LCA OF THREE DIFFERENT SCHOOL LUNCHES WITH THE SAME NUTRITIONAL CONTENT

December 2012

Kungl. Tekniska Högskolan
Division of Environmental Strategies Research
Course: AG2800 Life Cycle Assessment
Supervisor & Examiner: Anna Björklund

By Group 1:
Anders Berggren
Erik Marklund
Nicklas Magnusson

Abstract

Studies have shown that the production of food is a major contributor to global warming, eutrophication, acidification and other environmental issues. In the procurement processes for Swedish school lunches, only economic and nutritional aspects are considered. Since environmental impacts from food production are severe, such aspects also might be necessary to consider. This report aims to conduct a life cycle analysis of three different lunch dishes with the same nutritional content for lunches to be served in elementary schools (age 10-12). The lunch dishes that have been evaluated are pasta Bolognese, chicken with potato gratin and soy patties with rice. The results showed that the Bolognese dish had the worst environmental impacts (in 10 of 18 impact categories), followed by the soy patties dish (7 of 18). The two main ingredients in the vegetarian dish (rice and soy beans) are imported from China and the US, whereas the other dishes are based on mostly domestically products. The results may therefore be imbalanced. In order to better aid the procurement processes, LCA data should be presented on an ingredient basis instead of calculating impacts on predefined dishes. With such information, a variety of dishes can be composed based on price, nutrients and environmental impacts.

Contents

1 Introduction

Studies have shown that the production and consumption of food is a major contributor to global warming, eutrophication, acidification along with other environmental issues. For instance, the Swedish Environmental Protection Agency concluded in a study that the Swedish emissions of carbon dioxide equivalents related to food consumption were two tones per person, which corresponds to around a third of a Swede’s total emissions of carbon dioxide equivalents (Naturvårdsverket, 2010). The agricultural release of phosphorus and nitrogen does furthermore contribute to eutrophication, which e.g. the Baltic sea has been suffering of for many years (Naturvårdsverket, 2006). The magnitude of the various impacts depends on various aspects, such as food category and type of production means, and there is of interest to map out and evaluate the impacts stemming from different food types to be able to take precautionary measures.

In the Swedish school law (SFS 2010:800) it is stated that the pupils should be provided with nutritious food, free of charge. In the procurement process, decision-makers should hence not only take economic aspects into consideration but also make sure that the lunches are healthy and nutritious. Due to the various environmental impacts stemming from food production it is reasonable to think that environmental aspects also could and should be taken into account in the procurement process of school lunches in the future.

1.1 Research question

What are the main environmental impacts of three different Swedish school lunches with the same nutritional content?

1.2 Aim and objectives

The study aims to conduct a comparative and accounting LCA for three separate Swedish school lunches with the same nutritional content, to determine the environmental impacts for each dish. Such information would ideally serve as guidance in the procurement process of the school lunches. The objectives for reaching the aim are:

- To define three different lunch dishes in regards to the protein sources: (i) beef, (ii) chicken and (iii) soy beans.
- Model the dishes in the Life Cycle Assessment modelling tool, SimaPro v.7.3.3
- Calculate the global warming impact from the ingredients of each dish
- Interpret and draw conclusions from the acquired results

1.3 Functional unit

The function is to deliver nutritious food lunches – based on recommendations from the Swedish National Food Agency (Livsmedelsverket) – to children in elementary school (age 10-12) in Sweden. The functional unit is 100 lunches, each with 625 Kcal (2,6 MJ) of energy, where

- max. 20% (or 30 grams) is protein;
- max. 30% (or 20 grams) is fat, wherein saturated fat is max. 10% (or 7 grams);
- min. 50 % (or 78 grams) is carbohydrates.

1.4 Goal of the study

The LCA results are intended to serve as guidance in the procurement process of the school lunch menus by showing the most important environmental impacts and providing supplemental information to economic costs and nutritional content.

The intended audience is considered to be policy-makers on regional and municipal level, as well as decision-makers on local levels such as meal planners and headmasters in elementary schools. Parents to children in the addressed target group may also be considered as audience due to their possibility to affect and cause minor changes in the local school activities.

The LCA study is of comparative and accounting design, since the three lunch dishes (with different composition of elements but the same nutritional content) are evaluated in respect to their potential environmental impacts.

1.5 System boundaries

The ingredients needed to compose the chosen dishes are transported to a central kitchen in the city of Stockholm, and after prepared they are delivered to a school (Norra Real) in the centre of the town. The origin of the ingredients varies, but the majority is domestically produced (Sweden). Ingredients that are not possible to cultivate in Sweden have been chosen based on agricultural statistics.

The LCA study is applicable for the year of 2012. Old data of food impacts may not be of major concern in this case, since food production technologies are not considered to change in same pace as for example electronic technology.

Of the biological food waste in the Stockholm municipality (from restaurants, central kitchens and households), approximately 8 % is sent to biological treatment and biogas production (Stockholms Stad, 2010). The anaerobic treatment of food waste from central kitchens is larger than 8 %, but no exact number has been found. Since the national goal is to increase the amount of biologically treated waste (to 35 % by 2010), the waste management method for organic waste is in this study set to be biological treatment methods (anaerobic digestion). This might however give an inaccurate result. The only waste considered in the study is food scrap waste, i.e. food that is not eaten but thrown away by the school children. The food scrap waste is between 8 and 36 % of the total amount (VästerviksTidningen, 2009). In this study, the amount is set to 10 %. The LCA study does not consider waste water treatment processes for the waste generated from the human metabolism.

Possible identified allocation problems are in the milk and beef production and chicken and eggs production. For the chicken and egg production, it is assumed that these are two separate processes, where chickens are bread only for the meat, not laying eggs, and the hens producing eggs are not used for chicken meat. As for the meat production, minced meat production levels are given by milk production quotas, independent of meat demand. Therefore the environmental impacts of the minced meat are determined by the pork meat this overproduction of beef displaces. The same milk quotas create an excess of cream, allowing cheap butter production. Therefore the environmental impacts of cream are also determined by the butter it displaces, giving a negative net impact. (LCAFood.dk, 2007)

A second allocation issue occurs in the waste treatment scenario. The scenario is of a multi-input type (biological waste from several different sources) and the output emissions need to be allocated based on the input substances of the dish.

The three dishes that are analyzed are: Pasta Bolognese (beef dish), Chicken and Potato gratin (chicken dish) and Soy patties with Rice (soy dish). The dishes are presented more detailed in chapter 2. Simplified flowcharts for the lunch dishes are presented in Figure 1, Figure 2 andFigure 3.The inner square represents the foreground system of the LCA. Fertilizer and farm equipment is included into the system boundaries, and human waste from consumed food is excluded.

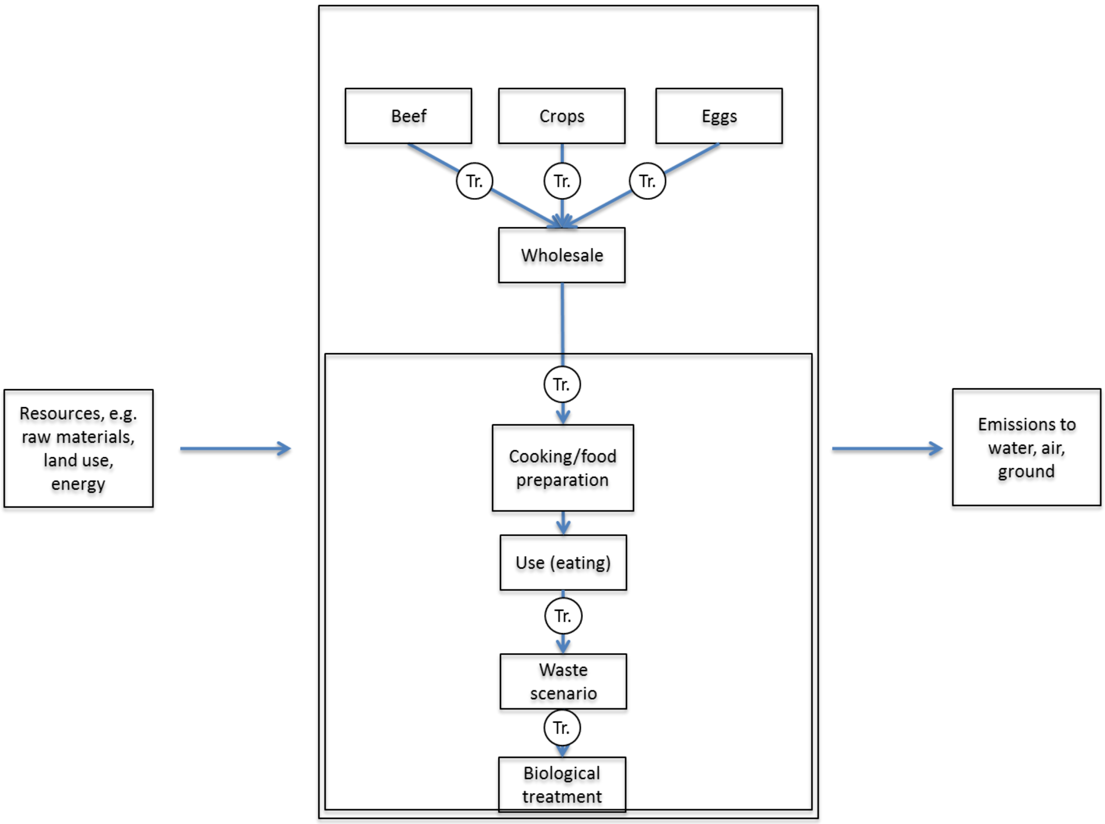

Figure 1 Simplified flowchart of the Pasta Bolognese dish

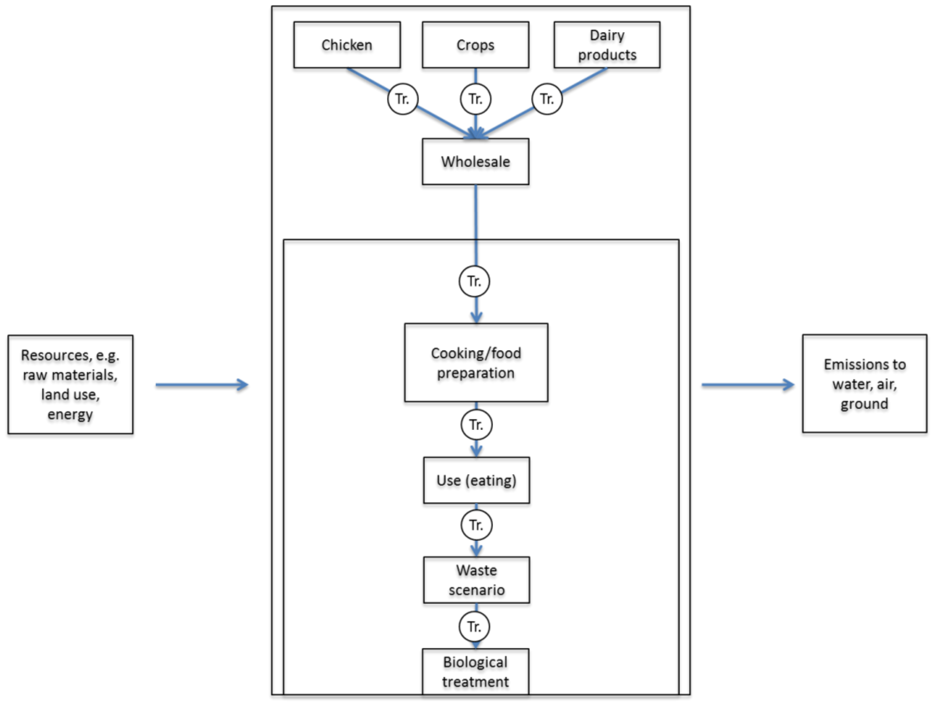

Figure 2 Simplified flowchart of the Chicken dish

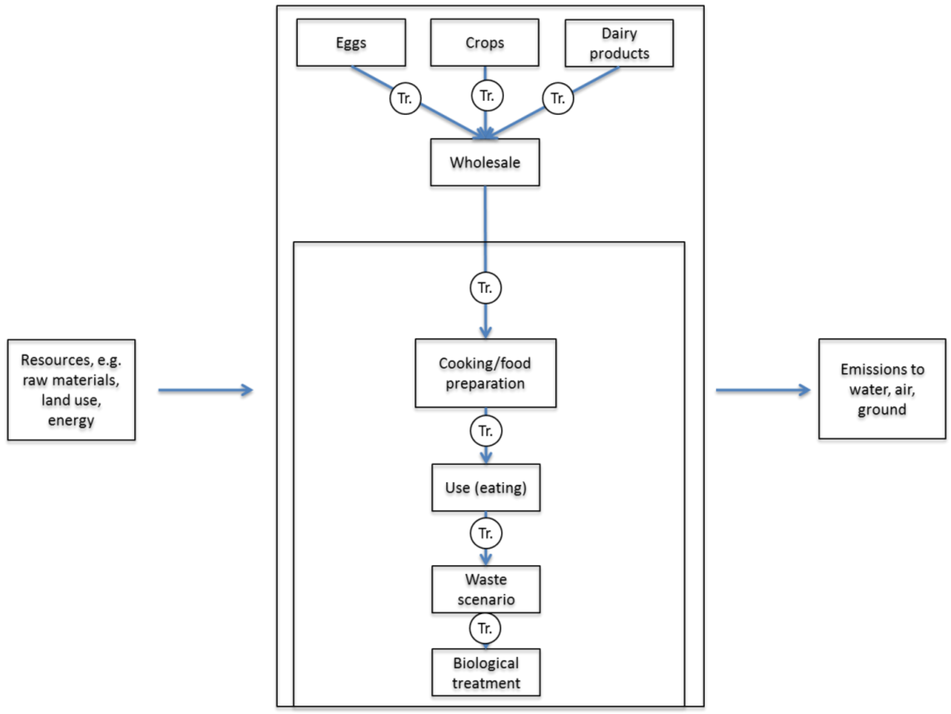

Figure 3 Simplified flowchart of the Soy dish

1.6 Assumptions and limitations

The study is limited to three aspects in the composition of nutritious food lunches: protein, fat and carbohydrates. Other elements that are required for a healthy dish, such as vitamins and minerals, are not considered in the scope of the study.

Additional food ingredients that are used in school lunches, e.g. salad, milk, bread, salt and pepper, are assumed to be the same amount or nutritional content for each dish. This amount is simply subtracted from the total amount of 625 Kcal.

The study is limited to data availability in the modeling tool, SimaPro, and may therefore not reflect the actual food situation in Sweden. For an accurate study, statistics of the origin of each ingredient of the lunch dishes must be addressed from a Swedish import/produced perspective, to determine their specific environmental impact. However, due to the workload and possible time dedication for this project, the study will depend on the data that can be found in the SimaPro database.

The food cooking unit (central kitchen) and the school have been merged to one unit for this study, i.e. it is assumed that the lunches are cooked – not only re-heated – at the elementary school.

1.7 Impact categories and impact assessment method

The impacts categories are calculated as midpoint values using the ReCiPe methodology in SimaPro with the Hierarchist perspective. In this report all impact categories from that method have been included and analyzed. These impact categories are: Climate change, Ozone depletion, Human toxicity, Photochemical oxidant, Particulate matter formation, Ionising radiation, Terrestrial acidification, Freshwater eutrophication, Marine eutrophication, Terrestrial ecotoxicity, Freshwater ecotoxicity, Marine ecotoxicity, Agricultural land occupation, Urban land occupation, Natural land occupation, Water depletion, Metal depletion and Fossil depletion.

The choice of midpoint values was conducted due to the high uncertainty of endpoint valuation. It is considered that e.g. carbon dioxide emissions are more precise than endpoint values measured in DALY.

1.8 Normalisation

The environmental impacts are normalized using the same method as above, the ReCiPe methodology, for an European average. This means that the emissions from the life cycle is shown as a fraction of the emissions of an average European (EU-27 +3) citizen during 1 year. (ReCiPe, 2012)

2 Life cycle inventory analysis

Below the data used in the Life Cycle Asessment is presented. First the contents and composition of the whole school meal is presented, then the compositions of the different dishes, and finally the details regarding ingredients and cooking procedures are shown.

2.1 Process flowchart

The figures below show the process flowchart for each lunch dish in scope for the study. All energy inputs and all emissions to soil, water and air have been excluded in the flowcharts.

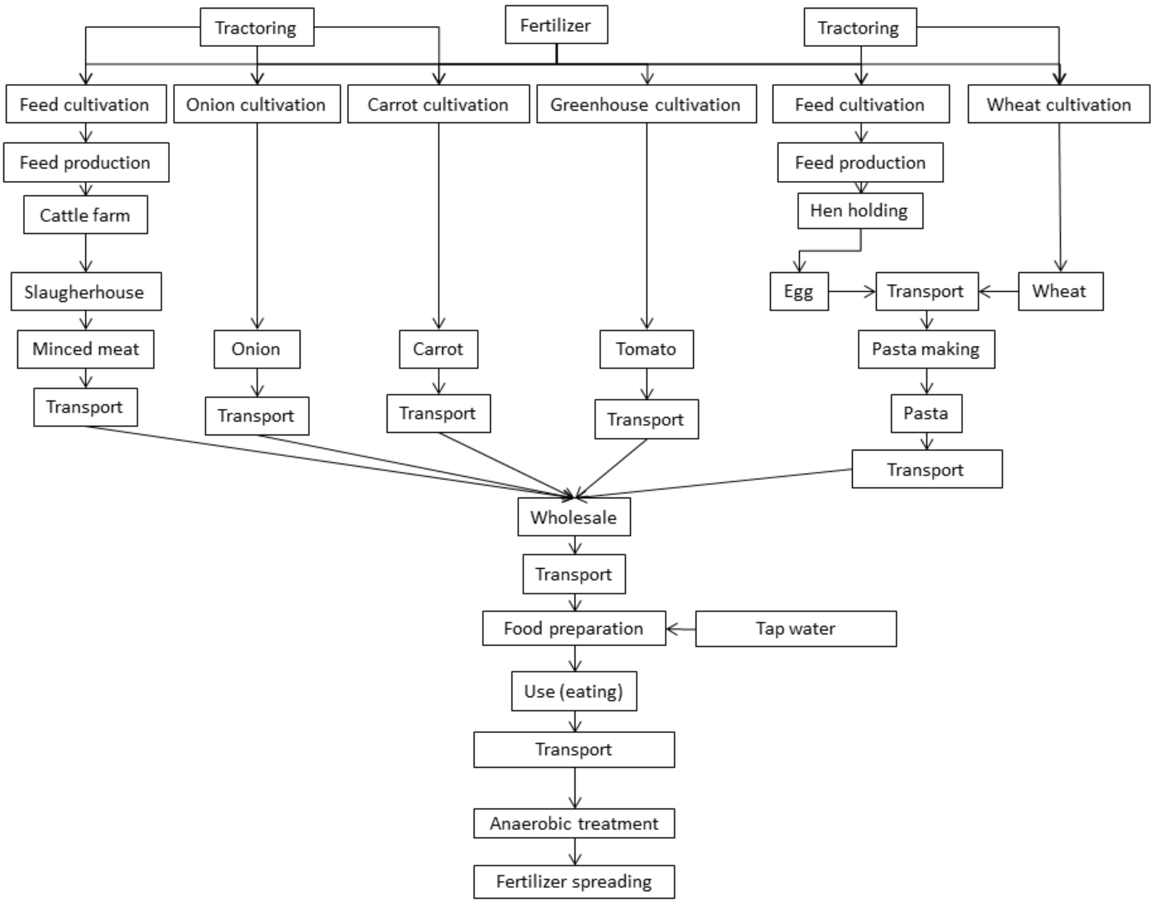

Figure 4 Detailed process flowchart for the Pasta Bolognese dish

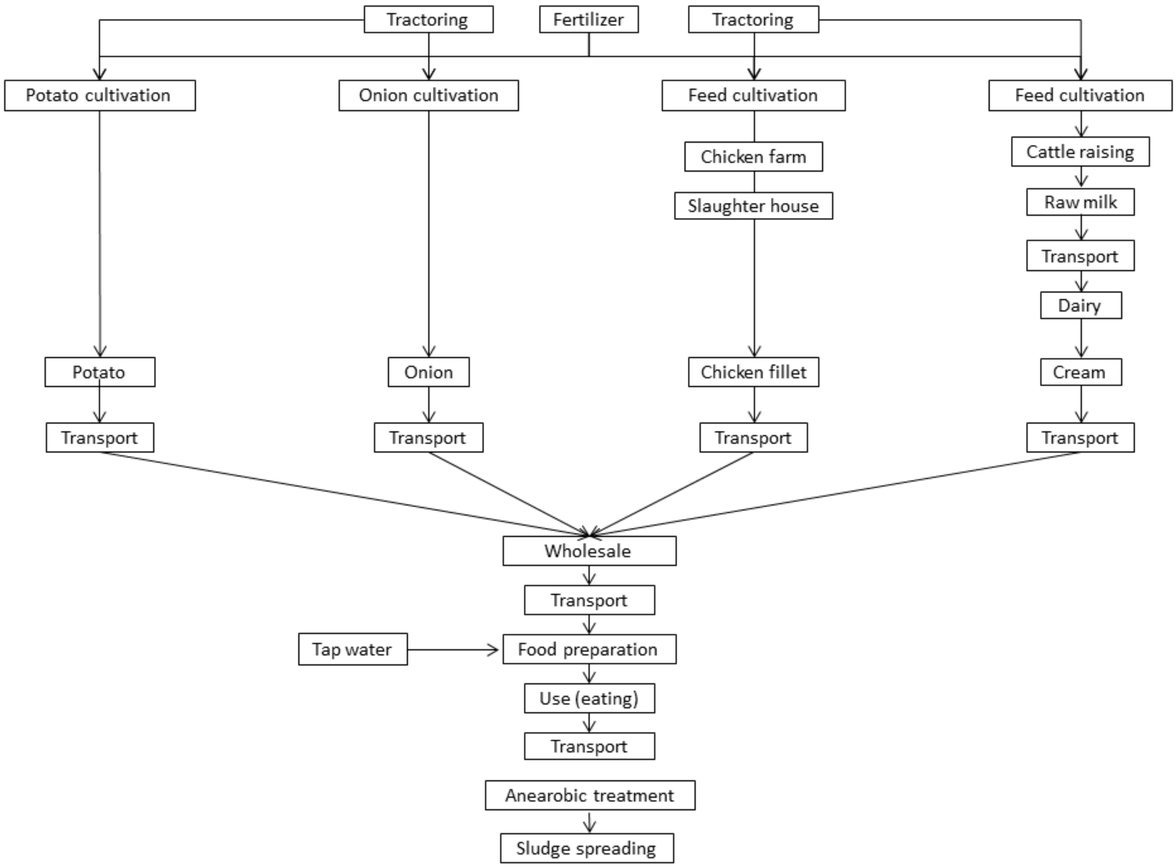

Figure 5 Detailed process flowchart for the chicken dish

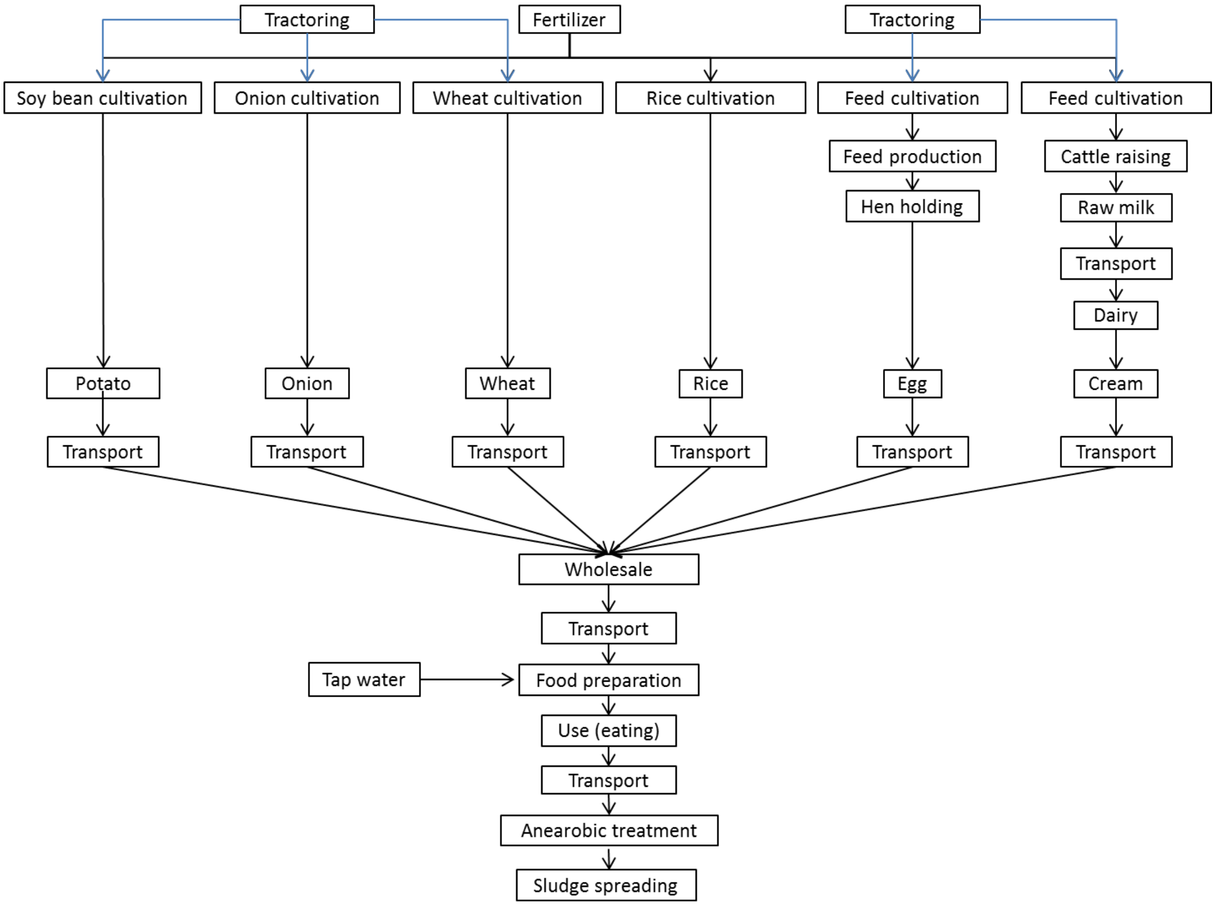

Figure 6 Detailed process flowchart for the Soy patties dish

2.2 Data

The nutrient values for each dish is based on guidelines from the Swedish national food agency (SLV, 2011). The recommended values to children in elementary school (age 10-12) are shown below in Table 1.

Table 1 Nutrient values of the entire lunch meal, age 10-12.

Total dish composition		
kcal	625	
Protein (gram)	30	Maximum
Fat (gram)	20	Maximum
Carbohydrates (gram)	78	minimum

In addition to the elements shown in Table 1, the Swedish national food agency recommends that a schools lunch should contain 100-125 grams salad, one glass of milk and a slice of bread. In order to not exceed the recommended values, the calories contained in one glass of milk, one slice of bread with butter and 100 grams salad are subtracted from the total amount of recommended calories. As seen in Table 2, these additional components contain 267 Kcal.

Table 2 Mass, calorie and nutrient values of the additional food dish components

Food	Weight (g)	Kcal	Protein (g)	Fat (g)	Carbon hydrates (g)
Milk	250	119	9	4	13
Husman bread	24	85	2	1	16
Butter	5	27	0	3	0
Carrots	20	8	0	0	2
Lettuce	20	2	0	0	0
Sweet cron	20	21	1	0	4
Cucumber	20	2	0	0	0
Tomato	20	3	0	0	1
Sum	**379**	**267**	**12**	**8**	**35**

As described in chapter 1.6, these accompanying lunch elements are assumed to be the same for each lunch dish since they are served independently of the main dish. That means that there are 358 Kcal left for the main dish, see Table 3.

Table 3 Nutrient values for the lunch plate (excluding salad, milk and bread)

Plate composition		
kcal	358	Maximum
Protein (gram)	18	Maximum
Fat (gram)	12	Maximum
Carbohydrates (gram)	43	Minimum

The composition of the dishes as shown below (Table 4, Table 5, and Table 6) is done using guidelines from the Swedish national food agency (Livsmedelsverket, 2007), and modified to correspond to the nutrient values above. The dishes does not follow this plate composition in full however. This is since the balance between different nutrients in some cases could not be obtained using the guidelines from Swedish National food agency. Also the dishes is composed to reflect the authors view of a normal and intuitive dish composition, e.g. a not unreasonably large or small serving of meat. Therefore, for example, the protein values may be too high for some dishes, and other values may exceed or be less than the above shown composition.

Data on the nutrient content is collected from the Swedish Food Agency Nutrient Database (Livsmedelsverket 2012)

Table 4 Nutrient and ingredient composition of Pasta Bolognese

Pasta Bolognese	Grams	Kcal	Protein	Fat	Carbs
Beef	80	119	16	6	0
Tomato	90	15	1	0	3

Onion	30	9	0	0	2
Carrot	40	15	1	0	4
Egg	22	30	3	2	0
Wheat	48	169	4	1	35
Water	8	0	0	0	0
Sum	**318**	**358**	**24**	**9**	**44**

Table 5 Nutrient and ingredient composition of Chicken and potato gratin

Chicken and potato gratin	Grams	Kcal	Protein	Fat	Carbs
Chicken fillet	60	80,4	16,5	1,5	0,0
Onion	20	6,1	0,1	0,0	2,2
Potato	200	158,0	3,4	0,2	32,8
Cream	30	112,5	0,6	12,0	0,9
Sum	**310**	**357,0**	**20,7**	**13,7**	**35,9**

Table 6 Nutrient and ingredient composition of soy patties with rice

Soy patties with rice	Grams	Kcal	Protein	Fat	Carbs
Soy beans	100	128	11	6	6
Onion	10	3	0	0	1
Egg	10	14	1	1	0
Wheat	10	35	1	0	7
Cream	35	54	1	5	1
Rice	110	124	3	0	28
Water (to sauce)	35	0	0	0	0
Sum	**310**	**358**	**16**	**12**	**42**

Origin of ingredients and mean of transportation

The origin of each ingredient influences the total impact of the lunch dishes due to travel distance and mean of transportation. All ingredients except from rice, soy beans and tomatoes are assumed to be domestically produced. Such an assumption favor dishes where most of the ingredients are locally produced and it is necessary to take into account that if the origins are altered the results may be different, e.g. beef produced in Brazil instead of Sweden. The origin and mean of transportation for each ingredient are shown in Table 7. The wholesale is in Table 7considered to be the end destination for the ingredients.

Table 7 The origin and mean of transportation for each ingredient

Ingredient	**Origin**	**Distance i**	**Distance ii**	**Distance iii**
Beef	Skara	Stockholm, 400km, Lorry 32 + refrigeration		
Carrot	Skövde	Årsta, 330 km, Lorry 32t		
Chicken	Hjo	Årsta (via Valla), 340 km, Lorry 32t + refrigeration		
Cream	Ekerö	Årsta (via Kallhäll), 50 km, Lorry 32t		
Egg	Adelsö	Stockholm, 100 km, Lorry 32t		
Onion	Stockholm	100 km, Lorry 32t		
Potato	Eslöv	Årsta, 545 km, Lorry 32t		
Rice	Jiangsu (CN)	Shanghai, 303 km, Lorry 32t	Gothenburg, 20300 km, Transoceanic freight ship	Stockholm, 471 km, Lorry 32t
Soy beans	Iowa (US)	New York, 1783 km, Lorry 32t	Gothenburg, 6608 km, Transoceanic freight ship	Stockholm, 471 km, Lorry 32t
Tomato	Enschede (NL)	Stockholm, 1300km, Lorry 32t		
Wheat	Skövde	Stockholm, 300 km, Lorry 32t		

Distances are calculated using google maps and sea-distances.com.

Food preparation

From the wholesale, all ingredients are transported to Norra Real for cooking. The mean of transportation is a lorry, 16t, and the distance is set to 10 km. The cooking equipment is assumed to consist of:

- Stove, 3.8 kW
- Stove, 5 kW
- Oven, 14.5 kW
- Warm-keeping (water bath), 4.5 kW
- Oven for re-heating, 19 kW

Cooking time varies dependent on what type of dish which is to be prepared. For the Bolognese dish, the 5 kW stove is assumed to be used for 30 minutes to prepare 100 dishes, which results in 0.09 MJ per dish. Cooking time for the pasta (including time for boiling water) is 22 minutes, which results in 0.067 MJ per dish. For the chicken dish, the 14.5 kW oven is assumed to be used for 45 minutes. That includes preparation of both chicken and the potato gratin, and results in 0.39 MJ per dish. The soy patties dish is assumed to use the 5 kW stove for boiling the soy beans (1.75h) and the rice (0.5h), and the 3.8 kW stove for frying the patties (0.1h). That result in 0.315 MJ, 0.09 MJ and 0.034 MJ respectively per process. The data is summarized inTable 8 .

In order to facilitate these food preparation processes in the software, new processes are created for the boiling the pasta and soybeans. For the Pasta dish, 0,56 kg (per plate of food) of tap water is used; water that is later flushed down the kitchen drain, thus not ending up in the food waste going to anaerobic treatment. For the soy bean preparation, 33 grams of water per portion is considered to be evaporated while cooking the beans.

Table 8 Data about lunch preparation

	Cooking time (h)	**Power (kW)**	**Energy (MJ)**
Cooking Bolognese sauce	0,5	5	0,090
Cooking pasta	0,37	5	0,067
Cooking chicken and potato gratain	0,75	14,5	0,392
Boiling beans	1,75	5	0,315
Boiling rice	0,5	5	0,090
Frying patties	0,1	3,8	0,034

The re-heating and warm-keeping time is assumed to be the same for each lunch dish. For re-heating, the 19kW oven is used for 15 min and warm-keeping is set to 2 h. Calculated per dish that result in 0.18 MJ and 0.324 MJ.

Data used in SimaPro

Table 9 andTable 10 shows the materials and processes that are used in the SimaPro model.

Table 9 Materials used in SimaPro.

Material	**Database**
Beef minced meat (oksesmåkød og div.)	LCA Food DK
Carrot, conventional, washed and packed, from field	LCA Food DK

Chicken, fresh, from slaughterhouse	LCA Food DK
Corrugated board boxes, technology mix, prod. mix, 16,6 % primary fibre, 83,4 % recycled fibre EU-25 S	ELCD
Cream (38%)	LCA Food DK
Egg	LCA Food DK
Flour, wheat, conventional	LCA Food DK
Onion, dried	LCA Food DK
Potatoes IP, at farm/CH S	Ecoinvent system process
Rice at farm / US S	Ecoinvent
Soy bean IP at farm / CH S	Ecoinvent
Tap water, at user/RER S	Ecoinvent system process
Tomato, standard	LCA Food DK

Table 10 Processes used in SimaPro

Processes	**Database**
Electricity, high voltage, production SE, at grid/SE S	Ecoinvent system process
Transport, lorry >32t, EURO3/RER S	Transport, lorry >32t, EURO3/RER S
Transport, transoceanic freight ship/OCE S	Ecoinvent system process
Wholesale (5* C)	LCA Food DK

Pasta making

For the production of one serving of pasta, the following ingredients and processes were used. This is assumed to take place in Järna south of Stockholm.

Table 11 Inputs to pasta making

Flour	48 grams
Egg	22 grams
Tap water	8 grams
Carton packaging	1,75 grams (Bevilacqua et al, 2007)
Transports of flour	14,4 kgkm, 300 km from skövde
Transports of egg	2,2 kgkm, 100km from Adelsö
Electricity for drying	0,1155 kWh (Bevilacqua et al, 2007)

Waste scenario

In the waste scenario, this report considers that 10 % of the served food dish is left as food scraps. The other 90 % is thought to be eaten and metabolized. The weight of 10 % food scraps is 318 grams for the Pasta Bolognese, and 310 grams for the chicken and soy patties dish. The chosen waste management treatment process is anaerobic digestion at a facility in Uppsala. That distance to Uppsala from Stockholm is approximated to 69 km. The food scrapes are transported in a large 16 to 32 ton truck. A kilo kilometer figure is calculated with the above presented number, these calculations are presented in Table 12. The kilo kilometer values are used as input data in a SimaPro process that models the waste scenario.

Table 12 Input data to waste scenario process

Food Dish	Food scraps (g)	Distance to waste management facility (km)	Kilo kilometer
Pasta Bolognese	318	69	2,19
Chicken dish	310	69	2,14
Soy Patties	310	69	2,14

3 Life cycle interpretation

The potential environmental impacts for each impact category (using ReCiPe Midpoint (H) Europe) are quantified and shown for the lunch dishes in Table 13.

Table 13 Quantified environmental impacts for the lunch dishes

Impact category	Unit	Chicken dish	Beef dish	Soy patties dish
Climate change	kg CO2 eq	20,59464	81,2458	18,1803
Ozone depletion	kg CFC-11 eq	3,6E-06	1,15E-05	1,68E-06
Human toxicity	kg 1,4-DB eq	21,25548	22,00894	21,6472
Photochemical oxidant formation	kg NMVOC	0,062868	0,320534	0,06606
Particulate matter formation	kg PM10 eq	0,069986	0,20353	0,038857
Ionising radiation	kg U235 eq	22,09285	21,1826	20,07226
Terrestrial acidification	kg SO2 eq	0,410673	1,30056	0,157694
Freshwater eutrophication	kg P eq	0,004524	0,00697	0,006493
Marine eutrophication	kg N eq	0,228762	1,233193	0,15775
Terrestrial ecotoxicity	kg 1,4-DB eq	0,251216	0,251625	0,296469
Freshwater ecotoxicity	kg 1,4-DB eq	0,068185	0,048024	0,195711
Marine ecotoxicity	kg 1,4-DB eq	0,074685	0,055888	0,093447
Agricultural land occupation	m2a	15,20945	61,0782	22,04854
Urban land occupation	m2a	0,059968	0,040075	0,577198
Natural land transformation	m2	0,001502	0,001399	0,002302
Water depletion	m3	0,238209	0,32737	4,242688
Metal depletion	kg Fe eq	1,163736	0,804451	1,285177
Fossil depletion	kg oil eq	2,585127	14,87395	2,665714

The characterized results are given in Figure 7, and Figure 8 shows the normalized results.

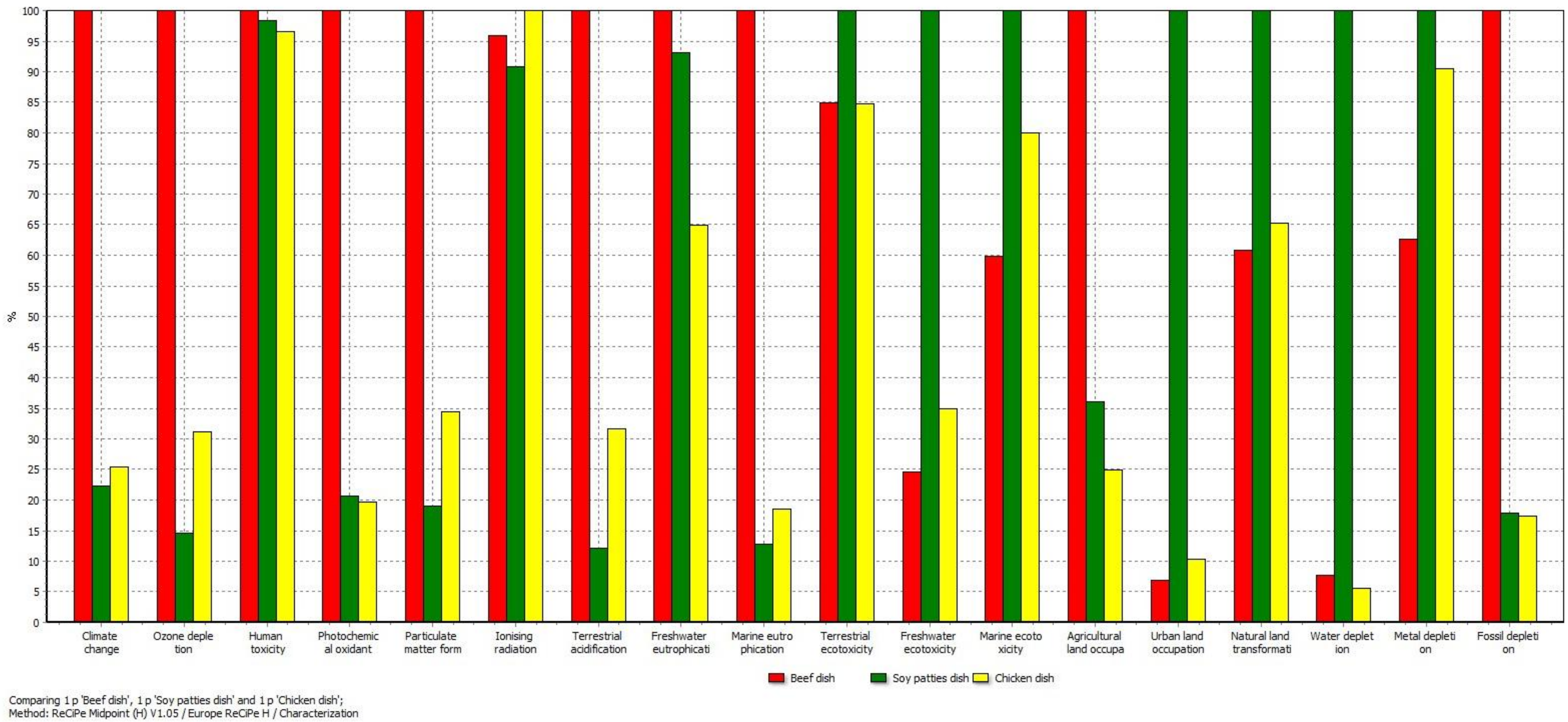

Figure 7 Characterized results of the lunch dishes

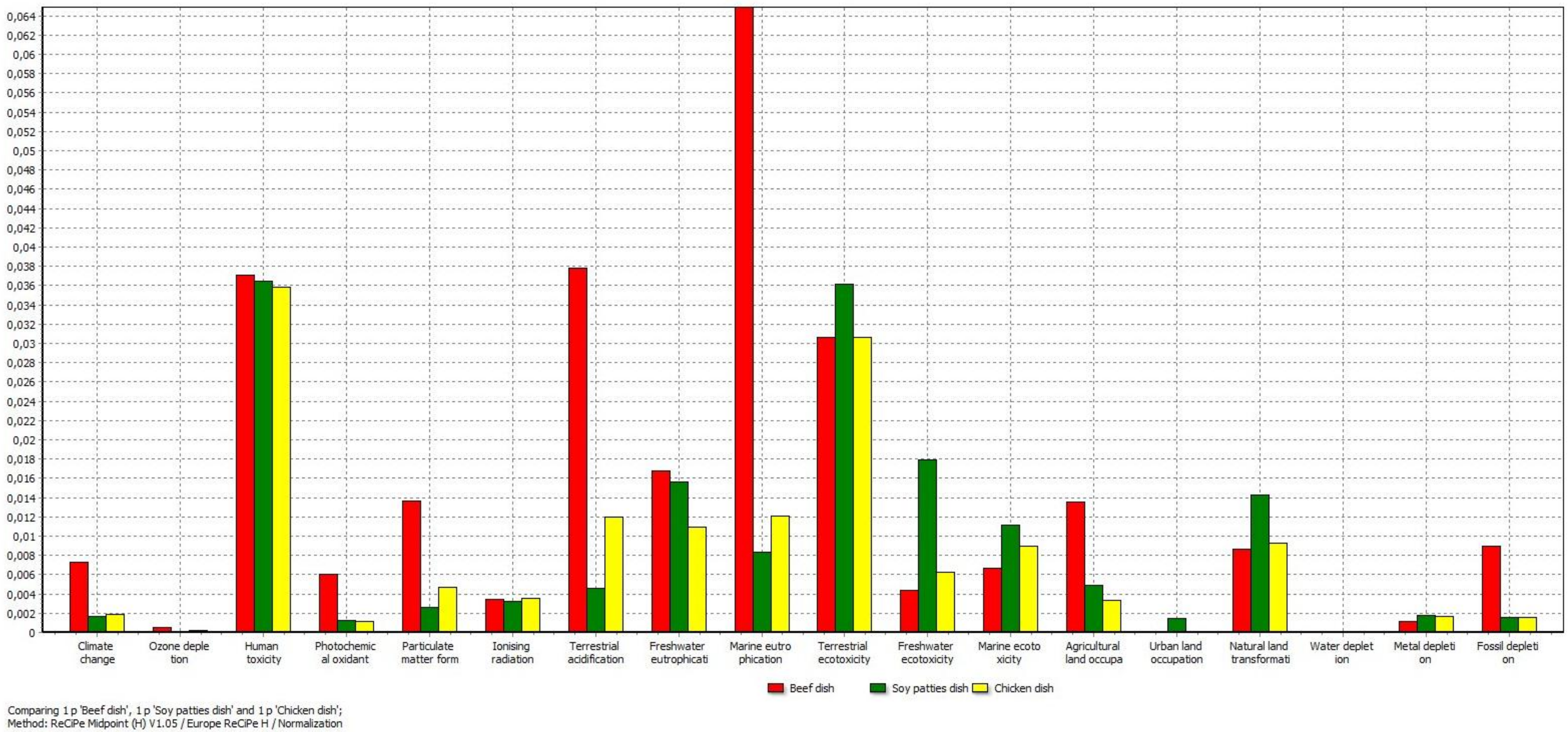

Figure 8 Normalized results of the lunch dishes

As shown in Figure 7 Characterized results of the lunch dishesFigure 7, the pasta Bolognese dish has the highest contribution in 10 out of 18 impact categories (climate change, ozone depletion, human toxicity, photochemical oxidant, particulate matter, terrestrial acidification, freshwater eutrophication, marine eutrophication, agricultural land occupation, fossil depletion), and the vegetarian soy patties dish in 7 out of 18 categories (terrestrial ecotoxicity, freshwater ecotoxocity, marine ecotoxicity, urban land occupation, natural land transformation, water depletion, metal depletion). The chicken dish has the highest contribution in only one impact category; ionising radiation.

Once the results are normalized (Figure 8), one can see that the environmental impact that has the highest contribution to the total European amounts is marine eutrophication, which is given by the beef dish. That is due to manure generated from cattle at farm, seeFigure 9.

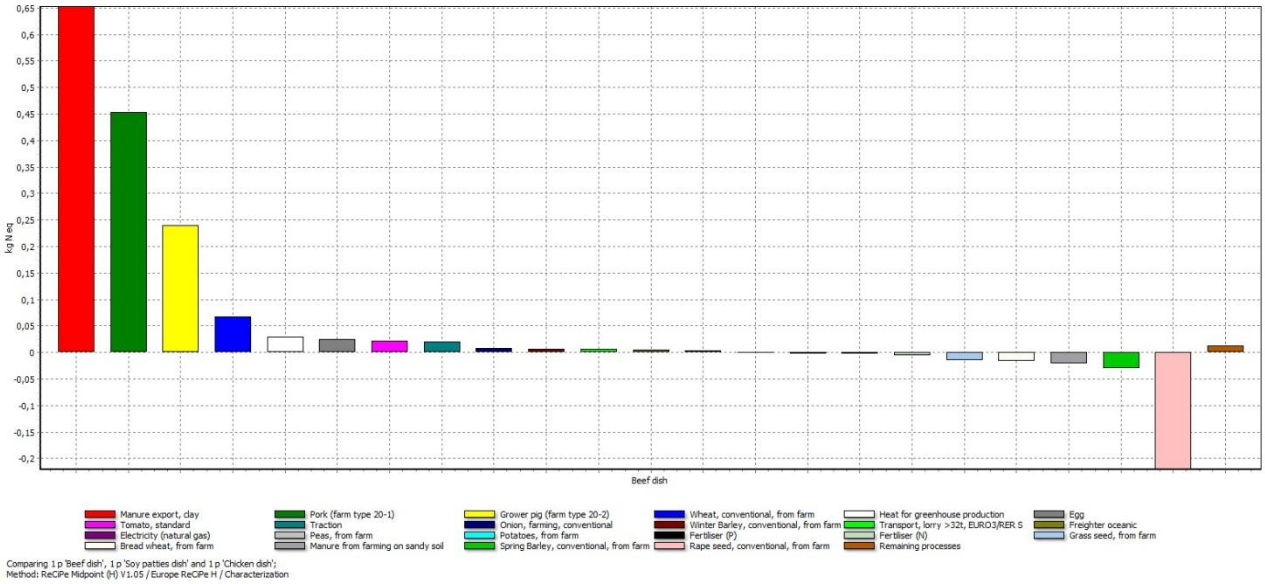

Figure 9 Pasta Bolognese dish contribution to marine eutrophication, specified per processes

Overall, the lunch dishes have the highest relative contribution in the impact categories human toxicity and terrestrial toxicity, compared to the impacts of an average European (according to the ReCiPe model), see Figure 8The food dishes have negligible effects on the impact categories urban land occupation, water and ozone depletion. Below, each lunch dish is presented in more detail.

3.1 Pasta Bolognese

As shown in following figures, the term “Pork” is used. That is because of the LCA Food DK process used in the analysis is based on dairy cows and not ox animals, and then re-calculated as avoided burdens in terms of avoided pig production. That means, dairy cows are used to produce milk – which would have been produced anyways – and when they are slaughtered the meat is considered as food, which then replaces pork. Such scenario is considered to reflect the Danish, but also the Swedish beef production, and therefore that process is used.

The beef production and the related release of manure is the major contributor to the environmental impacts generated by the pasta Bolognese dish. It accounts for most of the eutrophication and acidification problems in different freshwater, marine, and terrestrial ecosystems, see Figure 10 and Figure 11

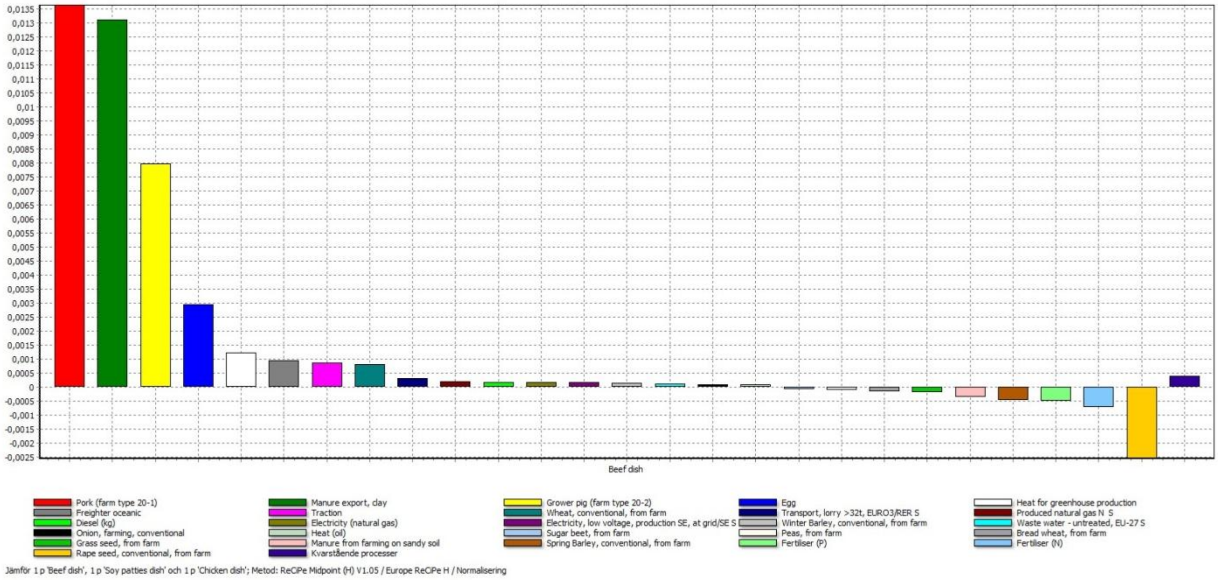

Figure 10 Pasta Bolognese dish contribution to terrestrial acidification, specified per processes

In addition, the anaerobic digestion of the food residues adds on to such environmental problems. Fossil fuel used in transportation and greenhouse heating contributes to the emissions synonymous with climate change, photochemical oxidants and particle matter formation. The use of fossil fuels to heat the greenhouse is the greatest emission source of carbon dioxide equivalents, see Figure 11.

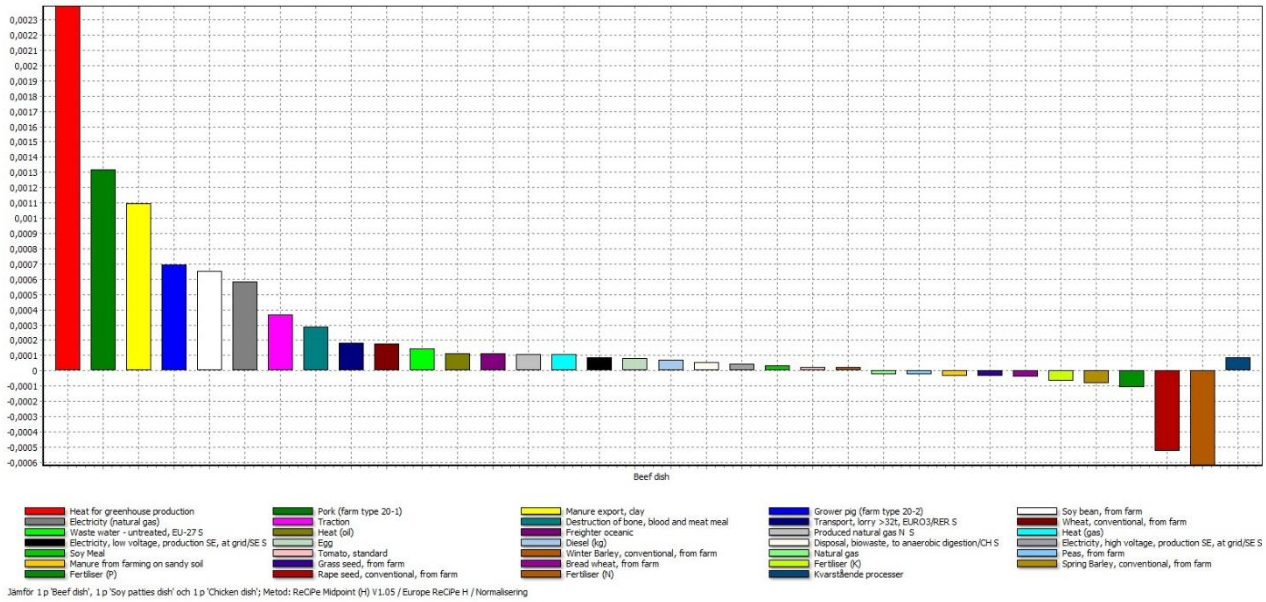

Figure 11 Pasta Bolognese dish contribution to climate change, specified per processes

3.2 Chicken and potato gratin

For the chicken dish, the chicken feed production and the chicken production itself are the main contributors to climate change, particular matter formation and eutrophication, see Figure 12for marine eutrophication.

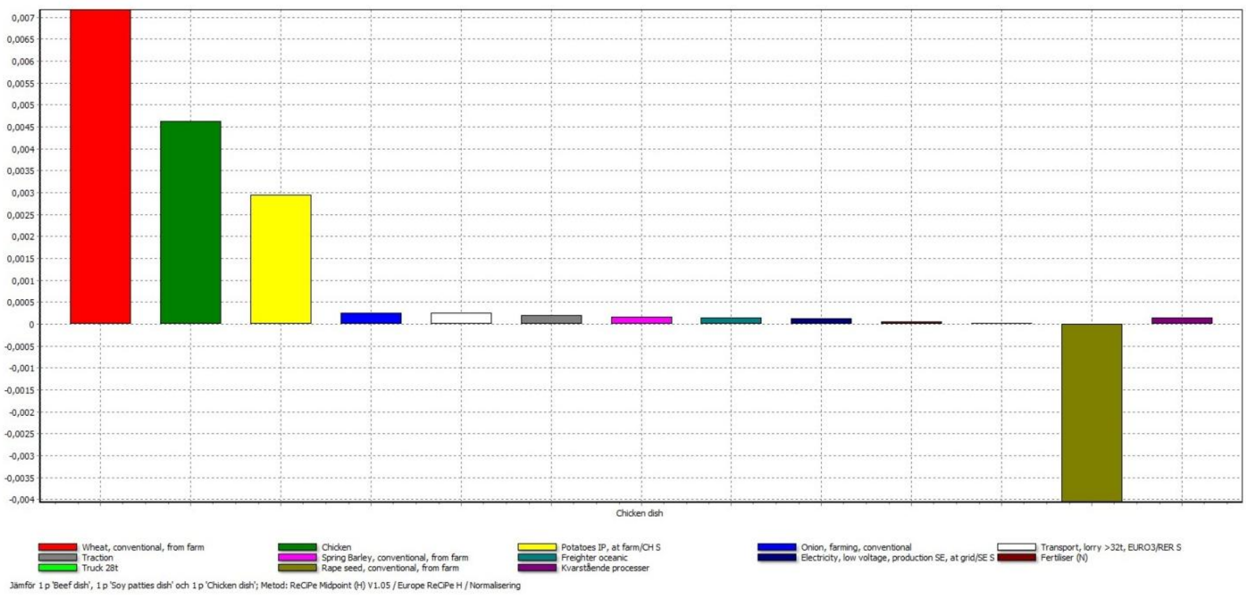

Figure 12 Chicken dish contribution to marine eutrophication, specified per processes

Potatoes also have a large environmental impact, leading to eutrophication, acidification, fossil fuel depletion and natural land transformation, also seen in Figure 13.

As seen in Figure 13, all dishes have a huge impact on human toxicity and terrestrial toxicity. The reason for such impacts is the same for all dishes, and is due to the disposal of biowaste to anaerobic digestion. Figure 14 shows the contribution to human toxicity for the chicken dish.

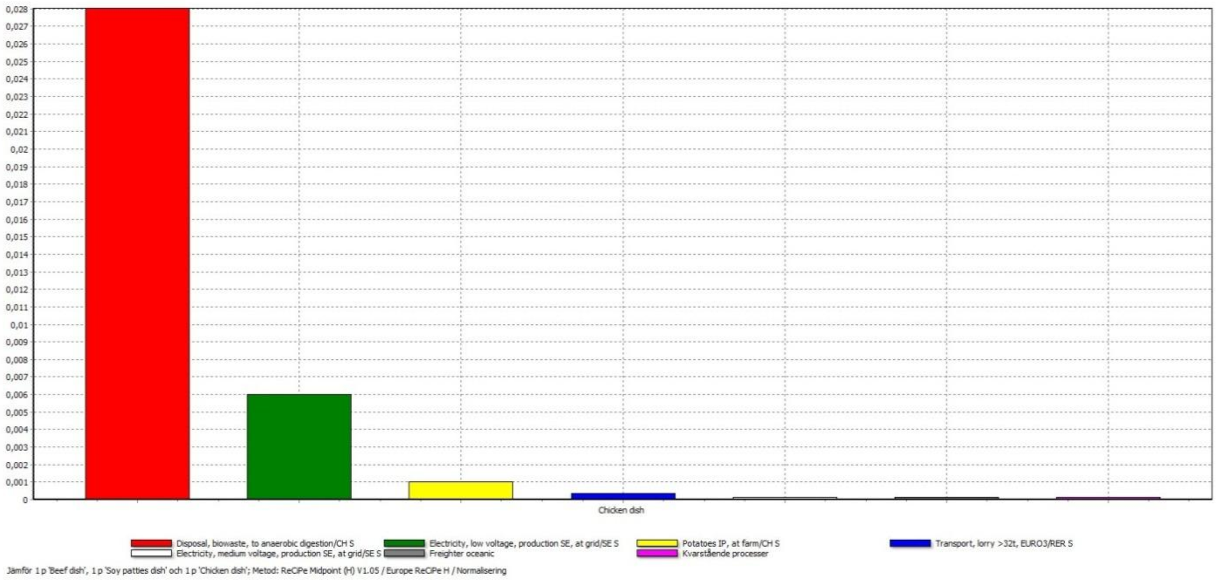

Figure 13 Chicken dish contribution to human toxicity, specified per processes

3.3 Soy patties

For the soy dish, the cultivation of rice and soy beans has a large impact on most categories, including climate change, toxicity, eutrophication, acidification and urban land occupation. As seen in Figure 8 the soy patties dish has by far the highest contribution of the three dishes in the category freshwater ecotoxicity. That is also mainly due to the cultivation of rice and soy beans, see Figure 14.

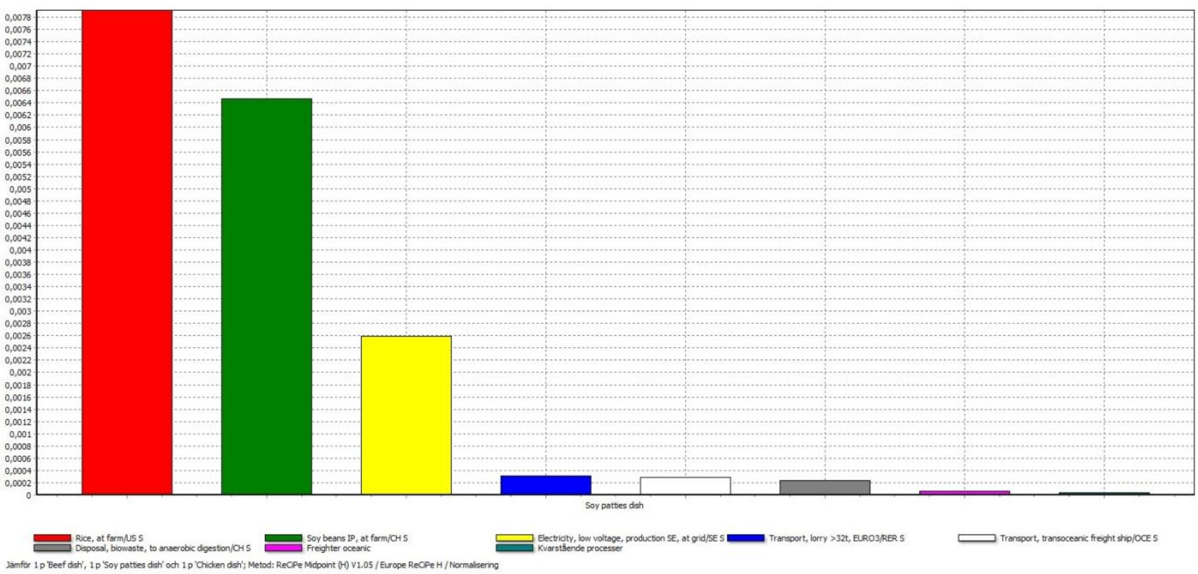

Figure 14 Soy patties dish contribution to freshwater ecotoxicity, specified per processes

As seen in Figure 15, the soy patties dish has also the highest contribution of the dishes in the category natural land transformation. That is also due to the rice and soy beans, but in this case because of the import of these products from the US and China, i.e. transportation.

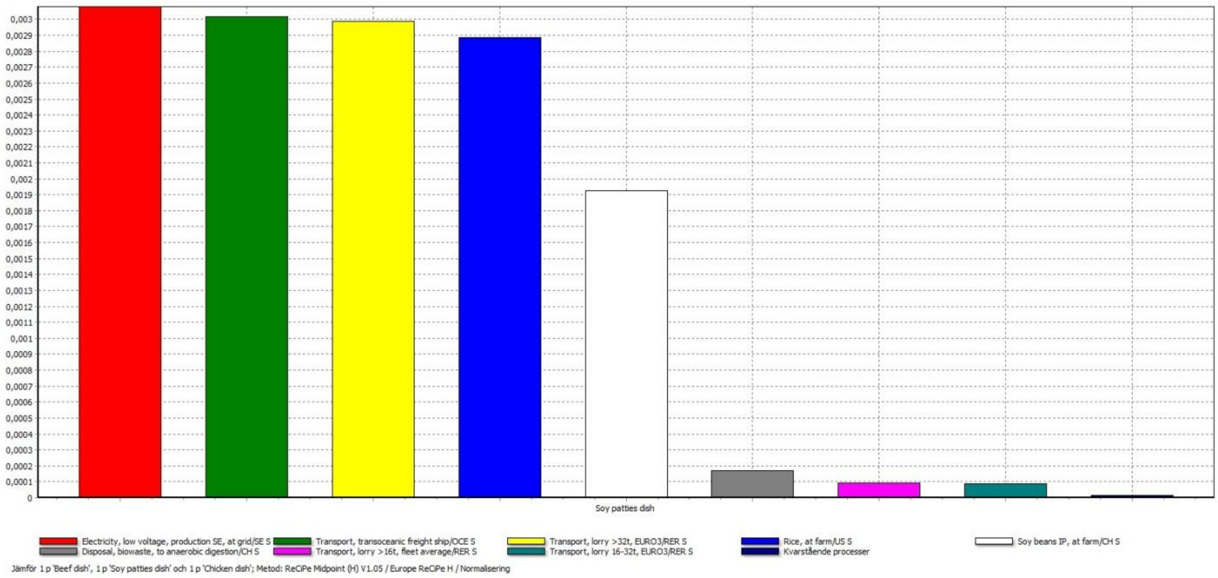

Figure 15 Soy patties dish contribution to natural land occupation, specified per processes

However, as seen in Figure 7, the contribution to climate change is still minor for the soy patties dish in relation to the other lunch dishes. Just as for the other two dishes, the largest impact on human toxicity is caused by the waste management treatment process.

4 Conclusions and recommendations

According to the aims of the report, the research question could be answered. The results are close to assumptions that the group members had before the project was initiated. The biological waste connection to the ecotoxicology impact categories, relatively low contribution of transports in different impact categories and effects from manure use were expected results.

The food dishes that are examined in this report have been arbitrarily combined by the group members with aid from a lunch menu at an elementary school in Stockholm. As shown in chapter 3, the Bolognese dish has the highest contribution in most of the impact categories (10 out of 18), closely followed by the soy patties dish (7 out of 18). Since the chicken dish only has the highest contribution in one impact category, one can draw the conclusion that this particular chicken dish may be considered as most environmentally friendly of the lunch dishes in scope.

When comparing the vegetarian dish to the chicken dish only, the chicken dish has higher contribution in 6 of 18 impact categories. The two main ingredients in the vegetarian dish (the soy beans and the rice) are not typically cultivated nearby Sweden, and need to be transported long ways. These transportation effects are also shown in the results (Figure 15), and could make the comparison unfair since almost every ingredient in the other two dishes are domestically produced. Furthermore, as rice and beans cultivation is water and land intensive, these particular ingredients have a high impact on the final results. With this in mind, one can draw the conclusion that if the vegetarian dish would have been composed with domestically produced ingredients – as the other two dishes – the results might have favored the vegetarian dish over the other.

The report concludes that the pasta Bolognese dish has the highest carbon dioxide equivalent emissions. That was expected when starting the project. However, the source of such emissions is surprising. It was considered that raising cattle and their living would be the largest source of carbon dioxide equivalent emissions (due to the methane production caused by rumination), but the results tell that cultivating tomatoes in a Dutch greenhouse holds higher emission levels due to use of fossil fuels to heat the greenhouse.

In this project, the food dishes were combined first, and then their environmental impacts were analyzed. It might have been more real-life practical to study the environmental impacts of the ingredients only – with different specified origins, cultivation methods, etc. – and with that create a library of different ingredients where the environmental impact is specified next to the nutrient value. With such information one can create a variety of dishes based on price, nutrient values and environmental impacts.

References

Bevilacqua. M, Braglia. M, Carmignani. G, Zamori. F.D,, 2007, Life cycle assessment of pasta production in Italy, *Journal of Food Quality* v 30:6, pp 932–952,

Google, 2012, Google Maps, [Online] Available at Http://maps.google.com [Accessed 2012-12-06]

LCAFoods.dk, 2007, Cattle meat (Oksekød) [Online] Available at: http://www.lcafood.dk/products/meat/cattlemeat.htm [Accessed 2012-12-14]

Livsmedelsverket, 2007, Swedish food agency, Bra mat i skolan, [PDF] Available at: http://www.slv.se/upload/dokument/mat/mat_skola/bra_mat_i_skolan_2007.pdf [Accessed 2012-12-06]

Livsmedelsverket, 2007, Swedish food agency, Livsmedelsdatabasen [Online] Available at: http://www7.slv.se/Naringssok/ [Accessed 2012-12-14]

Naturvårdsverket, 2010, Swedish environmental protection agency, Övergödningen av Sveriges kuster och hav [PDF] Available at: Http://www.naturvardsverket.se/Documents/publikationer/620-5587-9.pdf [Accessed 2012-12-06]

Naturvårdsverket, 2010. Swedish environmental protection agency, The Climate Impact of Swedish Consumption. [PDF] Available at: http://www.naturvardsverket.se/Documents/publikationer/978-91-620-5992-7.pdf [Accessed 2012-12-06]

ReCiPe, 2012, ReCiPe Downloads Data sheet, [Online] Avaliable at: http://www.lcia-recipe.net/ [Accessed 2012-12-06]

Sea-distances.com, 2012, [Online] Available at http://sea-distances.com/ [Accessed 2012-12-06]

SFS 2010:800, Swedish School Law, 2010, Available at http://www.riksdagen.se/sv/Dokument-Lagar/Lagar/Svenskforfattningssamling/Skollag-2010800_sfs-2010-800/ [Accessed 2012-12-06]

Stockholms Stad, 2010. *Matavfall till biologisk behandling* [Online] (Updated 9 September 2011) Available at: http://miljobarometern.stockholm.se/key.asp?mo=9&dm=1&nt=5 [Accessed2012-12-14]

VästerviksTidningen, 2009. *Skolmat för en halv miljard kasseras varje år i Sverige*. [Online] (Updated 31 August 2009) Available at: http://www.vt.se/nyheter/default.aspx?articleid=5037563 [Accessed: 14 December]