RELACS

IMPROVING INPUTS FOR ORGANIC FARMING

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1. Executive summary

Sustainable organic farming closes nutrient cycles and strives for balanced nutrient budgets in order to maintain soil fertility in the long term, and to minimise nutrient losses. To facilitate regional planning of nutrient supply to organic farms, we developed an online planning tool entitled NutriGap. This tool allows organic farmer associations and authorities to calculate a demand-supply-balance for nitrogen, phosphorus and potassium on a regional basis, either in order to evaluate current nutrient supply and improve it by balanced sourcing of external nutrient inputs, or to examine different scenarios of growing areas under organic production. For organic farming in Switzerland, NutriGap clearly identified a deficit in P supply of 4 kg P/ha*year which needs to be addressed by increasing the use of recycled fertilizers in organic agriculture in Switzerland. The tool is publicly available under nutrigap.fibl.org/.

2. Introduction

The European Commission recently set a target of increasing the area of organic agriculture from 7.7% (2018) to 25 % of total farmland by 2030. Given that nutrients removed from the farms in marketed products need to be replaced by biological nitrogen fixation (BNF), recycling and/or permitted external inputs, there is a need to assess the nutrient demand of organic farms across Europe as well as the availability of nutrient sources that might be used on organic farms in future.

In task 3.3 of the project RELACS, a software to assess the current nutrient demand of organic farms in a given region was developed, addressing the three main plant nutrients nitrogen (N), phosphorus (P) and potassium (K). It balances crop nutrient demand based on crop areas entered by the user with manure produced, based on animal numbers entered by the user. The tool then allows matching the nutrient demand of crop production with a range of nutrient inputs, including recycled fertilizers, manures and commercial fertilizers. By changing crop areas and animal numbers, scenarios for future changes in the area under organic farming can be established.

This web-based planning tool is publicly available under nutrigap.fibl.org/. Its main features are described below, and its application to Swiss organic farms is demonstrated, using data made available by BioSuisse.

3. Methodology

3.1 How the tool works

On the start screen (Figure 1), new users can register for free for using the tool. After logging in, the country selection (CH, DK, D, HU, EST) is displayed. In the current version, different regions are stored for each of the five countries. The country selection has no further effects, i.e. stored figures and calculations are the same everywhere. Therefore, the tool can also be applied to other regions or countries that were not part of the RELACS consortium. To facilitate the naming of projects, the selection of certain regions within a country is included in the proposed project name, which can be changed immediately or any time later.

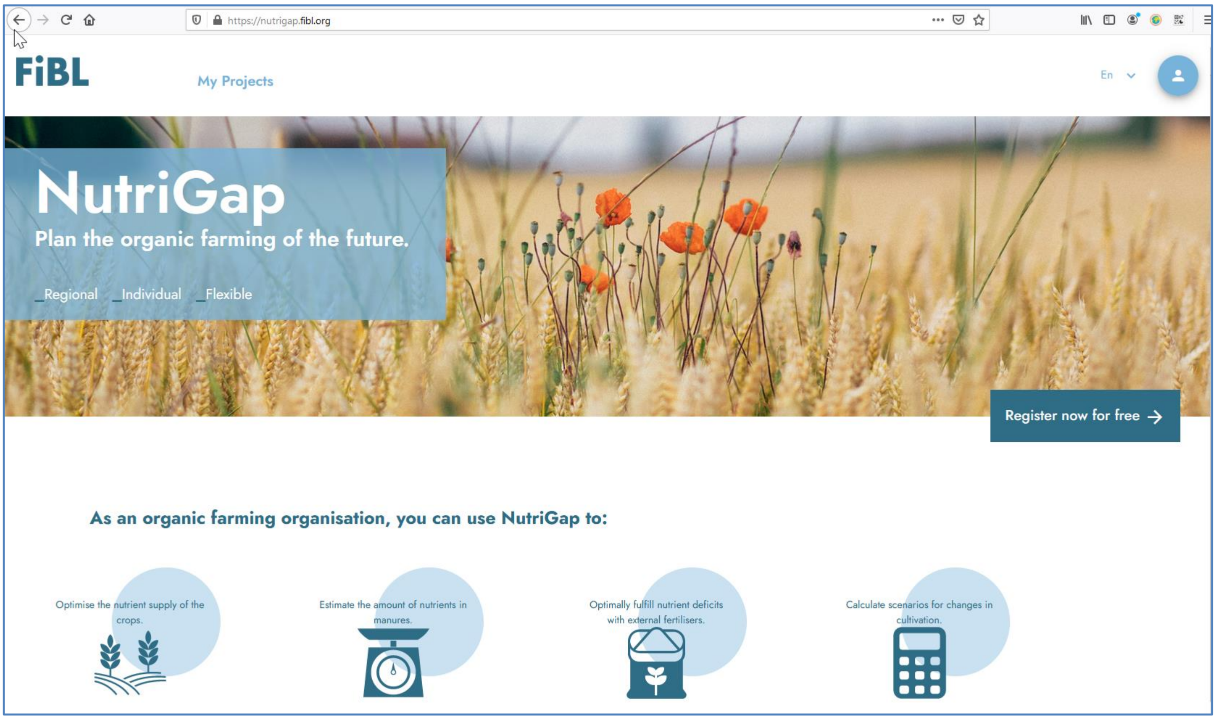


Figure 1: Start screen of the planning tool NutriGap available at nutrigap.fibl.org

The next screen is the crop production tab (Figure 2). Here, one specifies the total agricultural area of the region. The calculations are done on the basis of the summed area of the specified crops. Thus, for planning purposes, the calculation can be carried out for the most important crops occupying e.g. 90% of the area, thus not all crops of minor importance need to be entered.
The total amount of nutrients (in t or kg/ha) needed to optimally supply the crops with nutrients is calculated based on the area of each crop. A typical yield (t/ha) and the associated nutrient requirement (kg/ha) are stored for each crop. The stored values can be seen in the detailed view on the right-hand side as soon as a crop is selected. Additional crops can also be entered, and yields and nutrient requirements can be changed for existing crops. At the end of this step, the nutrient requirement corresponds to the nutrient deficit.

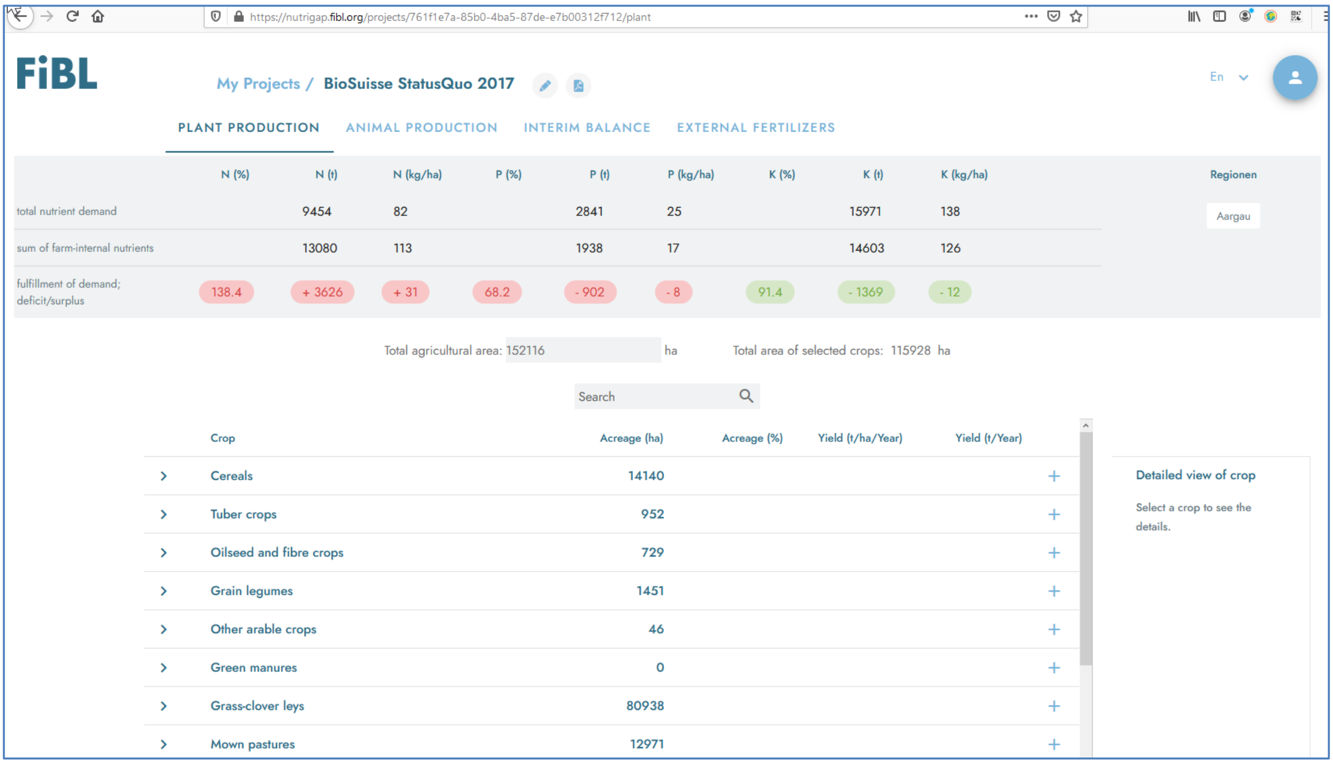


Figure 2: NutriGap tab on plant production, using the example of organic agriculture in Switzerland (2017)

In the animal production tab (Figure 3), the amount of nutrients in manures is calculated based on animal numbers and stored values for nutrients in manures (in kg/year per animal, place or unit). Through these values, indirectly also the usual feeding for a certain animal species is included. In the case of dairy cows, nutrients in manure depend on the selected annual milk yield. As with crops, additional animal species can be entered or existing ones changed. In addition, known nutrient quantities in manures can be entered directly in the category “Direct input of farm-specific nutrients”. In this case, the calculation via animal numbers is omitted. At the end of this step, the sum of nutrients in manures and the resulting fulfilment of crop demand in percent, absolute values (t) and in relation to the area of the specified crops (kg/ha) are displayed in the upper area of the tab with a grey background.

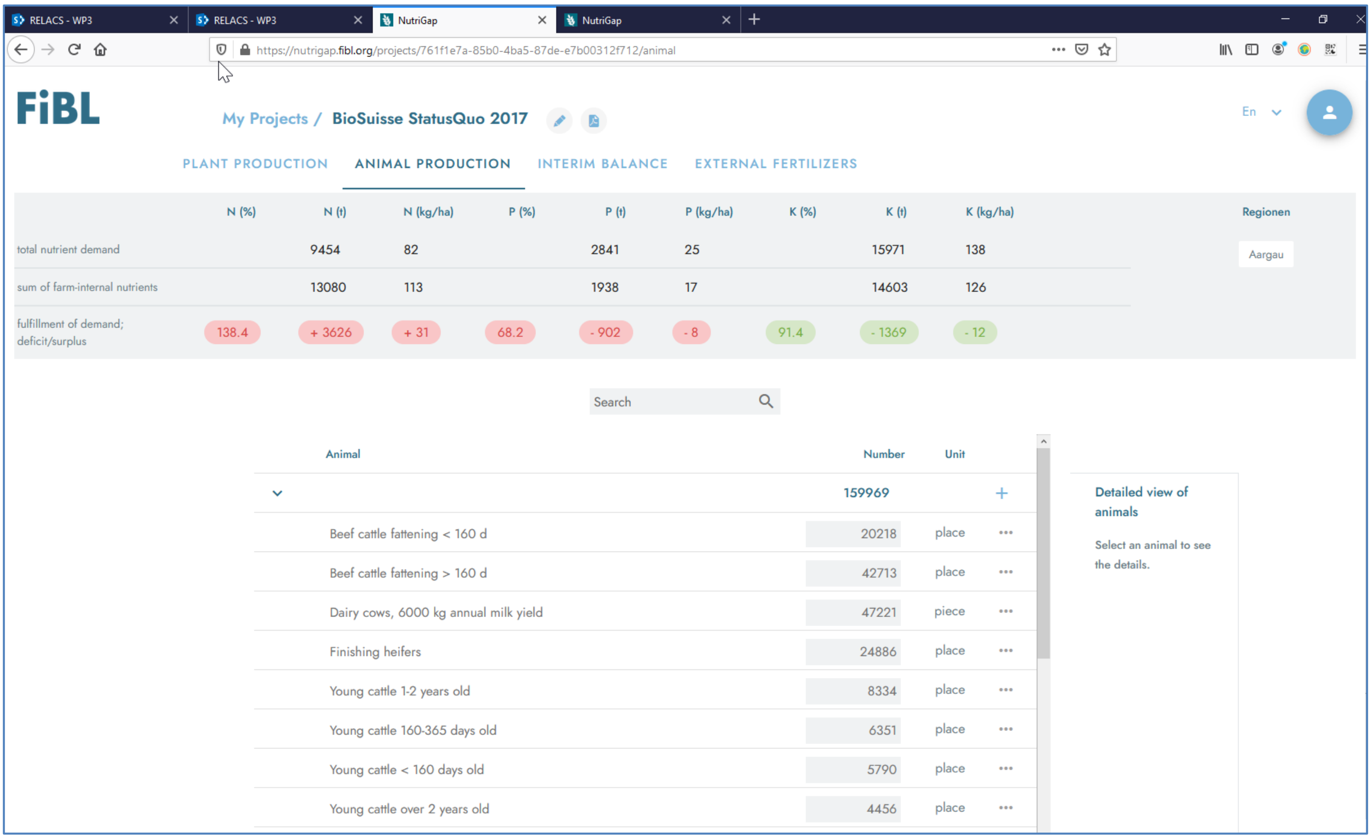


Figure 3: NutriGap tab on animal production, using the example of organic agriculture in Switzerland (2017)

The next screen is the interim balance tab (Figure 4), where crop nutrient demand and manures are listed per category and in total. In addition, N input via biological N_2 fixation is shown, resulting from the areas under legumes. For atmospheric deposition, 25 kg N/ha is deposited as a default value that can be modified. Unavoidable N losses can be adjusted in a two-step, factorial procedure. First, unavoidable losses in the stable and in the storage of manures are entered as a percentage of total N in manures. Then, the remaining amount of N in manures is corrected for unavoidable losses during application. Since NutriGap works everywhere with contents and amounts of total N, the reduced N utilisation of organic fertilisers compared to mineral fertilisers could also be taken into account here, in addition to losses during application.
In the upper area of the tab, the interim balance of nutrient demand and supply from manures after corrections for N inputs and N losses is now shown.

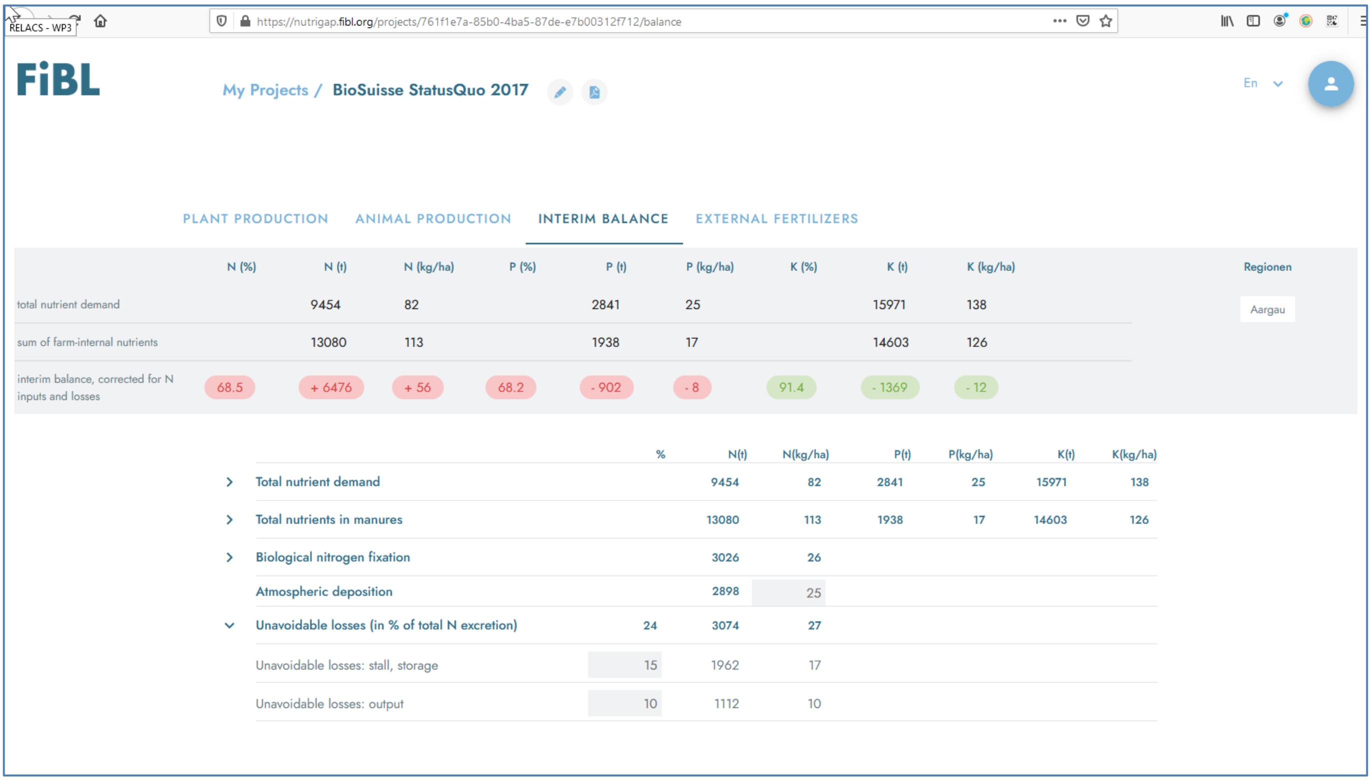


Figure 4: NutriGap tab showing the interim balance between plant nutrient demand and farm-internal nutrients available from animal production, using the example of organic agriculture in Switzerland (2017)

Finally, in the **external fertilisers** tab (Figure 5), different scenarios can be created for covering the nutrient demand via external fertilisers. Within such a scenario, the interim balance of nutrient demand, manures and corrections for further N inputs and losses is repeated in the upper, grey shaded area. The balance changes through the selection of different nutrient sources in the categories of recycled fertiliser, manures, commercial fertilisers and industrial wastes, for which usual nutrient concentrations are stored. Own fertilisers can be added (+) or existing ones duplicated ("…") and changed.

The balance resulting from the interim balance and entries for external fertilisers is displayed in green if the fulfilment of crop demand is between 90-110%, and coloured red above or below that range. The same colour scheme is also implemented in the previous tabs.

For exporting the project as a pdf, there is an icon to the right of the project name (to the right of the pencil icon). Here, each scenario is listed separately with the resulting balance. Even without export as pdf, each project is saved under the respective user. When deleting the user account, however, the data would be deleted. Therefore, finished projects should be exported as pdf.

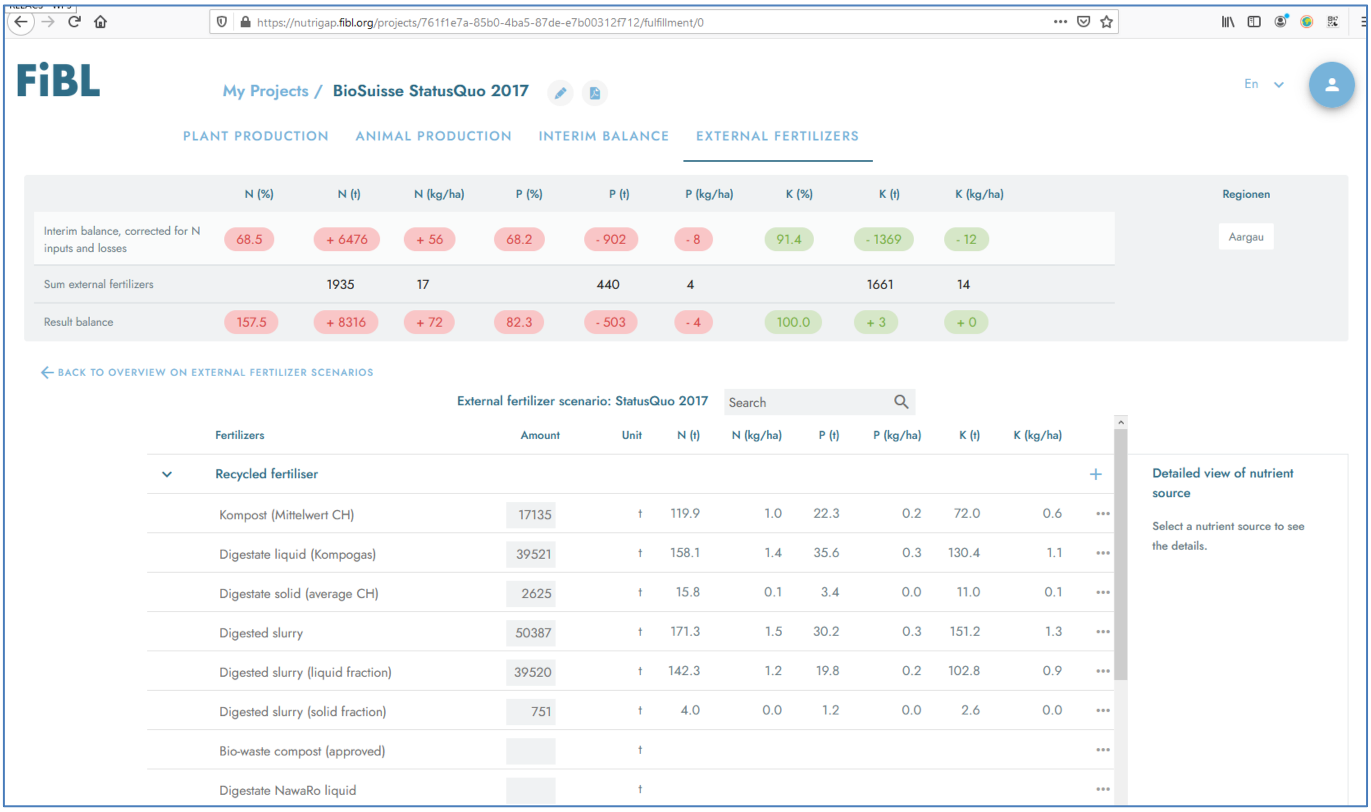


Figure 5: NutriGap tab showing an external fertilizer scenario, using the example of organic agriculture in Switzerland (2017)

3.2 Data behind the calculations in NutriGap

In principle, NutriGap is based on the data from the Swiss demand-supply balance (Suisse-Bilanz, Wegleitung Suisse-Bilanz Ed. 1.16). Further information available at

https://www.blw.admin.ch/blw/de/home/instrumente/direktzahlungen/oekologischer-leistungsnachweis/ausgeglichene-duengerbilanz.html (accessed on 30.03.2022)

The «Suisse-Bilanz» is based on the guidelines for the fertilisation of agricultural crops in Switzerland (GRUD 2017, grud.ch). The data are therefore not specific to organic farming. Crop nutrient demand generally corresponds to the fertilisation recommendation and not necessarily to nutrient export, since for some crops, e.g. biological N-fixation or soil N mineraliation are also taken into account. In contrast to Suisse-Bilanz, NutriGap calculated the balance not only for N and P, but also for K.

In NutriGap, data from Tab. 3 (meadows & pastures), Tab. 4 (arable crops), Tab. 5 (vegetables) and Tab. 6 (permanent crops) from the Suisse-Bilanz guidelines are stored in the plant production tab. Tab. 1 (nutrient accumulation) and Tab. 2a (correction of nutrient accumulation according to milk yield) from the Suisse-Bilanz guidelines are stored in the animal production tab.

Nitrogen input through biological N-fixation is displayed in the interim balance tab. For grain legumes, grain silage with legumes and legume green manure, it is based on the N balance according to the "Faustzahlen für den Ökologischen Landbau" (KTBL, 2015). Only for soy bean, the negative N balance was replaced by 0. For artificial meadows (leys) and mown pastures, the calculation was carried out according to Spiess & Liebisch (2020; Nährstoffbilanz der schweizerischen Landwirtschaft für die Jahre 1975 bis 2018. Agroscope Science Nr. 100. https://doi.org/10.34776/as100g). A clover share of 30% was assumed, with an above-ground fixation capacity of 4.15 kg N/ha per percent clover share. By multiplying the resulting above-ground N input from fixation by a factor of 0.4, only the non-harvested, largely below-ground N input was taken into account, since the above-ground N input from fixation is represented in the nutrient input from animal production.

In the external fertiliser tab, nutrient contents of various nutrient sources were compiled (GRUD Kap. 4, Tab. 6 und Tab. 8; Betriebsmittelliste der Schweiz (FiBL, 2020); table values in the Excel tool NutriGadget (Reimer et al. 2020, NutriGadget-Farm gate nutrient budgets for organic farming (https://orgprints.org/id/eprint/38025/)).

3.3 Case study Organic Farming in Switzerland (2017)

Data on organically cropped areas and organic animal production in Switzerland was available from BioSuisse for the year 2017. This data was entered in NutriGap and the outcome compared to results of a previous detailed study on nutrient budgets of 973 organic farms, corresponding to about 15% of all organic farms in Switzerland. In addition, data on inputs of recycled fertilizers and manure imported to organic farms was available from the database "Hoduflu".

4. Results

4.1 Case study Organic Farming in Switzerland (2017)

The average crop N demand of 82 kg N/ha calculated by NutriGap based on all crop areas under organic farming in Switzerland in 2017 (Figure 6) was similar to the average crop N demand of 973 organic farms found in the detailed study (Table 1). P demand was slightly higher as calculated by NutriGap (25 kg P/ha) compared to P demand found in the detailed study (22 kg P/ha). K demand was not calculated in the detailed study and the output of NutriGap can therefore not be validated.

Total farm-internal nutrients from animal production, i.e. in manures, averaged 113 kg N/ha and 17 kg P/ha (Figure 6), which again is similar to the values found in the detailed study (data not shown).

The resulting interim balance, where N inputs from BNF and atmospheric deposition as well as unavoidable N losses from animal production have been taken into account, was positive for N (56 kg N/ha) and negative for P (-8 kg P/ha) and K (-12 kg P/ha). When taking known inputs of recycled fertilizers and imported farmyard manures into account, the balance turned more positive for N, less negative for P and balanced for K (Figure 6).

The resulting P deficit of 4 kg P/ha for all organic farms in Switzerland was similar to the average P deficit observed in the detailed study of 973 organic farms (Table 1). For N, the comparison is not straightforward since values in the detailed study are given as available N, thus reducing total N by the fraction of manure N that is typically unavailable to plants. Assuming only 60% of N in farm-internal nutrients being available to plants would result in a N deficit that is roughly similar to the findings in the detailed study.

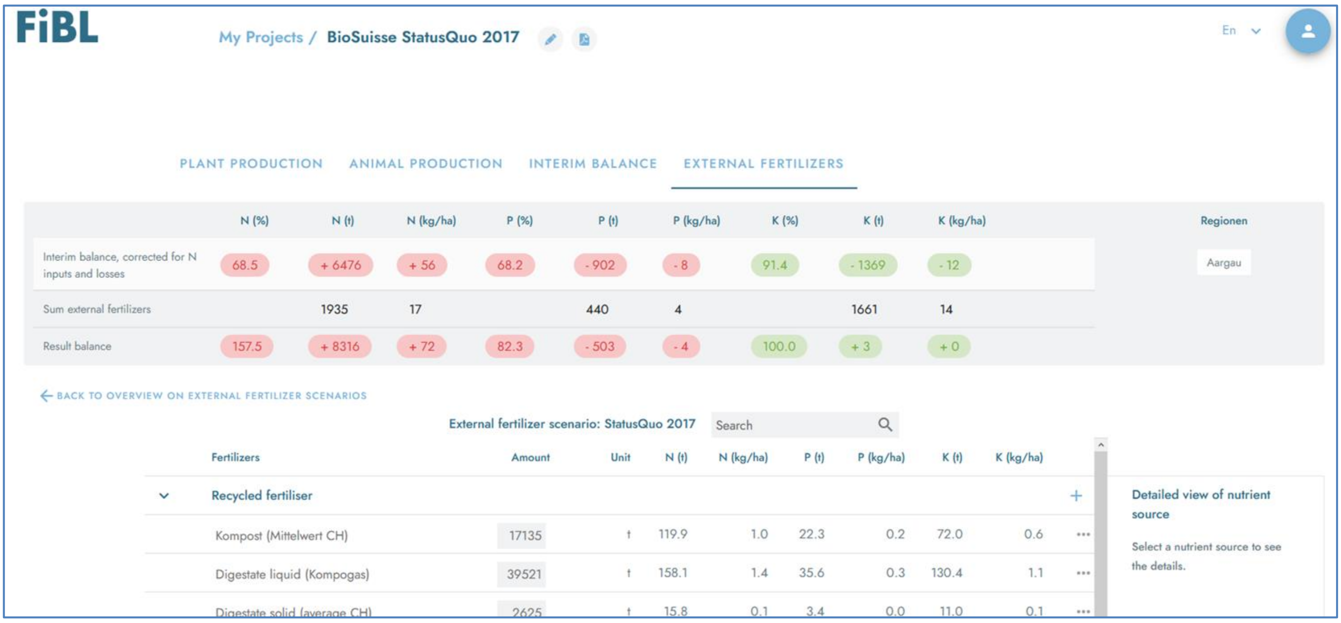


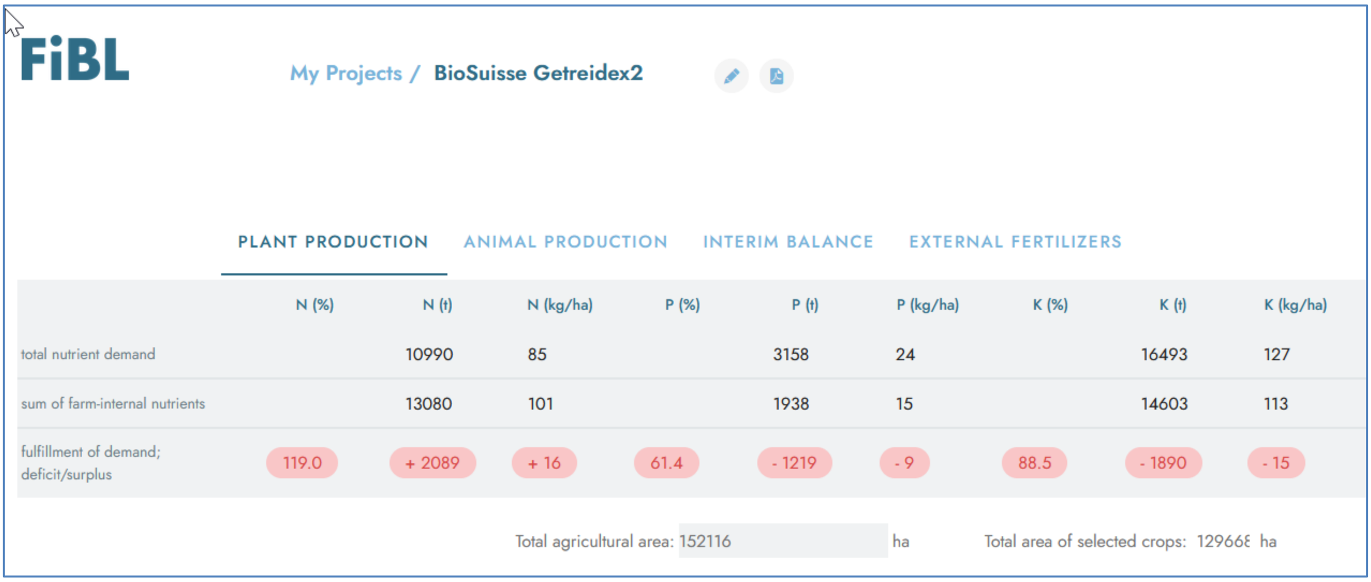
Figure 6: Resulting nutrient balance of organic agriculture in Switzerland after accounting for nutrients imported to Swiss organic farms with recycled fertilizers and imported manures (2017)

Table 1: Average crop N and P demand as well as available N (Navail) and P balance of 973 Swiss organic farms (2017); means ± standard deviation

No. of farms	N demand	Navail balance		P demand	P balance	
	kg / ha	in % of N demand	in kg / ha	kg / ha	in % of P demand	kg / ha
973	81 ± 29	74 ± 18	-22 ± 19	22 ± 7	82 ± 20	-4 ± 4

4.2 Scenario: doubling of area under organic cereal production in Switzerland without change in animal production or in use of external nutrient sources

Once a project with all the data from a given region has been set up, it can be duplicated, renamed and modified in order to assess the effects of changes in land use on the nutrient balance. For example, if the area under organic cereal production in Switzerland would double without any change in animal production, the balance of N demand and N supply would decrease from 31 kg N/ha (Figure 2) to 16 kg N/ha (Figure 7), and the P and K deficits would increase to -9 kg P/ha and -15 kg K/ha.



	N (%)	N (t)	N (kg/ha)	P (%)	P (t)	P (kg/ha)	K (%)	K (t)	K (kg/ha)
total nutrient demand		10990	85		3158	24		16493	127
sum of farm-internal nutrients		13080	101		1938	15		14603	113
fulfillment of demand; deficit/surplus	119.0	+ 2089	+ 16	61.4	- 1219	- 9	88.5	- 1890	- 15

Figure 7: Comparison of nutrient demand and farm-internal nutrients if the area under organic cereal production in Switzerland would double without any change in animal production.

5. Recommendations

5.1 Further development of the software

The first version of NutriGap presented here is intuitive and functional, but there are also many ways in which NutriGap could be developed further:

1. Import of crop areas and animal numbers instead of manual entries
2. Map-based, flexible selection of the region in connection with region-specific data for e.g. typical yields, nutrient uptake and animal categories, replacing current standard values from Switzerland.
3. Simplification of crop and animal lists
4. Map-based presentation of available external fertilizers with coordinates. This would allow optimization of transport distances and could be further developed into a market place of recycled fertilizers.

5.2 Use of recycled fertilizers in organic agriculture

For organic farming in Switzerland, NutriGap clearly identified a deficit in P supply of 4 kg P/ha*year which needs to be addressed by increasing the use of recycled fertilizers in organic agriculture in Switzerland.