomgeving. Met ongeveer 30 vestigingen, 6.000 medewerkers en 9.000 studenten behoort Wageningen University & Research wereldwijd tot de aansprekende kennisinstellingen binnen haar domein. De integrale benadering van de vraagstukken en de samenwerking tussen verschillende disciplines vormen het hart van de unieke Wageningen aanpak.