Converting food waste data into climate equivalents – a walk in the park?

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Key points

- Food waste should be assessed as lost resources bound in the food – and not as kilo food waste – *meat vs vege*
- How to assess and reduce the lost resources
- Food waste utilisation can reduce the lost resources, but assessments do not always include the lost resources in the food waste
- Need for better assessments of lost and gained resources

Life cycle of food production, sale and waste management

Lost resources in the food waste

Ref: Brancoli et al, 2017

Gained resources in the food waste

Why include food waste in environmental strategies and efforts?

Food one of the major contributors to GHG emissions: around 25%

- **Energy** and **non-energy** related emissions
- Big differences in emissions between different types of food – high emissions from animal-based products (dairy and meat)
- Increased global (animal) food consumption because of increased global (average) wealth

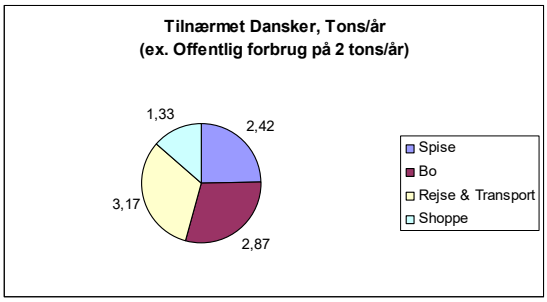
Increasing demand (competition) for agricultural land and fibres/nutrients

- from use of biomass for materials, like bioplast
- from use of biomass for biofuels, like bioethanol and biodiesel

Less GHG-heavy food AND less food waste => less wasted land and resources

4

An overview of an average Dane's annual GHG emissions

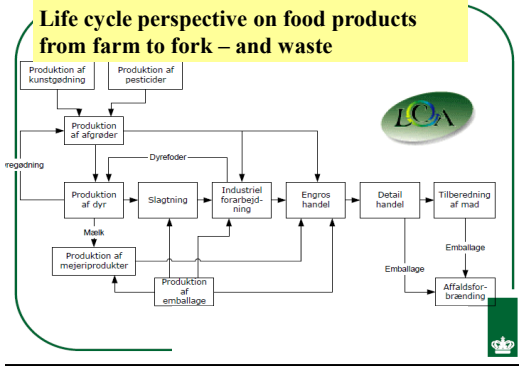


(Chrintz, 2009)

Three ways of obtaining higher resource efficiency

- Producing the same products in a more effective way: reducing food waste, energy and water consumption, etc. per consumed unit
- Producing the same products in a more sustainable way: reducing the environmental impacts per consumed unit
- Producing the same "nutritious and culinary value" with less resources and environmental impacts: reducing the amount of animal products and increasing the amount of vegetables, legumes, etc.

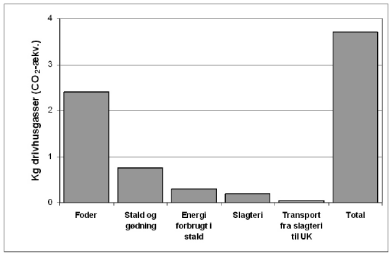
Life cycle perspective on food products from farm to fork – and waste



Halberg & Dalsgaard:
http://www.lcafood.dk/LCA/Dansk%20version/In%20Danish.htm

Greenhouse gas emissions from 1 kg Danish pork meat - from fodder production to retail shop in the UK

3,6 kg CO2-eqv. per kg



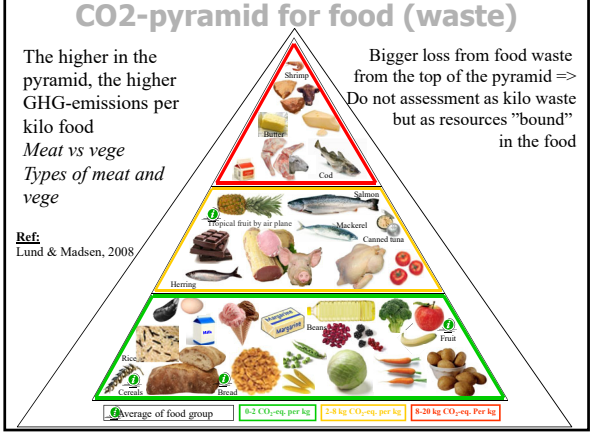
http://www.danishcrown.dk/page21782.aspx

CO2-pyramid for food (waste)

The higher in the pyramid, the higher GHG-emissions per kilo food
Meat vs vege
Types of meat and vege

Ref:
Lund & Madsen, 2008

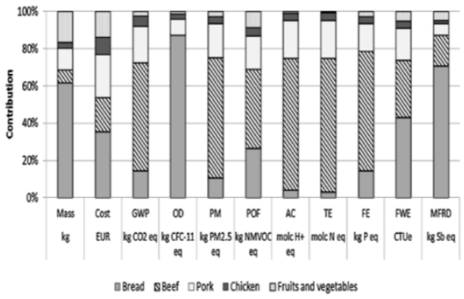
Bigger loss from food waste from the top of the pyramid => Do not assessment as kilo waste but as resources "bound" in the food



The climate impact from different food groups in the average Danish diet

- Meat products : 29%
- Diary products: 22%
- Fruit and vegetables: 17%
- Beverages: 15%
- Grain and bread: 7%
- Fish: 4%
- Fat: 3%
- Sugar and candies: 2%
- Eggs: 1%

Environmental impacts supermarket food waste



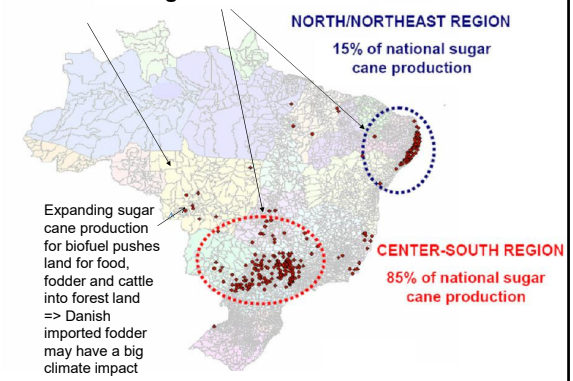
Ref: Brankoli et al, 2017

More sophisticated GHG-contribution from food (waste)

- **More local and season-based food supply!?**
  - Swedish greenhouse tomato: 66 MJ/kg Southern Europe: 5.4 MJ/kg
  - Apples in Sweden: Local: 3.5 MJ/kg. Central Europe: 4.8 MJ/kg. Overseas: 8.6 MJ/kg
  - Animal-based products: production the biggest GHG contribution: Max 20% of energy consumption from transport => the AMOUNT of meat is the most important
- **Organic food – some GHG reduction potential, but a complex picture**
  - Increased CO2-uptake by the soil
  - Lower input (fertiliser, pesticides, fuel etc.) and lower yield
  - Reduced chemical 'load'
  - Holistic perspective necessary - not only a GHG assessment!

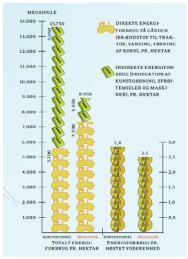
12

Global sourcing => more difficult GHG-calculation

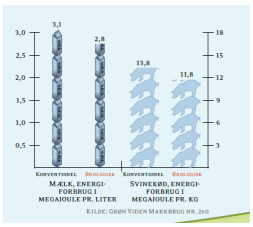


Comparing conventional and organic production

Fodder production



Milk and meat production



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14

CALCULATING GHG IMPACT FROM FOOD (WASTE)

Simple climate data for food (waste)

(Lund & Madsen, 2008) and (Barnett et al, 2008)

Excel data base with climate impact from 150 food products

Category	Food Specification	Life Cycle Inputs (MJ/kg)	Danish Energy Conv. Factor (kgCO2-eq/MJ)	Additional Inputs (kgCO2-eq/kg)	Total Emissions (kgCO2-eq/kg)
Lamb	Lamb,fresh,Sweden,cooked	43	0,09166	6,4	10,34
Lamb	Lamb,frozen,Sweden,cooked	46	0,09166	6,4	10,62
Lamb	Lamb,frozen,overseas,cooked	52	0,09166	6,4	11,17
Lamb	Sausage,fresh,Sweden,cooked	30	0,09166	6,4	9,15
Lamb	Lamb stew,Sweden,cooked	18	0,09166	6,4	8,05
Lamb	*lamb,average	-	-	-	9,86

Background data: Carlsson-Kanyama: products in life cycle perspective

Table 1
Life cycle energy inputs for foods ready to eat

Category	Food type, origin and preparation	MJ life cycle inputs per kg	kg per portion	MJ per portion
Lamb	Lamb, fresh, Swedish, cooked	43	0.125	5.4
	Lamb, frozen, Sweden, cooked	46	0.125	5.7
	Lamb, frozen, overseas, cooked	52	0.125	6.5
	Sausage, fresh, Sweden, cooked	30	0.125	3.8
	Lamb stew, Sweden, cooked	18	0.25	4.5
Chicken	Chicken, fresh, Sweden, cooked	35	0.125	4.4
	Chicken, frozen, Sweden, cooked	39	0.125	4.8
	Chicken, frozen, Central Europe, cooked	41	0.125	5.1
	Sausage, fresh, Sweden, cooked	20	0.125	2.5
	Chicken stew, cooked	13	0.25	3.4
Pork	Pork, fresh, Swedish, cooked	40	0.125	5.0
	Pork, Sweden, frozen, cooked	43	0.125	5.3
	Pork, frozen, Central Europe, cooked	44	0.13	5.5
	Sausage, fresh, Sweden, cooked	34	0.13	4.2
	Pork stew, cooked	17	0.25	3.9
Beef	Beef, fresh, Swedish, cooked	70	0.13	8.8
	Beef, frozen, Central Europe, cooked	75	0.13	9.4
	Cow, fresh, Swedish, cooked	26	0.13	3.2
	Beef stew, cooked	24	0.25	6.1
Fish and crustaceans	Cod, fresh, Sweden, cooked	105	0.13	13
	Herring, fresh, Sweden, cooked	22	0.125	2.8
	Mackerel, fresh, Swedish, cooked	37	0.125	4.7
	Canned tuna, overseas	37	0.125	3.6
	Fish gratin, Swedish, cooked	84	0.125	11
	Cheese, tinned, Sweden	19	0.125	2.3
	Shrimps, without shells, Sweden	220	0.125	27
Milk, cheese	Milk, Sweden, 4% fat	3.9	0.2	1.2
	Milk, Sweden, 1..5% fat	5.0	0.2	1.0
	Cream, Sweden, 40% fat	19	0.025	0.5
	Yoghurt, small pots, Sweden	11	0.2	2.2
	Yoghurt, small pots, Central Europe	12	0.2	2.5
	Cheese, Sweden	60	0.015	0.9
	Cheese, Central Europe	64	0.015	1.0
	Cheese, Southern Europe	65	0.015	1.0
	Milk powder, Sweden	58	0.008	0.5
Egg	Eggs, Sweden, cooked	18	0.1	1.8
Legumes	Brown beans, Sweden, cooked	8.9	0.19	1.70
	Yellow peas, Swedish, cooked	5.0	0.19	0.95
	Soya beans, overseas, cooked	7.9	0.19	1.51
	Brown beans, overseas, cooked	11	0.19	2.11
	Beans, canned, overseas	20	0.19	3.71
	Beans, canned, overseas	16	0.19	3.09
Sugar and candies	Sugar, Sweden	9.8	0.0035	0.03
	Honey, Sweden	1.3	0.0035	0.004
	Honey, overseas	3.6	0.0035	0.02

From energy to climate

- Consumed energy is mainly fuel and to less extent electricity
- Conversion from energy to climate impact by using national conversion factors
- Addition for non-energy related GHG (Rose, 2007)

Food group	Additional emissions from methan og nitrogen gasses (kg CO_2-eqv per kg food)
Milk	0,7
Milk products (cheese, butter, cream, milk powder)	6,4
Lamb	6,4
Beef	9,0
Rice (varies according to type of production – wet or dry)	0,5 (dry)

Developing database

Optimeret	405, Gammeldags okse-steg						
	Ingredienser	mængde	enhed	Produktionssted, oplyst fra Leh-mann	Antaget produktions-sted	Antaget LCA-kategori	LCA-udledningsdata (kgCO2-eq/kg)	Total udled-ning (kgCO2-eq)
	oksesteg	0,086	kg	Tysk	Europa	Cow,fresh,Sweden,cooked	11,383	0,973
	kartofler	0,125	kg	Tyske	Dansk	Potatoes,Sweden,cooked	0,422	0,053
	tyttebærmarmelade	0,02	kg	-	-	Raspberry jam,factory in Northern Sweden,55% fruit	1,467	0,029
	skysovs:			En blanding af flere				
	piskefløde	0,007	kg		Dansk	Cream,Sweden,40% fat	8,142	0,057
	oksebouillon	0,003	kg		Europa	Herbal spice,Southern Europe,commercially dried	3,300	0,010
	Total:	0,241	kg					1,122

Kommentarer:
Oksebouillon: Alle typer bouillon der bruges i køkkenerne er på pulverform. Dvs. der er blevet brugt en del energi på forarbejdning og ind-dampet under produktion. Derudfra er kategorisen antaget.

Maybe using menu plans for local database

GRP./VARE-OMSÆTNING 7/03/2008 14:06

Dato: 1/11/2007 30/11/2007 Levering: 1 9999 Alle Betaling: 1 9999 Side 2
Kunde: 1 99999999 Gruppe: 702 725 Distrikt: 1 9999
Vare: 1 999999 Gruppe: 1 9999 Varetype: Alle Kosttype: 1 9999 ID 2051

Nr	Navn	Lille	Normal	Stor	Total	Beløb
5234	Sprængt andebryst, kartofler, peberro	21	238	5	264	13.200,00
5236	Græske frikadeller, ris, tomatsauce,bl	32	383	7	422	21.100,00
5237	Hakkebøf med bacon, kartofler, vildts	14	117	5	136	6.800,00
5249	Sejcrepin m.porre, kartofler, persillesa	0	9	0	9	450,00
5264	Krydderurtekarbonade, kartofler, skys	1	1	0	2	100,00
5265	Hawaiischnitzel, ris, carrysauce, roma	0	1	0	1	50,00
5268	Oksefarsbrød, kartofler,bearnaisesauc	39	171	4	214	10.700,00
5269	Orientalsk fiskegrat, ris, lemonsauce,	31	193	8	232	11.600,00
5272	Blomkålsgratin, kartofler, smørsauce,	40	364	10	414	20.700,00
5273	Sejcrepin m.porre, kartofler, persillesa	40	226	8	274	13.700,00
5276	Mørbradbøf m.løg, kartofler, champig	27	308	9	344	17.200,00
5284	Sennepspaneret sild, kapersmør, kar	13	198	4	215	10.750,00
5286	Chop suey, ris	8	230	1	239	11.950,00
5287	Kalv i estragon, med ris og grøntsage	32	232	6	270	13.500,00

REDUCING GHG CONTRIBUTION FROM FOOD (WASTE)

Reducing GHG contribution from food

- *Life cycle thinking – from farm to fork – with a holistic perspetive on environmental aspects*
- Reduce GHG-intensive food like animal food products
  - From animal-based to vegetarian
  - Between animal-based products
- Reduce waste from distribution, manufacturing and consumption => less GHG-emissions wasted!
  - 20% of the food is wasted in the households!

22

Changing to more "climate friendly" food consumption

- Menu plan
  - Changing frequency of more GHG heavy recipes
- Recipes
  - Substitution among and within food groups
- Ingredients
  - Season and local

The future menu card?
Kg CO2 eqv per kg food

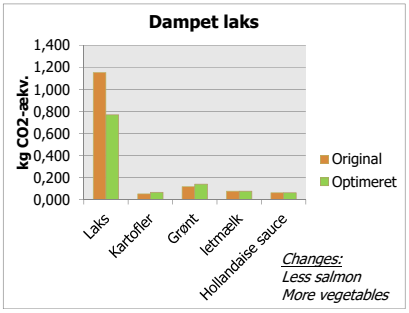
To day:
- Gullasch: 7,9
  - 2kg meat
- Beef Stroganoff: 8,2
  - 2 kg meat;
  - 0,3 kg onions
- Lasagne: 10,1
  - 1,5 kg meat;
  - 0,5 kg vegetables
- Shrimp salad: 7,3

Future (* heart friendly):
- *Gullasch: 4,3 (-46%)
  - 1 kg meat + 1 kg bread
- *Beef Stroganoff: 4,8 (-41%)
  - 1,1 kg meat
  - 1,1 kg onions
- *Green lasagne: 2,3 (-77%)
  - 2 kg vegetables
- Mussels salad: 1,8 (-75%)

Climate and nutrition optimisation of food for elderly

Climate optimisation of minced meat ball:
- 90% of normal size
- Include10% potatoes => easier to chew

-Ensure the food is eaten



Ref: Lund & Madsen, 2008

Climate impact reduced 12% + redistribution of dishes within plans

Gruppe	Antal retter	Ret der repræsenterer gruppen	kg CO2-eq pr. ret "Original"	Gennem-snit	kg CO2-eq "Original"	kg CO2-eq pr. ret "Op-timeret"	Gennem-snit	kg CO2-eq "Optimeret"	Besparelse kg CO2-eq
Grp: 1 Hovedret svinekød hel	44160	228, Skinke	0,820		36199	0,505		22315	
Grp: 2 Hovedret svinekød hak	30364	5228, Krebinetter	0,894		27152	0,852		25858	
Grp: 3 Hovedret svinekød sammenkogt	13380	5058, Forl. Skildpadde	0,568		7604	0,568		7604	
Grp: 4 hovedret oksekød hel	6244	405, Gammeldags oksesteg	1,230		7682	1,122		7007	
Grp: 5 Hovedret oksekød hak	15000	400, Hakkebof	1,308		19621	1,198		17977	
Grp: 6 Hovedret oksekød sammenkogt	11716	5652, kødsovs	1,584		18560	1,367		16015	
Grp: 7 Hovedret kalve-kød/lammekød	13416	5229, Kalvesteg som vildt	1,859		24934	1,700		22804	
Grp: 8 Hovedret indmad	1532	405, Gammeldags oksesteg	1,230		1885	1,122		1719	
Grp: 9 Hovedret vegetar	5856	5999, Vegetarhovedret	0,778	0,606	3549	0,778	0,606	3549	
		5247, Broccoligratin	0,434			0,434			
Grp: 10 Hovedret fisk	19828	5134, Stegt fisk	1,356	1,366	27086	1,356	1,337	26504	
		5269, Orientalsk fiskegrat	1,376			1,317			
Grp: 11 Hovedret fjerkræ	14556	5092, Sesamkylling	0,609	0,534	7779	0,564	0,493	7172	
		5254, st. kalkunbryst	0,460			0,421			
Grp: 12 børet forret	5296	8115, Skaldyrssalat	1,529		8095	1,391		7365	
Grp: 13 børet suppe	16828	8062, Hønsekødsuppe	0,189	0,200	3373	0,189	0,200	3373	
		8052, Champignonsuppe	0,212			0,212			
Grp: 14 børet dessert	72276	8047, chokolademousse	0,316		22861	0,316		22861	
Grp: 15 børet mælkemad	15472	8117, Frugtgrød	0,537		8309	0,483		7478	
total	285924		0,910		224690			199602	25088

Using local, seasonal fruit and vegetables

Tabel 1: Tabellen er en oversigt over hver måneds frugt og grønt og er fra Informationscenter for Miljø og Sundhed (2008).

Januar	Februar	Marts	April	Maj	Juni
Champignoner Gulerødder Hvidkål Jordskokker Kartofler Kinakål Løg Pastinak Persillerod Porrer Rosenkål Rødbeder Rødkål Selleri Æbler	Champignoner Grønkål Gulerødder Hvidkål Jordskokker Kartofler Løg Pastinak Persillerod Porrer Rosenkål Rødbeder Rødkål Selleri Æbler	Champignoner Grønkål Gulerødder Hvidkål Jordskokker Kartofler Løg Pastinak Persillerod Porrer Rosenkål Rødbeder Rødkål Selleri Æbler	Champignoner Gulerødder Hvidkål Jordskokker Kartofler Løg Porrer Rabarber Radiser Rosenkål Rødbeder Salat Selleri Spinat Æbler	Asparges Champignoner Persille Rabarber Radiser Salat Spinat	Juni Asparges Bladbeder Blomkål Broccoli Champignoner Gulerødder Jordbær Kinakål Løg Persille Rabarber Radiser Salat Spidskål Spinat Ærter
Juli	**August**	**September**	**Oktober**	**November**	**December**
Bladbeder Blomkål	Asier Bladbeder	Asier Bladbeder	Asier Bladbeder	Blomkål Champignoner	Blomkål Champignoner

Background of food waste => specific strategy necessary

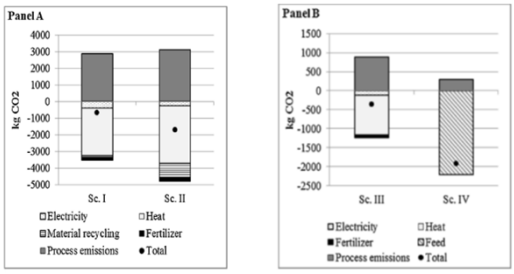
- **1/3 => waste (33 kg)**
- **40% of waste = unavoidable waste (peels etc.) (13 kg)**
- **60% of waste = avoidable waste (20 kg):**
  - 60% not processed food (12 kg)
    - 25% not opened (5 kg)
    - 8% still valid (1,6 kg)
  - 40% processed food, but left overs not used (8 kg)

CALCULATING GHG ASPECTS OF FOOD WASTE UTILIZATION

Life cycle of food production, sale and waste management

Ref: Brancoli et al, 2017

Environmental aspects of food waste management – including packaging (Brankoli et al, 2017)



More waste for fertilizer and animal feed ….. But remember the resources lost in the food production

SUPPLEMENTING

Four perspectives in (re-)design of products

- **Scenario** – the imagined future production and consumption
- **System** – the elements which are necessary for a "food system"
- **Life cycle** – from cradle to grave to…
- **Governance** – how to organise: manage, involve, assess, decide etc.

(Source: Jørgensen, 2014)

Reducing GHG contribution from food (3): A more sustainable agriculture

Mill tons CO_2 equiv	Reduction potential CH_4 + N_2O	Reduction potential Carbon in earth	Reduction potential Bioenergy	Reduction potential Total	Conditions
Reduced N excess	1,48			1,48	A duty of 12 kr/kg N
Multiannual energy crops (elephant grass)	0,33	0,99	2,76'	4,08	At 300,000 ha
Wood chips for biofuel			0,55	0,55	Utilization of thinned trees and felling waste
Increased fat in cattle feed	0,44			0,44	563,000 dairy cows
Removal of low lying ground from agricultural operations	0,07	1,01		1,08	At 100,000 ha
Afforestation on high ground	0,06	0,26		0,32	100,00 ha afforrestation
Reduced cattle population	(0,45)			(0,45)	15 % reduction''
Reduced pig population	(0,24)			(0,24)	15 % reduction'''
Nitrification restriction	0,30			0,30	200,000 N per year in trade manure
Animal manure for biogas	0,55	-0,09	0,35	0,81	45% of remaining slurry
Total	**3,23**	**2,17**	**3,66**	**9,06**	**With consideration to overlap'''**

Table 7: Proposal for reducing the climate impact of agriculture calculated as a reduction in CO_2 equivalents.

Adding up: A substantial GHG reduction – with system perspectives on food

	Basis	Climate plan 2050	Reduction in % of the basis
Danish agriculture and food production from a national production perspective (total)	19 million tons CO_2 equivalents per year, of which 7 million tons CO_2 equivalents per year from energy consumption.	Approximately 7 million tons CO_2 equivalents per year excluding improvements from energy savings and biomass's substitution of fossil energy	Approximately 60 %
Danish agriculture and food production from an international production perspective (total)	35 million tons CO_2 equivalents per year.	21 million tons CO_2 equivalents per year excluding improvements from energy savings and biomass's substitution of fossil energy	Approximately 40 %
Danish food consumption from a consumption perspective (total)	15.4 million tons CO_2 equivalents per year.	5.0 million tons CO_2 equivalents per year.	Approximately 68 %
Danish food consumption from a consumption perspective per Dane	2.8 tons CO_2 equivalents per Dane per year	0.9 tons CO_2 equivalents per Dane per year	Approximately 68 %

Table 8: Summary of climate impact from agriculture and foodstuffs – basis and potential reductions in 2050

Some policy tools to achieve environmental goals

- Reduction of climate impact from agriculture integrated into the principles for the allocation of agricultural support
- The implementations of initiatives that promote healthy and climate-optimal diet and reducing household food waste:
  - information campaigns
  - cook books
  - food price mechanisms
- Directed towards households, retail, the food industry and restaurants and canteens

36