DAFNAE
UNIVERSITY OF PADOVA
DEPARTMENT OF
AGRONOMY
FOOD
NATURAL RESOURCES
ANIMALS
ENVIRONMENT

# Greenhouse gas and animal productions

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Ph.D. School
Animal & Food Science
University of Padova

# Preface

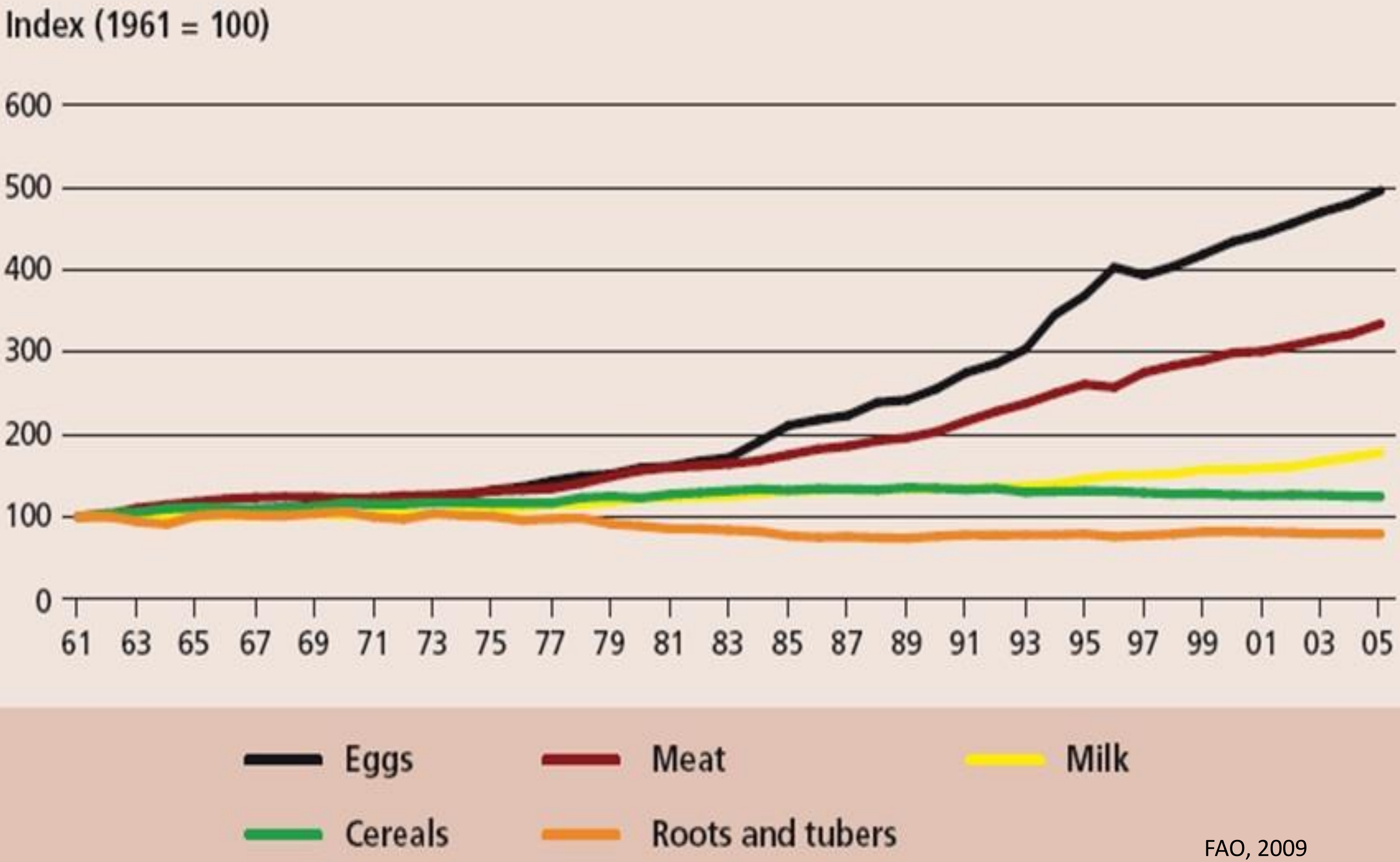
The increase of the world population intensify the demand for food but there are some uncertainties for:

- Animal behavior
- Human health
- Food safety
- Sustainability
- Competition (land, water, energy…)
- Environment (nutrient imbalance, eutrophication, GHG,…)

Charles, 2010

FIGURE 1

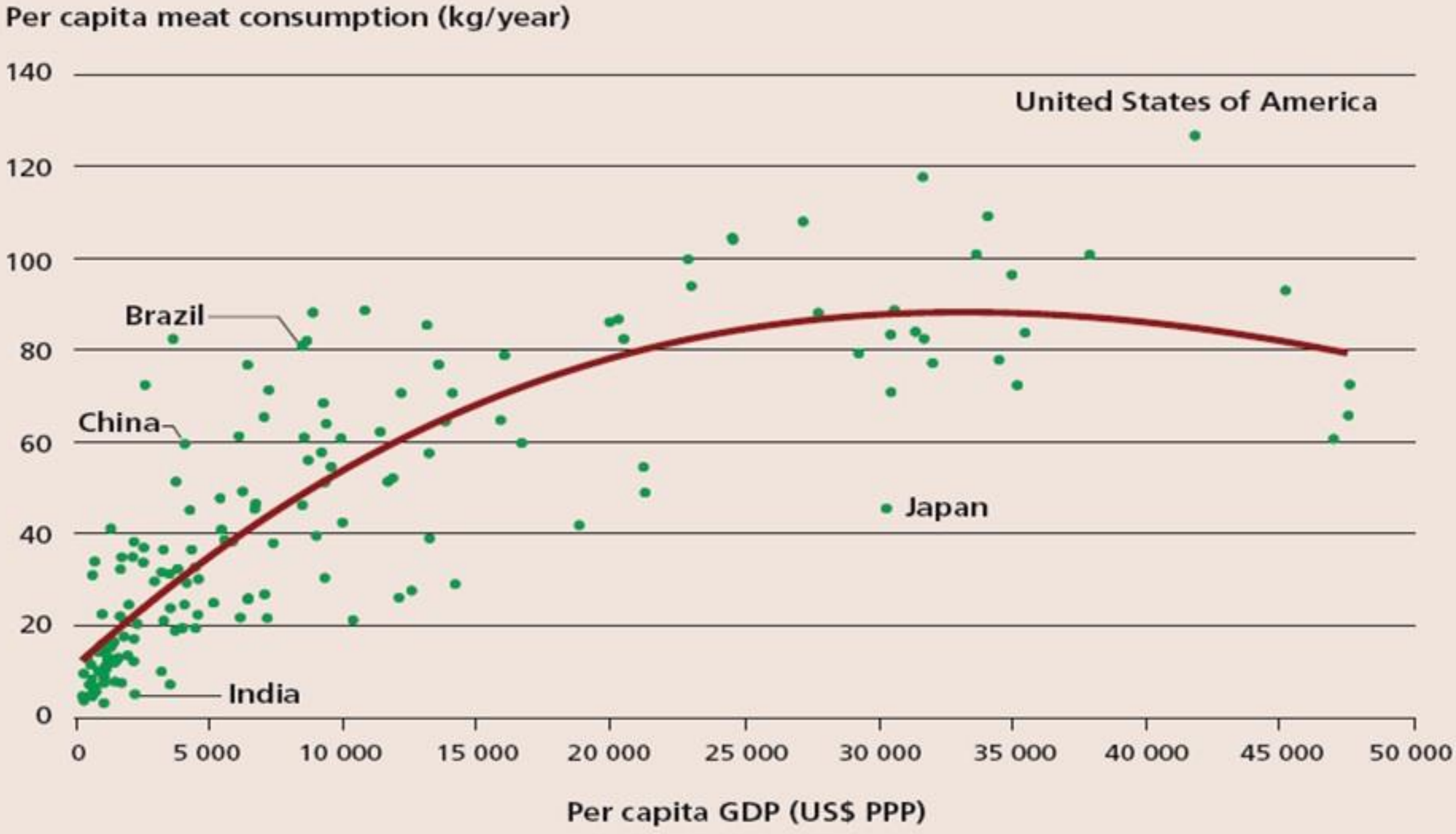
# Per capita consumption of major food items in developing countries, 1961–2005



FAO, 2009

FIGURE 3

**Per capita GDP and meat consumption by country, 2005**



*Note:* GDP per capita is measured at purchasing power parity (PPP) in constant 2005 international US dollars.

*Source:* Based on data from FAOSTAT (FAO, 2009b) for per capita meat consumption and the World Bank for per capita GDP.

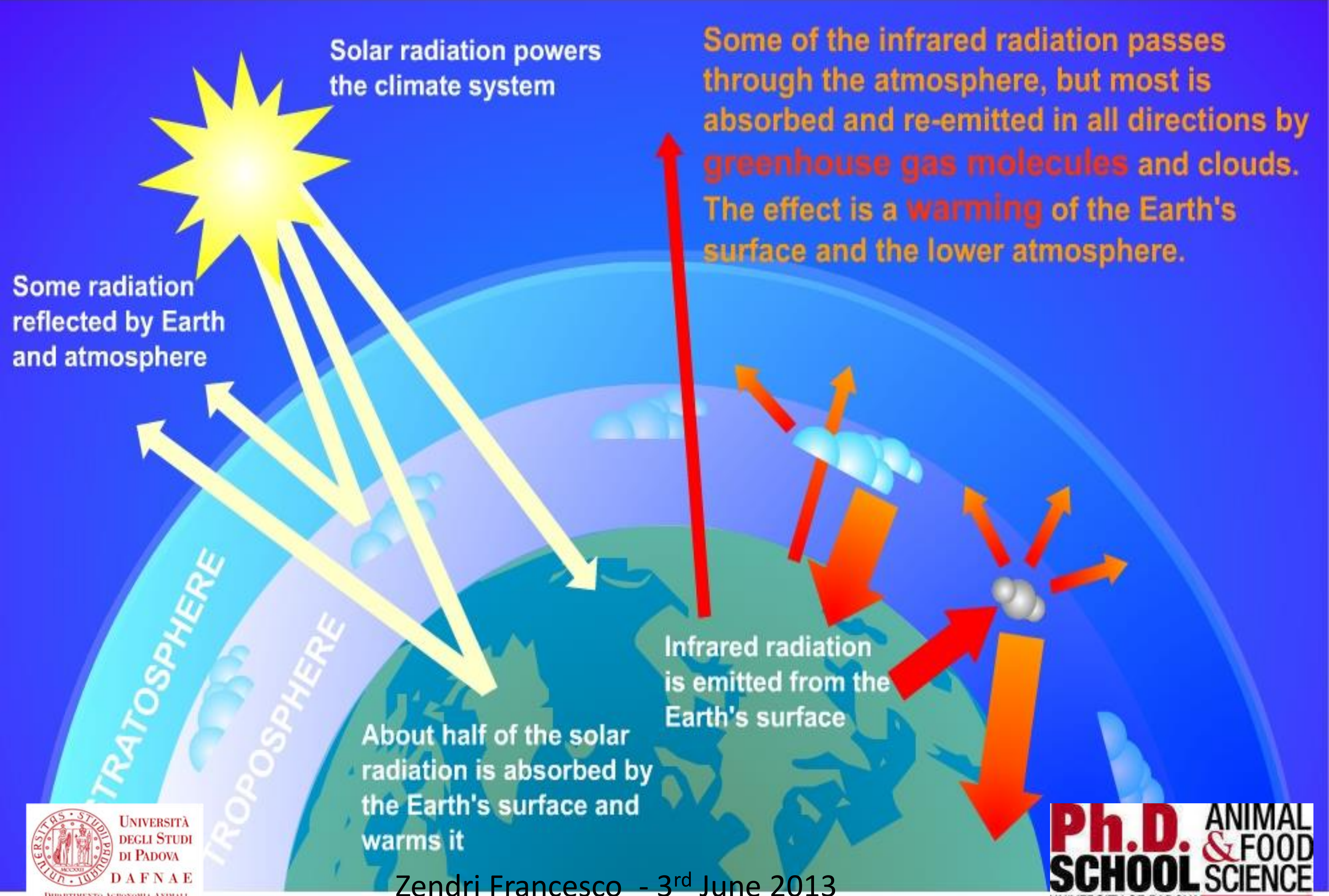
# Greenhouse gases

- Public opinion
- GHG from livestock sector
- Climate and energy package 20 – 20 – 20

These targets, known as the "20-20-20" targets, set three key objectives for 2020:

- A 20% reduction in EU greenhouse gas emissions from 1990 levels;
- Raising the share of EU energy consumption produced from renewable resources to 20%;
- A 20% improvement in the EU's energy efficiency.

# THE GREENHOUSE EFFECT



Solar radiation powers the climate system

Some of the infrared radiation passes through the atmosphere, but most is absorbed and re-emitted in all directions by greenhouse gas molecules and clouds. The effect is a warming of the Earth's surface and the lower atmosphere.

Some radiation reflected by Earth and atmosphere

Infrared radiation is emitted from the Earth's surface

About half of the solar radiation is absorbed by the Earth's surface and warms it

CHRISTOPH STEINER 2008

# Global warming

Global warming is the observed and projected increases in the average temperature of Earth's atmosphere and oceans. Last 150 years increased concentration of greenhouse gases whit an increase of temperature (IPCC, 2001). The Earth's average temperature rose about 0.6 °C in the 20th century.

# GHG

Gases that trap heat in the atmosphere are often called greenhouse gases – GHGs.

- Carbon dioxide ($CO_2$)
- Methane ($CH_4$)
- Nitrous oxide ($N_2O$)

associated with agriculture

- HFCs
- $SF_6$
- PFCs

# Emissions

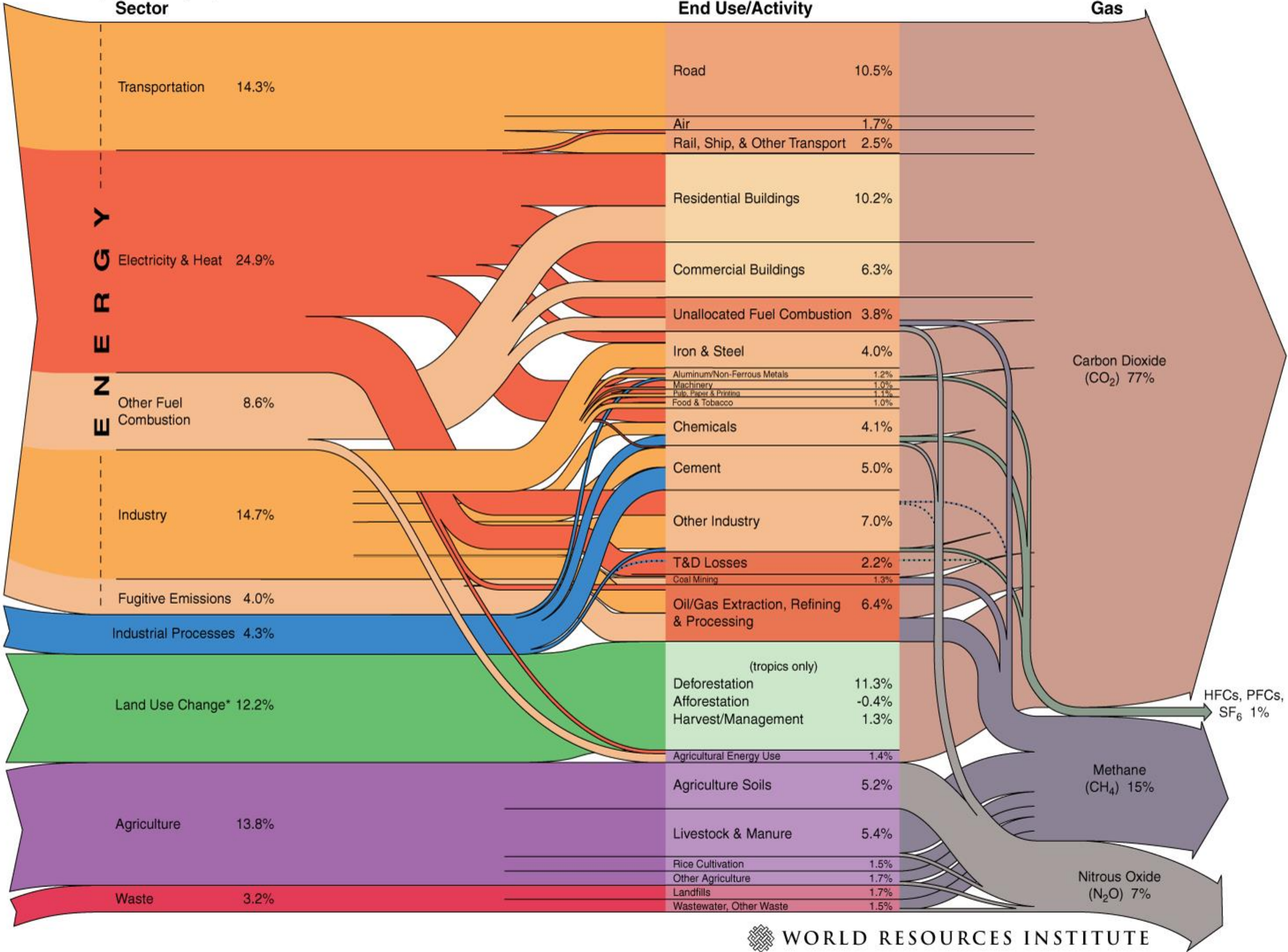
72% of the totally emitted greenhouse gases is carbon dioxide ($CO_2$), 18% Methane and 9% Nitrous oxide ($N_2O$). Carbon dioxide emissions therefore are the most important cause of global warming

IPCC, 2007

The agricultural sector in Italy is the second largest source emitting gas emissions, with 6.7% of national emissions, after the energy sector whit 82,9% (ISPRA, 2012).

The current target is to reduce GHG emissions by 80% by 2050.

**World Greenhouse Gas Emissions in 2005**
**Total: 44,153 $MtCO_2$ eq.**



WORLD RESOURCES INSTITUTE

# $CO_2$-eq

- The greenhouse effect is different for different gases involved
- The effects of emissions conform with the "$CO_2$ equivalent" (IPCC, 2007)

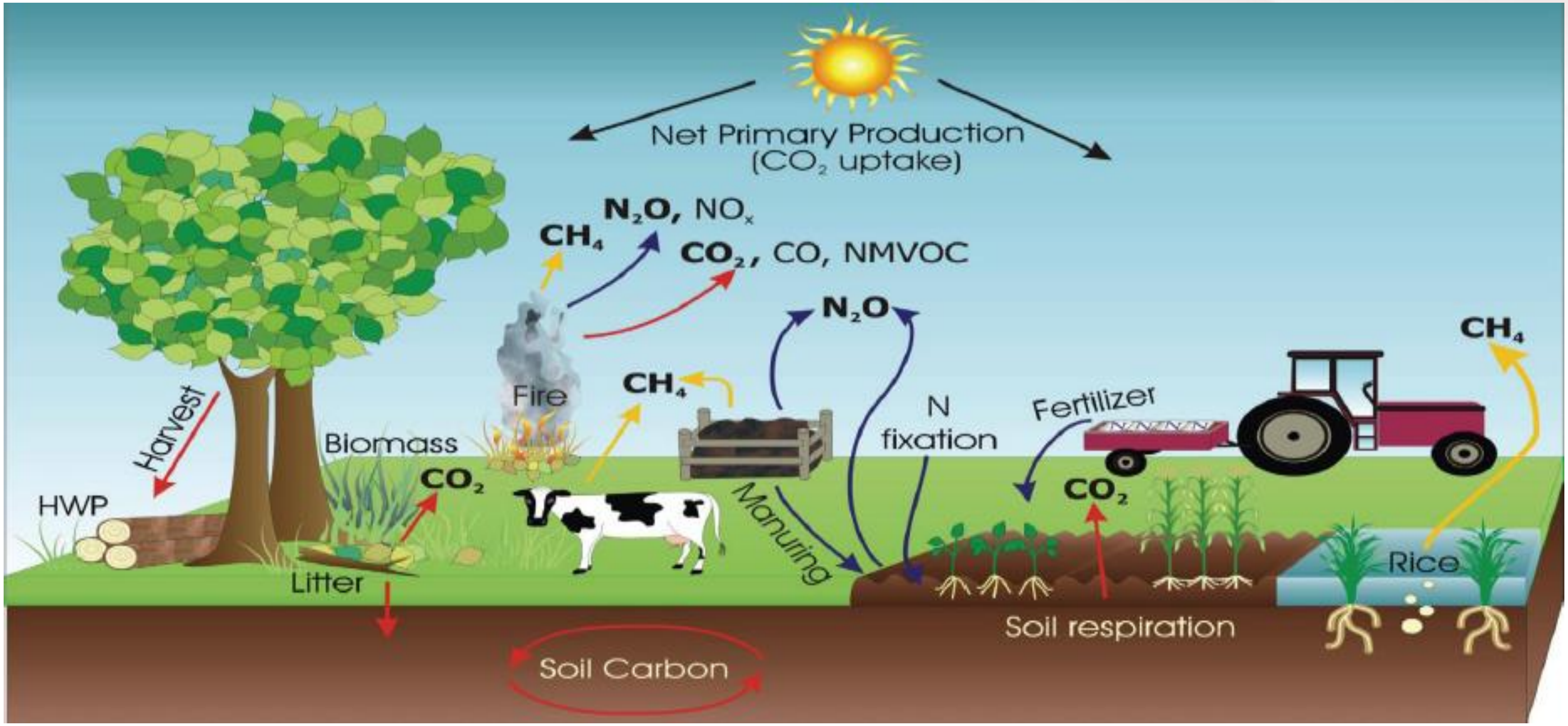
**Carbon dioxide-equivalent ($CO_2$-eq)**

1 kg $CO_2$ = 1 kg $CO_2$ equivalent

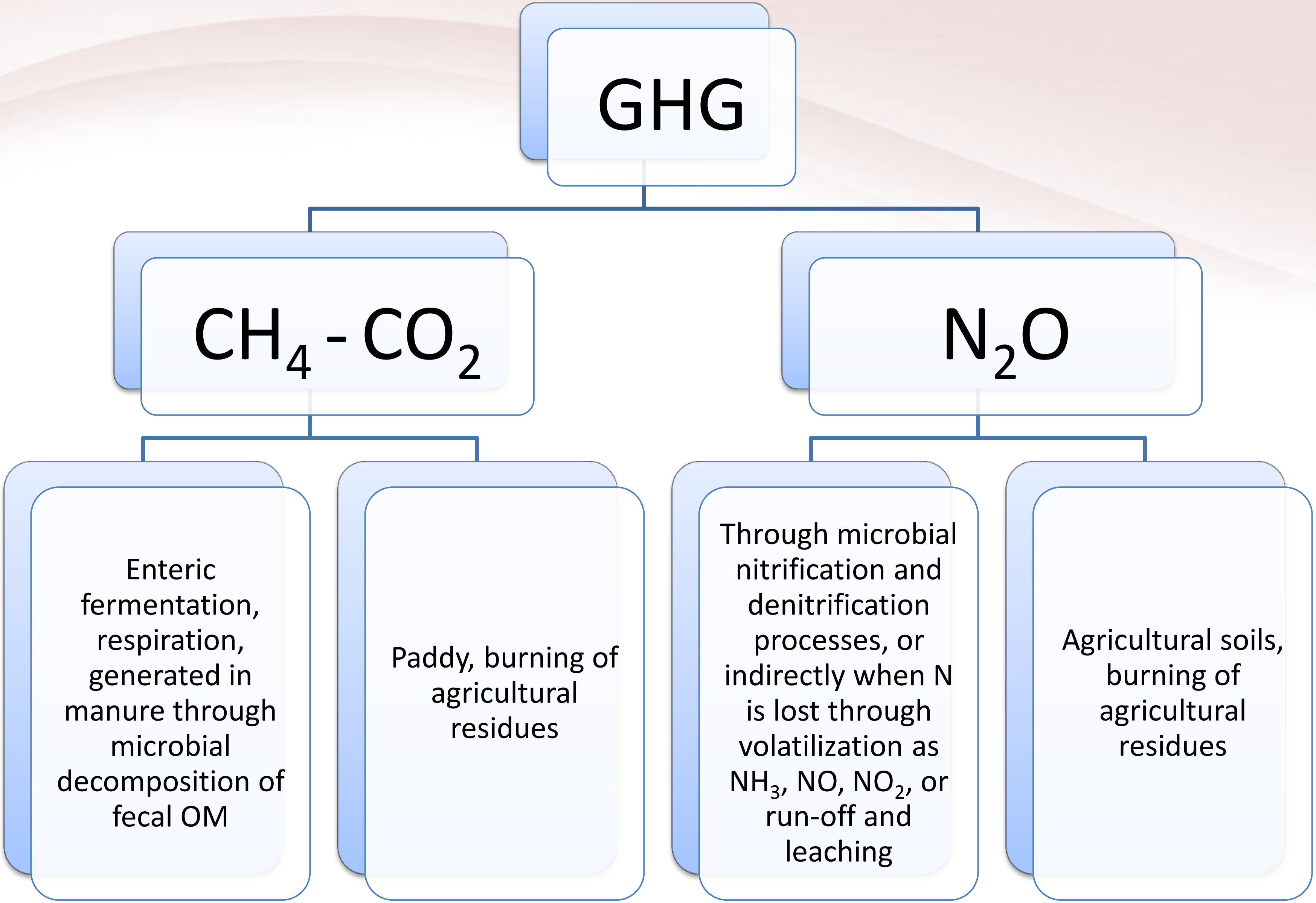
1 kg $CH_4$ = 25 kg $CO_2$ equivalent

1 kg $N_2O$ = 298 kg $CO_2$ equivalent

Schematic representation of the main greenhouse gas sources and removals from the atmosphere in managed agricultural ecosystems



IPCC, 2006; Volume 4 Chapter 1



GHG

$CH_4$ - $CO_2$

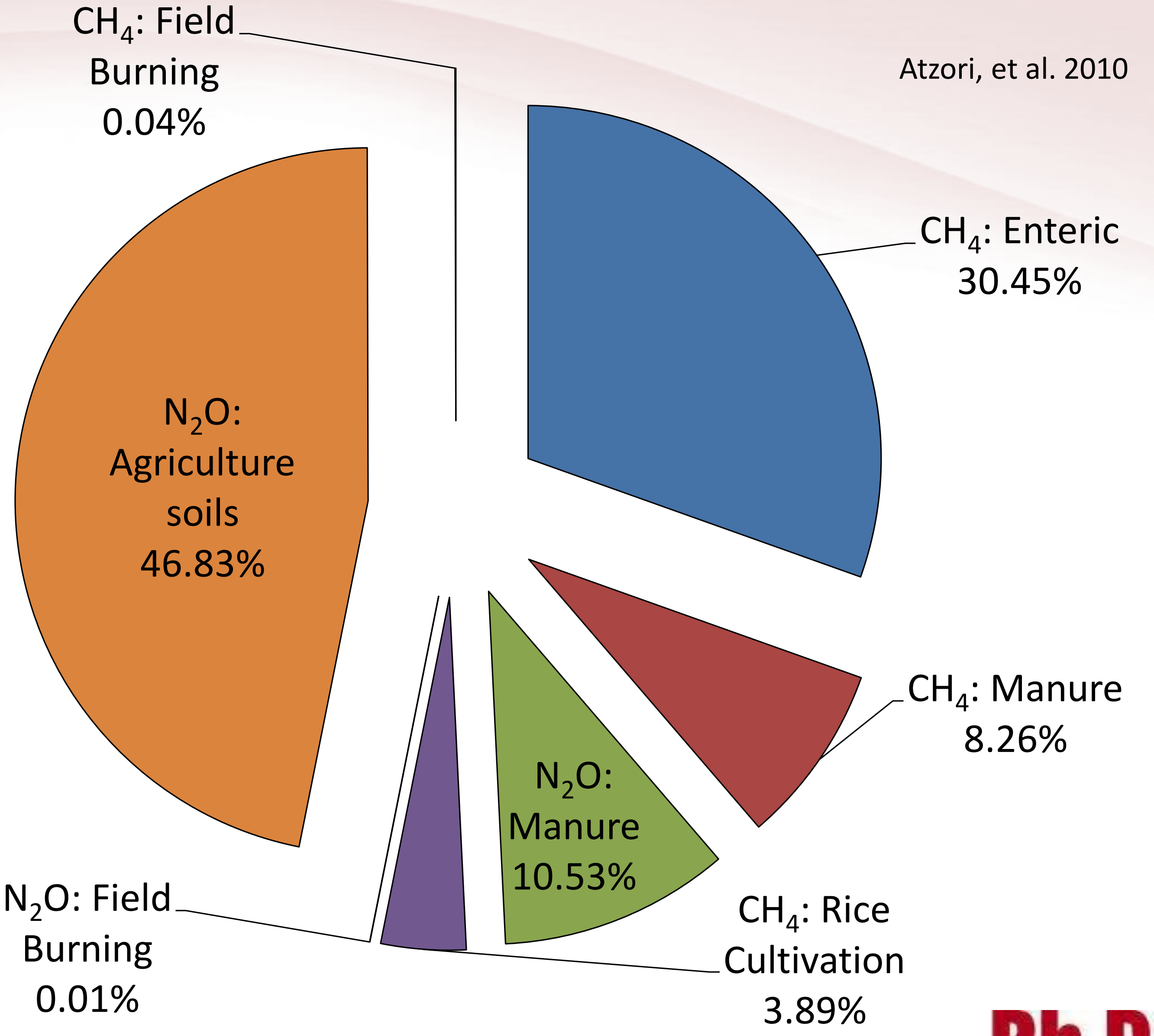
$N_2O$

Enteric fermentation, respiration, generated in manure through microbial decomposition of fecal OM

Paddy, burning of agricultural residues

Through microbial nitrification and denitrification processes, or indirectly when N is lost through volatilization as $NH_3$, NO, $NO_2$, or run-off and leaching

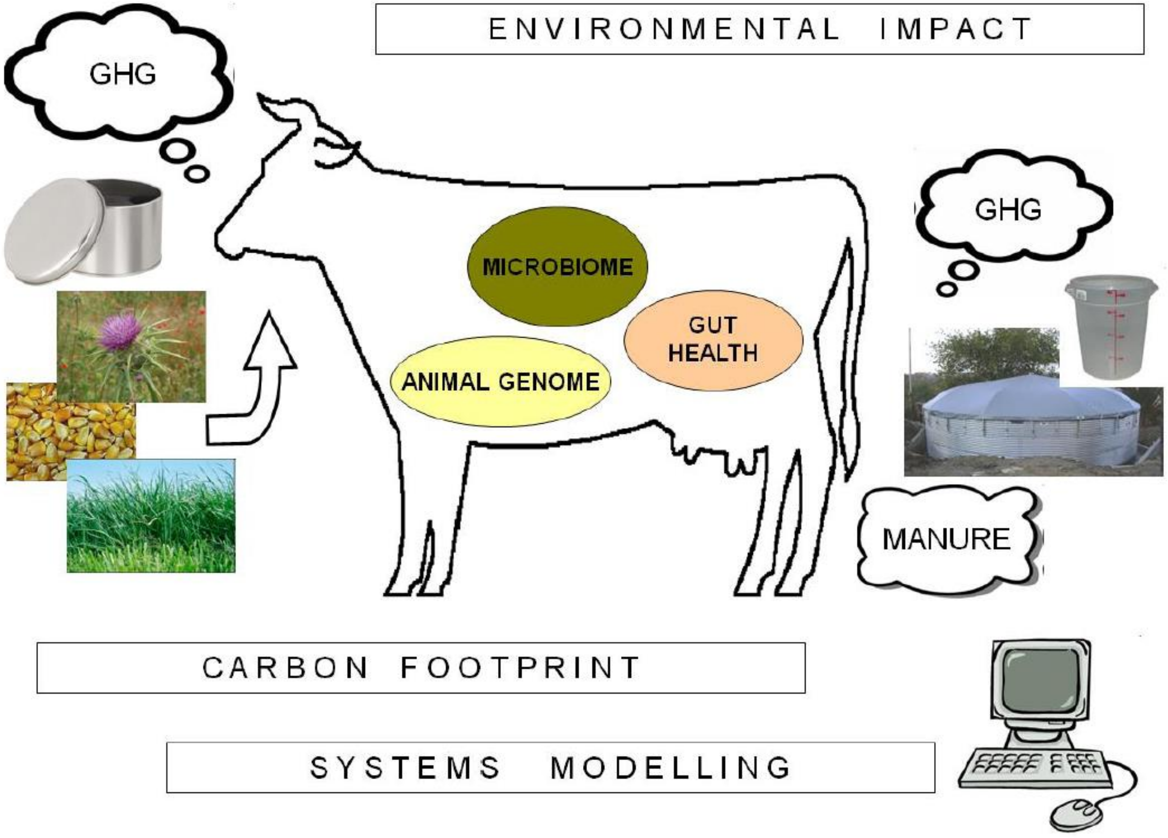
Agricultural soils, burning of agricultural residues



Atzori, et al. 2010

# Enteric fermentation in the cattle

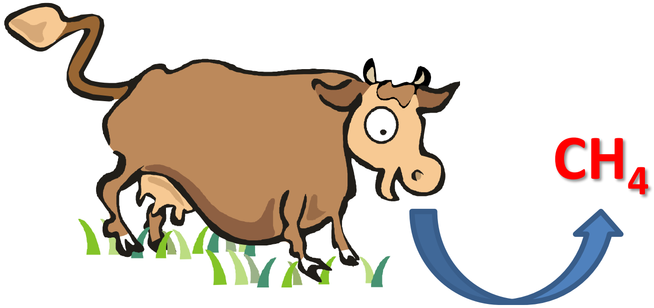
The production of $CH_4$ for ruminants is a physiological need



Sandri ,2011

# Enteric fermentation in the cattle

- Changing the diet, increase the daily intake, increase the degradability of starch, decrease the fiber of forage in the ration, add unsaturated fats in the ration,…
- Ruminal additives (Puchala et al., 2005; Tiemann et al., 2008; Wallace et al., 2006)
- Rumen microbial population
- Animal selection (Capper et al., 2009)
- Management

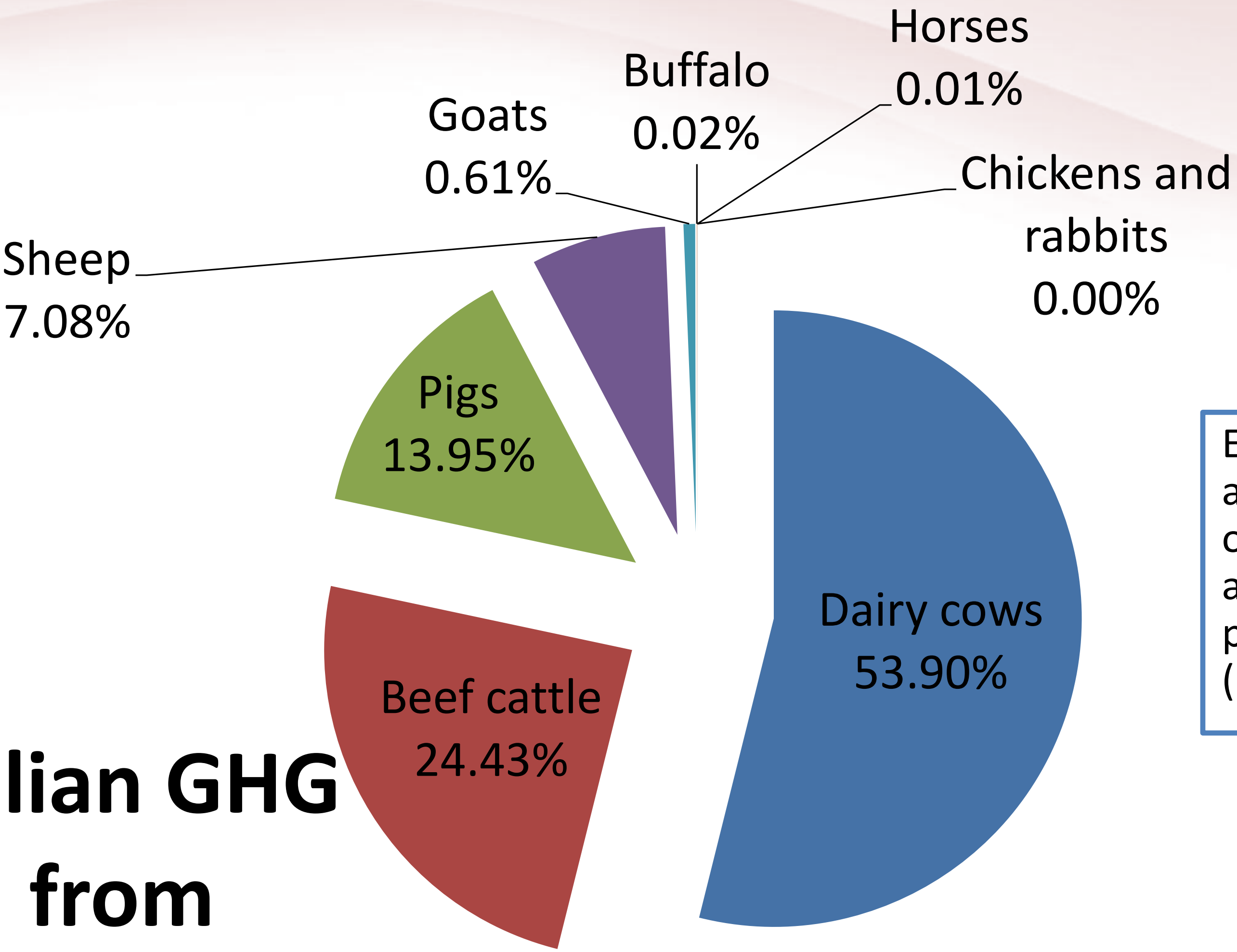


# GHG

| Species | Enteric fermentation, % | Manure, % |
|---|---|---|
| Dairy cows | 79 | 21 |
| Beef cattle | 67 | 33 |
| Pigs | 12 | 88 |
| Poultry | 0 | 100 |

Cannas, 2012

Italian GHG from livestock 3.0%
World GHG from livestock 5.4%

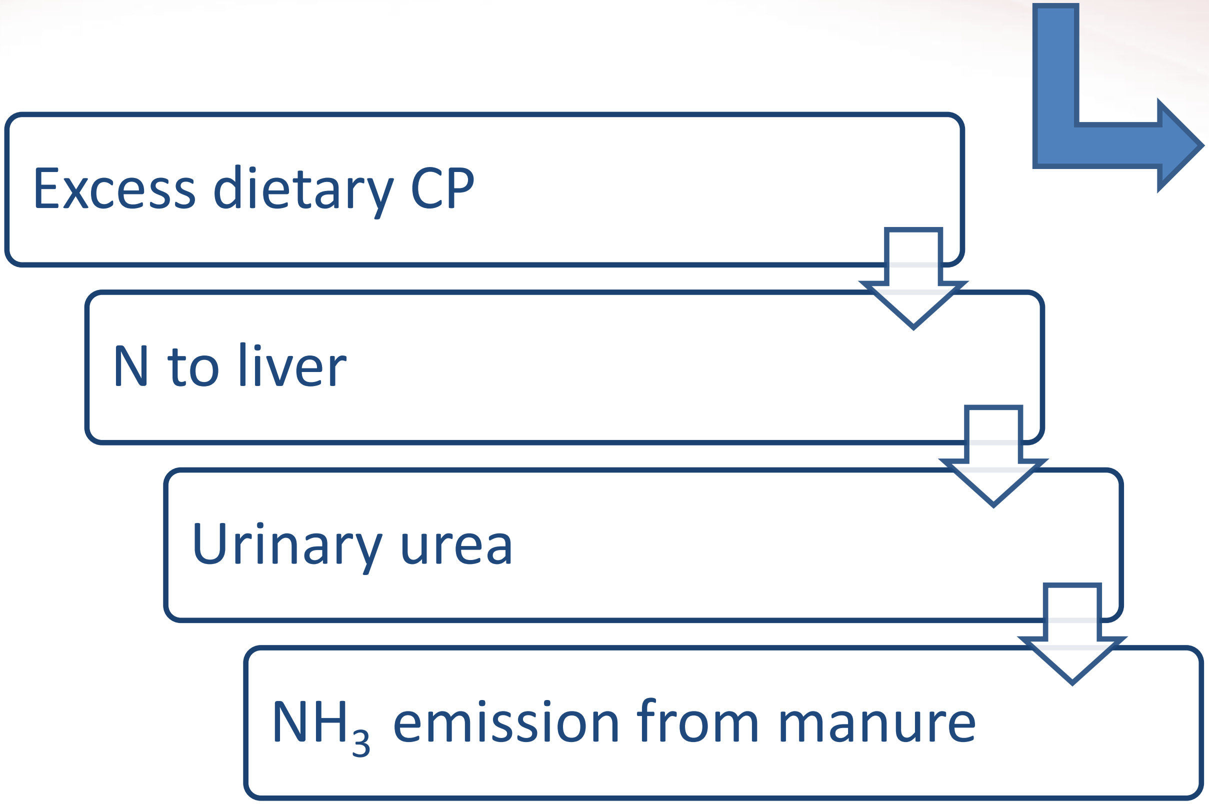


Emissions from agriculture: 6.6% of the total, animal productions 3.0% (ISPRA, 2012)

# Italian GHG from livestock

Atzori, et al. 2010

# Ammonia (NH$_3$)



Excess dietary CP

N to liver

Urinary urea

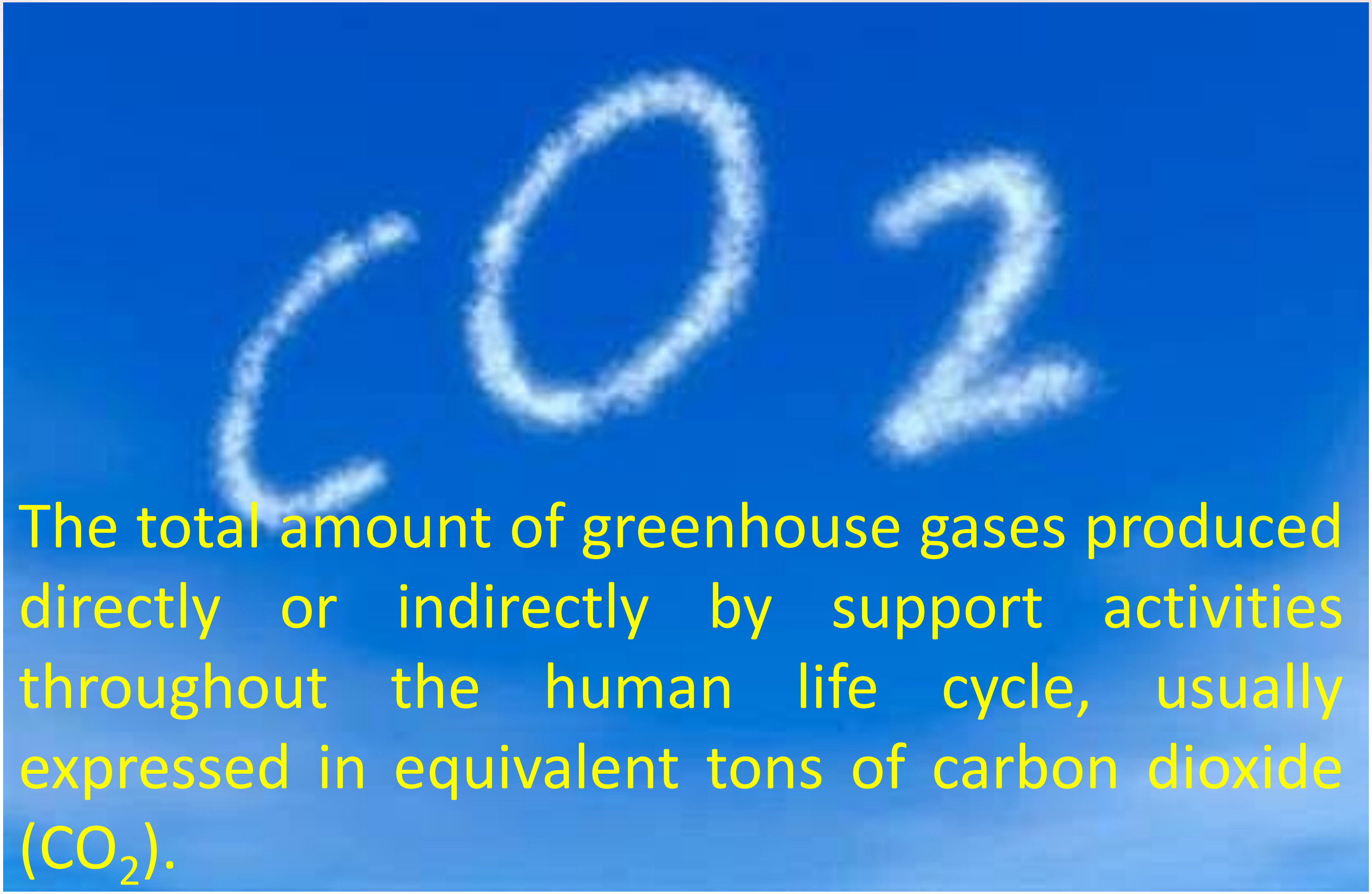
NH$_3$ emission from manure

- Has environmental and human health effects
- Eutrophication of surface waters
- Acidification of ecosystems
- Fine particulate matter formation in the atmosphere

In UE-27 the agriculture is responsible for most of the emissions of ammonia (94%) but the emissions have decreased by approximately 27% compared to 1990 (EEA, 2011)

# Carbon footprint

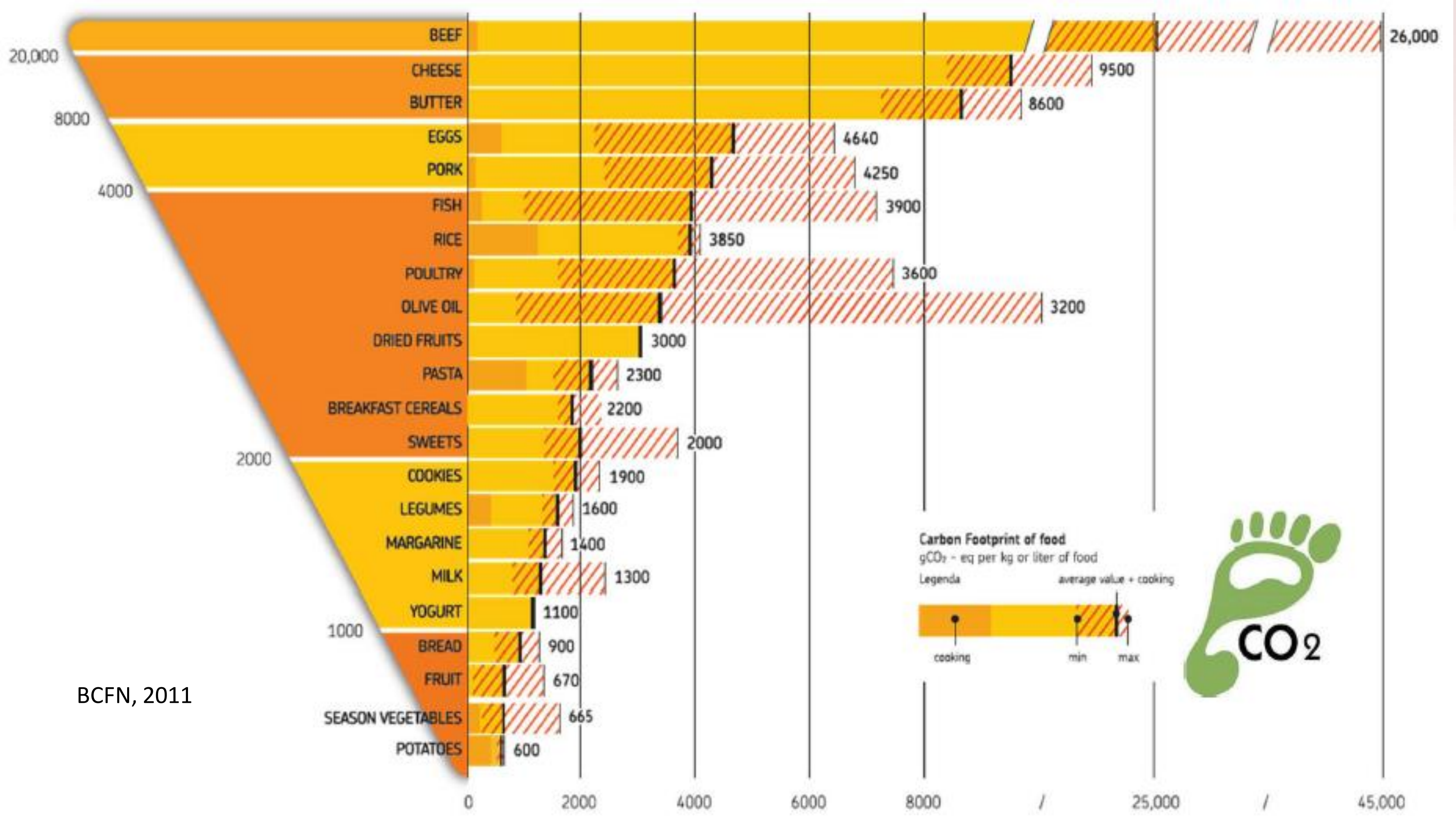
The carbon footprint is an environmental indicator that measures the impact of human activities on global climate; expresses quantitatively the effects on climate (from object or a service) by greenhouse gases generated by a person, an organization, an event or a product (ENEA, 2011).



The total amount of greenhouse gases produced directly or indirectly by support activities throughout the human life cycle, usually expressed in equivalent tons of carbon dioxide ($CO_2$).

The carbon footprint of products includes the absorption and emission of climate-altering gases over the lifecycle of a product or service, from the extraction of raw materials and their processing, their use and their final use, recycling or disposal (use of energy, fuels for transport, waste and losses, fixation of atmospheric $CO_2$ by plants or soil…) (ENEA, 2011)

# Environmental Pyramid: Carbon Footprint



BCFN, 2011

Zendri Francesco - 3rd June 2013

The goal would be the indication on the label of how much a product costs in terms of $CO_2$ equivalent emissions

Organic New Potatoes 1.5kg

The carbon footprint of these potatoes is 160g CO2 per 250g serving and we have committed to reduce it

Help to reduce this footprint by:
Boiling or microwaving these potatoes rather than roasting or baking them;
Boiling with the pan lid on can reduce the energy you use by as much as 25%

working with the Carbon Trust

The carbon footprint of this juice is 360g per 250ml serving and we have committed to reduce it

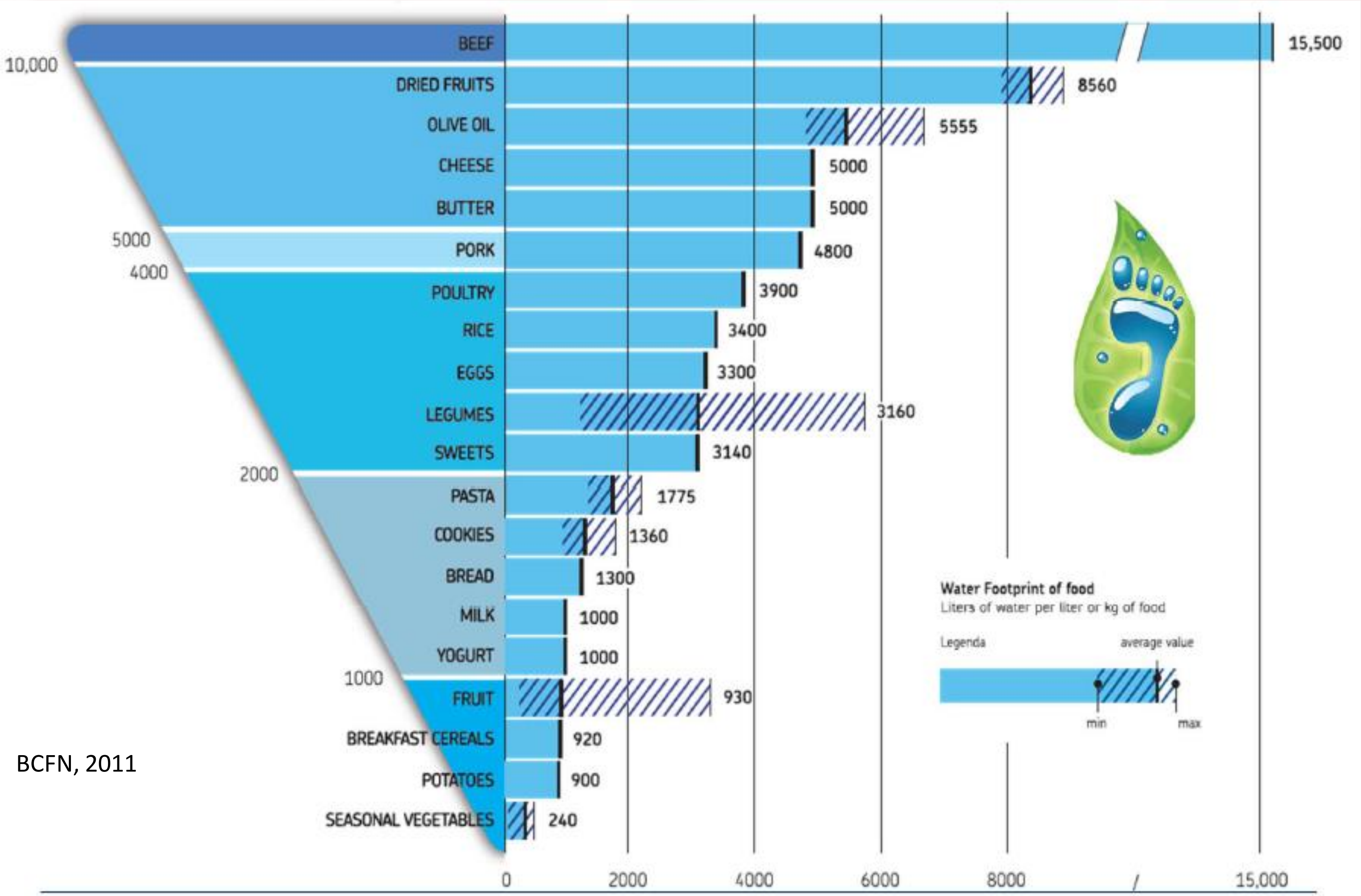
By comparison the footprint of Tesco Long-Life Pure Orange Juice is 240g per 250ml serving, which is lower because less energy is required to chill and transport concentrated juice than 100% pure squeezed juice

Carbon footprint → emissions that affect the climate change phenomenon and does not provide a result for the whole environmental impact

# Other ecological indicators…

**Water Footprint**: measure the consumption of water in terms of volumes used (evaporated) and / or polluted per unit of time always along the entire life cycle (Hoekstra, 2008).

# Environmental Pyramid: Water Footprint

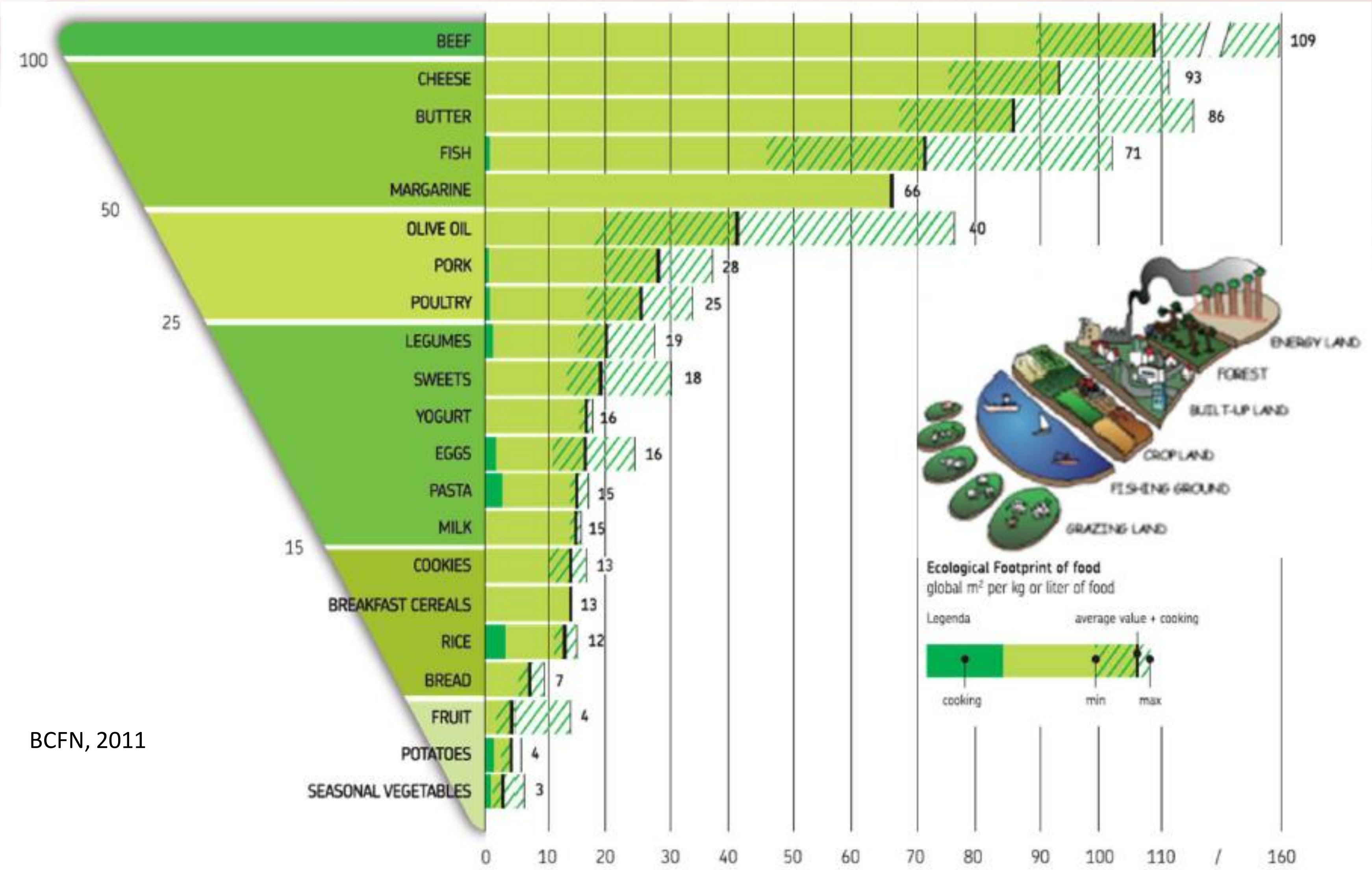


BCFN, 2011

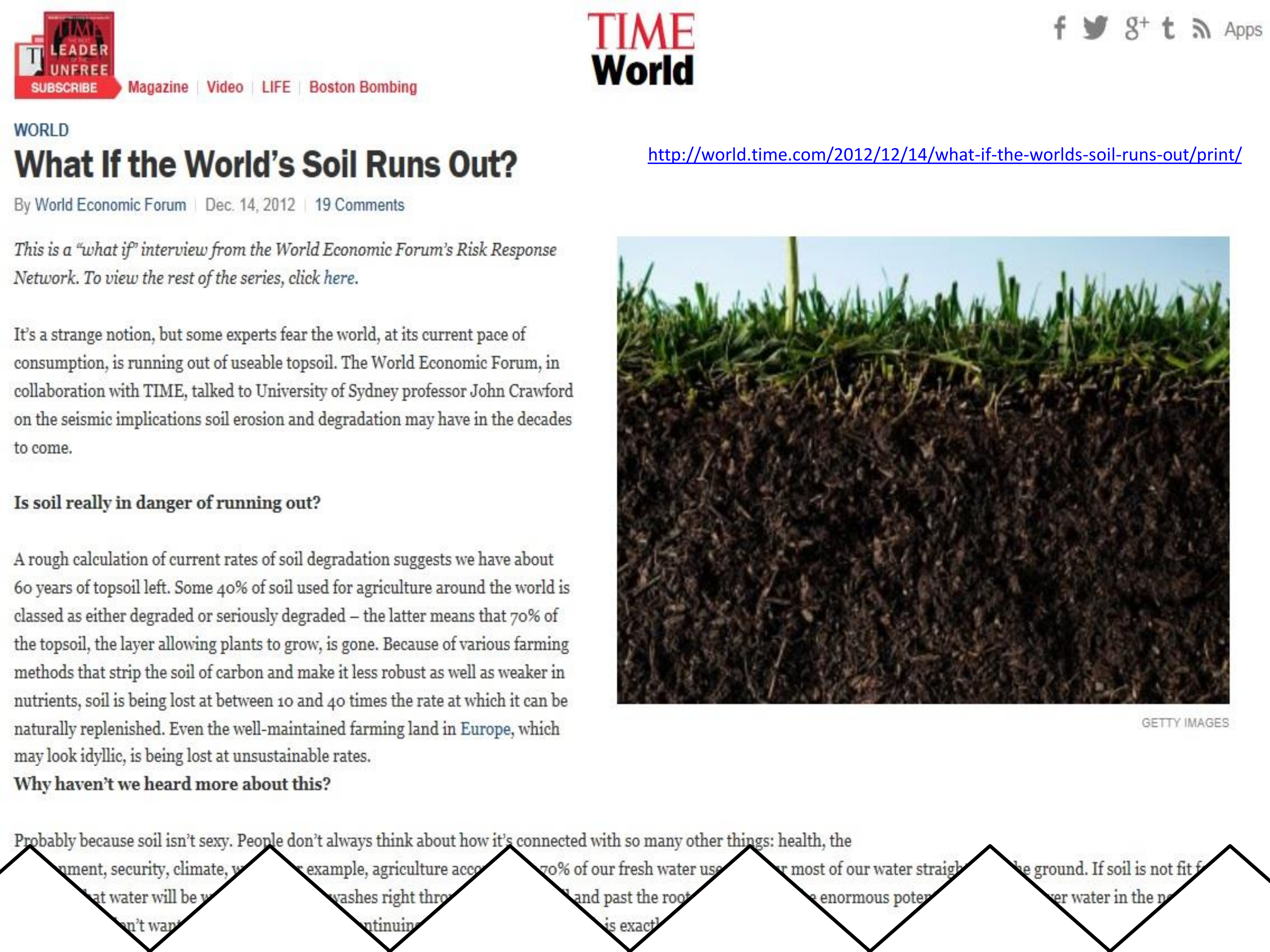
**Ecological footprint:** is a measure of how much biologically productive land and water an individual, population or activity requires to produce all the sources it consumes and to absorb the waste it generates using prevailing technology and resource management practices. It is measured in global hectares (gha).

ecologicalfootprint.com

# Environmental Pyramid: Ecological Footprint



BCFN, 2011



http://world.time.com/2012/12/14/what-if-the-worlds-soil-runs-out/print/

WORLD

# What If the World's Soil Runs Out?

By World Economic Forum | Dec. 14, 2012 | 19 Comments

*This is a "what if" interview from the World Economic Forum's Risk Response Network. To view the rest of the series, click here.*

It's a strange notion, but some experts fear the world, at its current pace of consumption, is running out of useable topsoil. The World Economic Forum, in collaboration with TIME, talked to University of Sydney professor John Crawford on the seismic implications soil erosion and degradation may have in the decades to come.

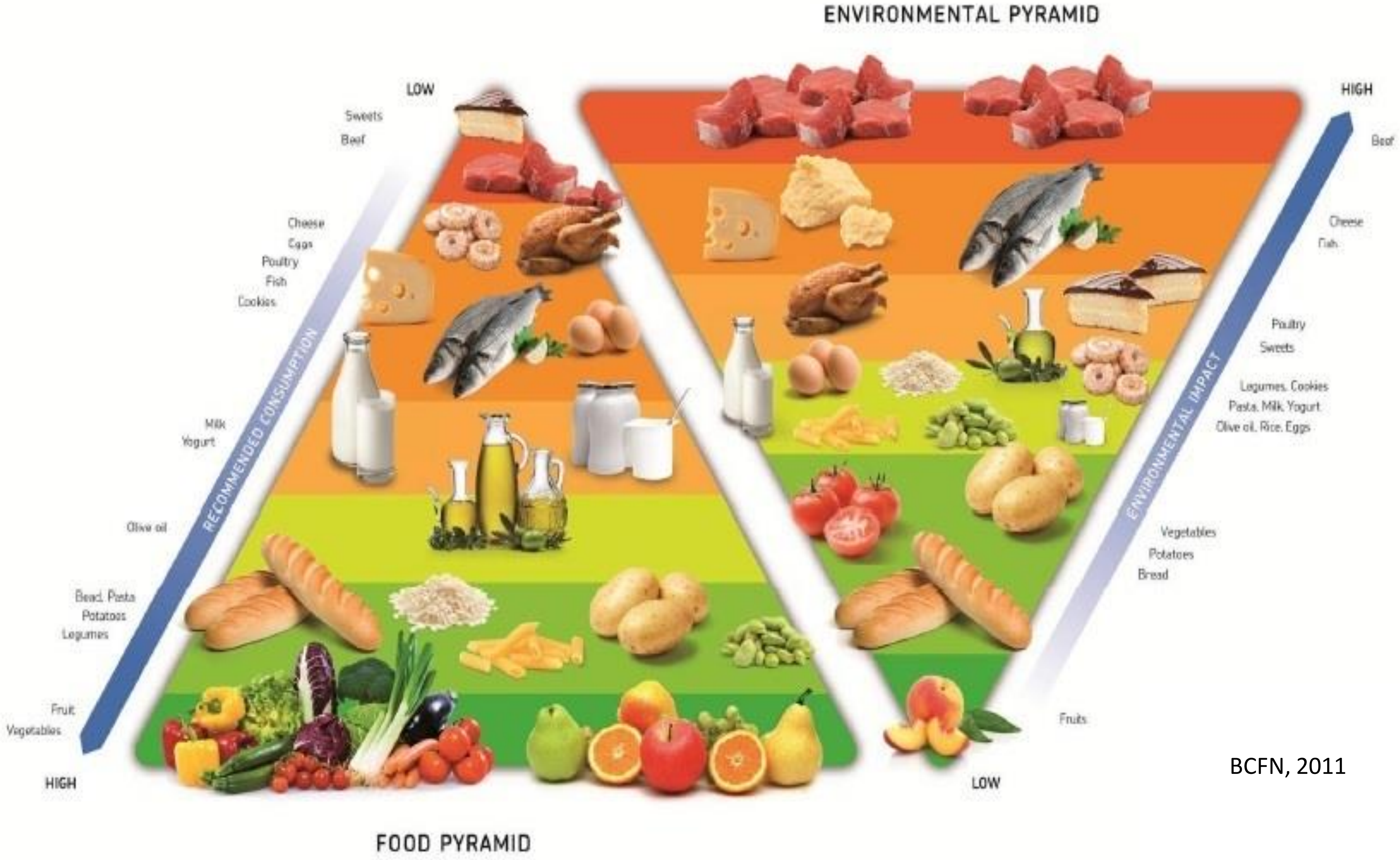
**Is soil really in danger of running out?**

A rough calculation of current rates of soil degradation suggests we have about 60 years of topsoil left. Some 40% of soil used for agriculture around the world is classed as either degraded or seriously degraded – the latter means that 70% of the topsoil, the layer allowing plants to grow, is gone. Because of various farming methods that strip the soil of carbon and make it less robust as well as weaker in nutrients, soil is being lost at between 10 and 40 times the rate at which it can be naturally replenished. Even the well-maintained farming land in Europe, which may look idyllic, is being lost at unsustainable rates.

GETTY IMAGES

**Why haven't we heard more about this?**

Probably because soil isn't sexy. People don't always think about how it's connected with so many other things: health, the
nment, security, climate, w r example, agriculture acco 70% of our fresh water use r most of our water straigh he ground. If soil is not fit f
at water will be w washes right thro l and past the roo e enormous poten er water in the n
n't wan ntinuin is exact


ENVIRONMENTAL PYRAMID
LOW
Sweets
Beef
Cheese
Eggs
Poultry
Fish
Cookies
RECOMMENDED CONSUMPTION
Milk
Yogurt
Olive oil
Bead, Pasta
Potatoes
Legumes
Fruit
Vegetables
HIGH
HIGH
Beef
Cheese
Fish
Poultry
Sweets
Legumes, Cookies
Pasta, Milk, Yogurt
Olive oil, Rice, Eggs
ENVIRONMENTAL IMPACT
Vegetables
Potatoes
Bread
Fruits
LOW
FOOD PYRAMID

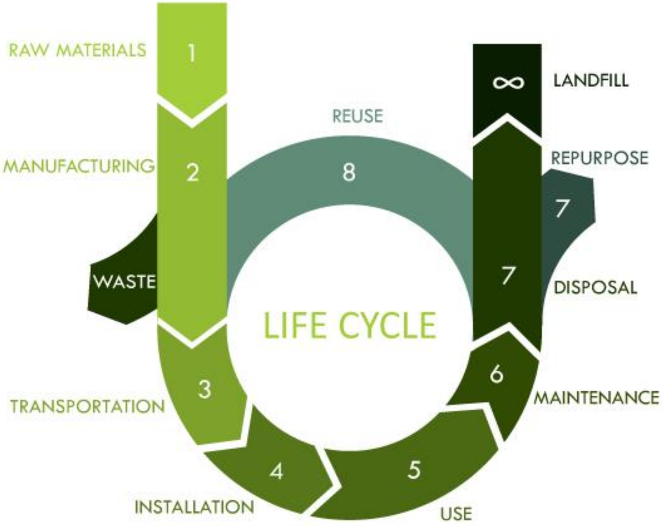
BCFN, 2011

# A growing part of the Ecological footprint derives from the livestock sector?

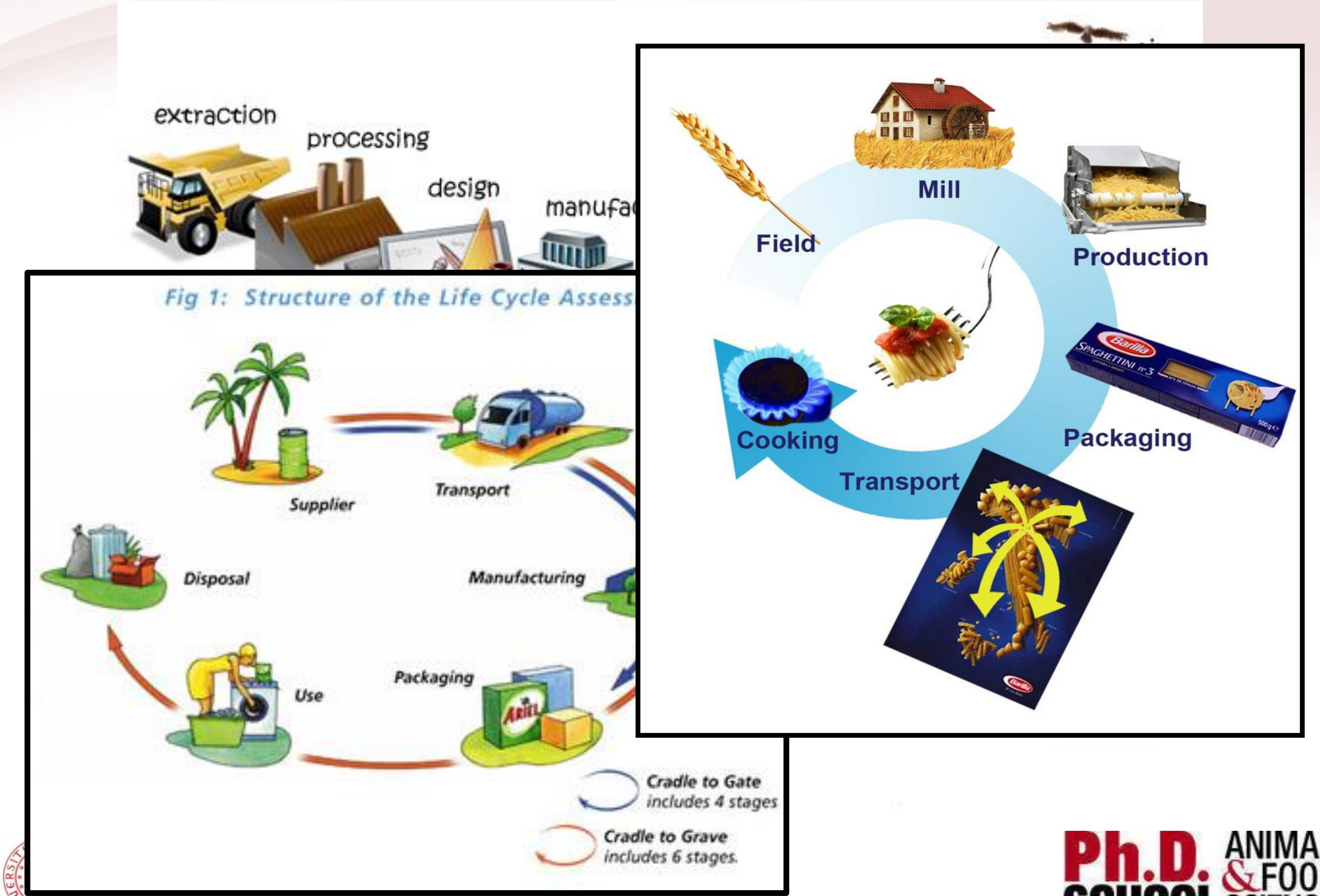
Zendri Francesco - 3rd June 2013

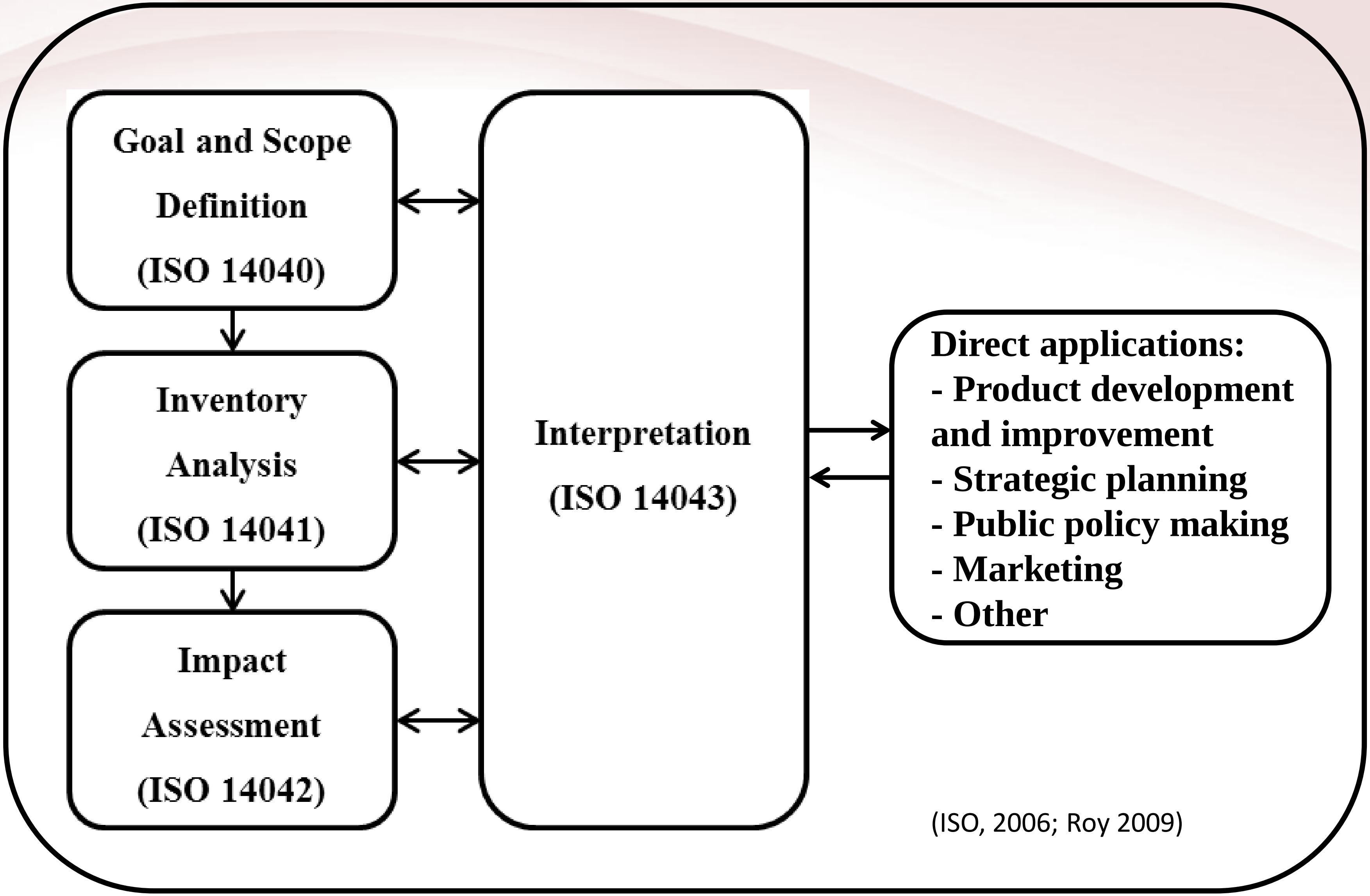
# LCA – life cycle assessment

It is an objective method (ISO) for the evaluation and quantification of the energy and environmental and potential impacts associated with a product/ process / activity over the entire life cycle, from raw material acquisition to the end of life ("cradle to grave").



Roy, 2009; Pelletier, 2008


extraction
processing
design
manufa
Fig 1: Structure of the Life Cycle Assess
Supplier
Transport
Disposal
Manufacturing
Use
Packaging
Cradle to Gate includes 4 stages
Cradle to Grave includes 6 stages.
Field
Mill
Production
Packaging
Transport
Cooking
Barilla
SPAGHETTINI n.3



Goal and Scope Definition (ISO 14040)

Inventory Analysis (ISO 14041)

Impact Assessment (ISO 14042)

Interpretation (ISO 14043)

**Direct applications:**
- **Product development and improvement**
- **Strategic planning**
- **Public policy making**
- **Marketing**
- **Other**

(ISO, 2006; Roy 2009)

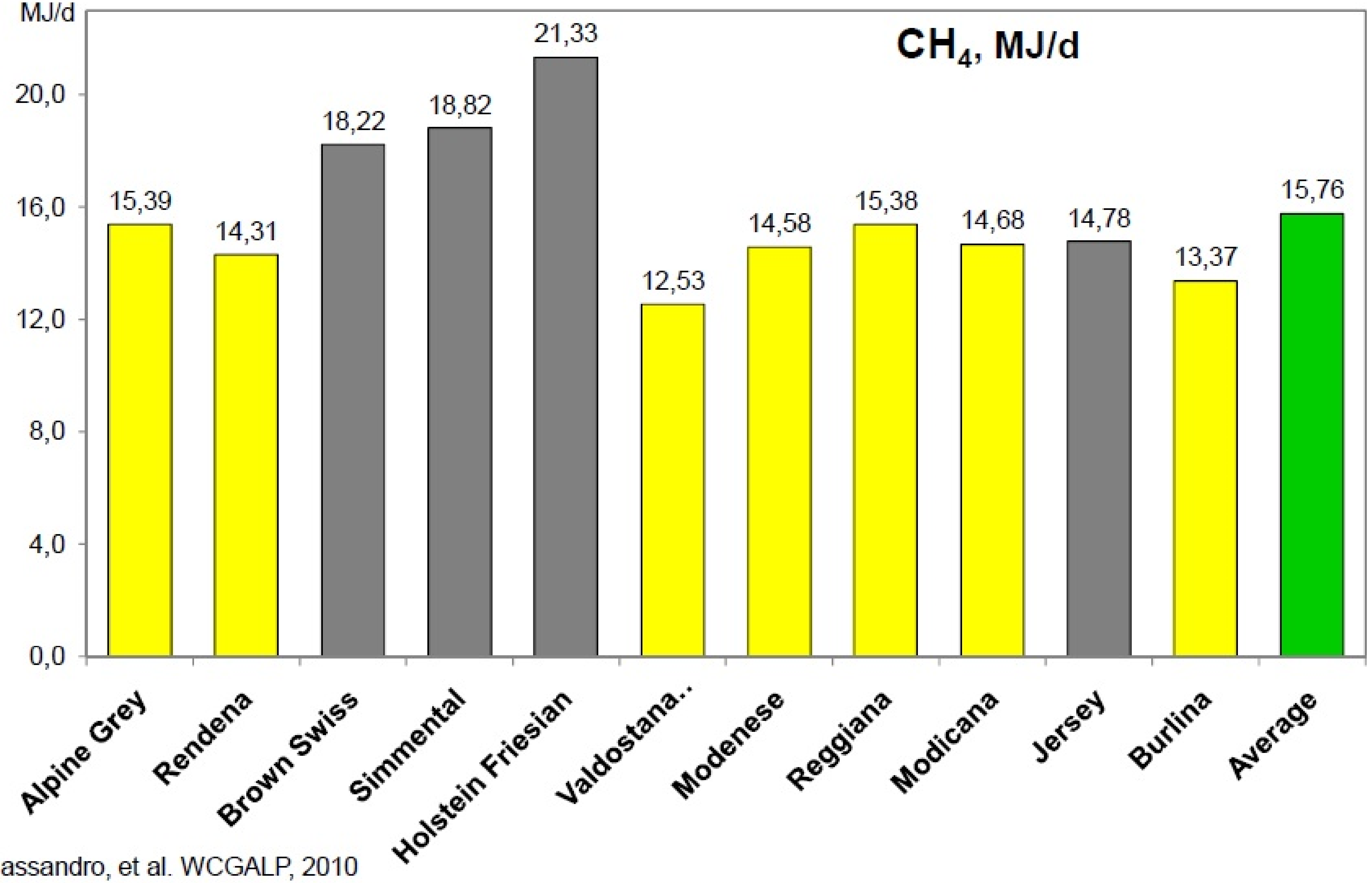
# Goal definition and scoping

The purpose of the study and which the use (e.g. Intensive, extensive and organic grassland farming; Hass et al. 2001)

The expected product of the study, system boundaries (farm gate,…), allocation (milk and meet), functional unit (ms, kg, kg/cattle,…) and assumptions

# Predicted Methane Production MJ/d

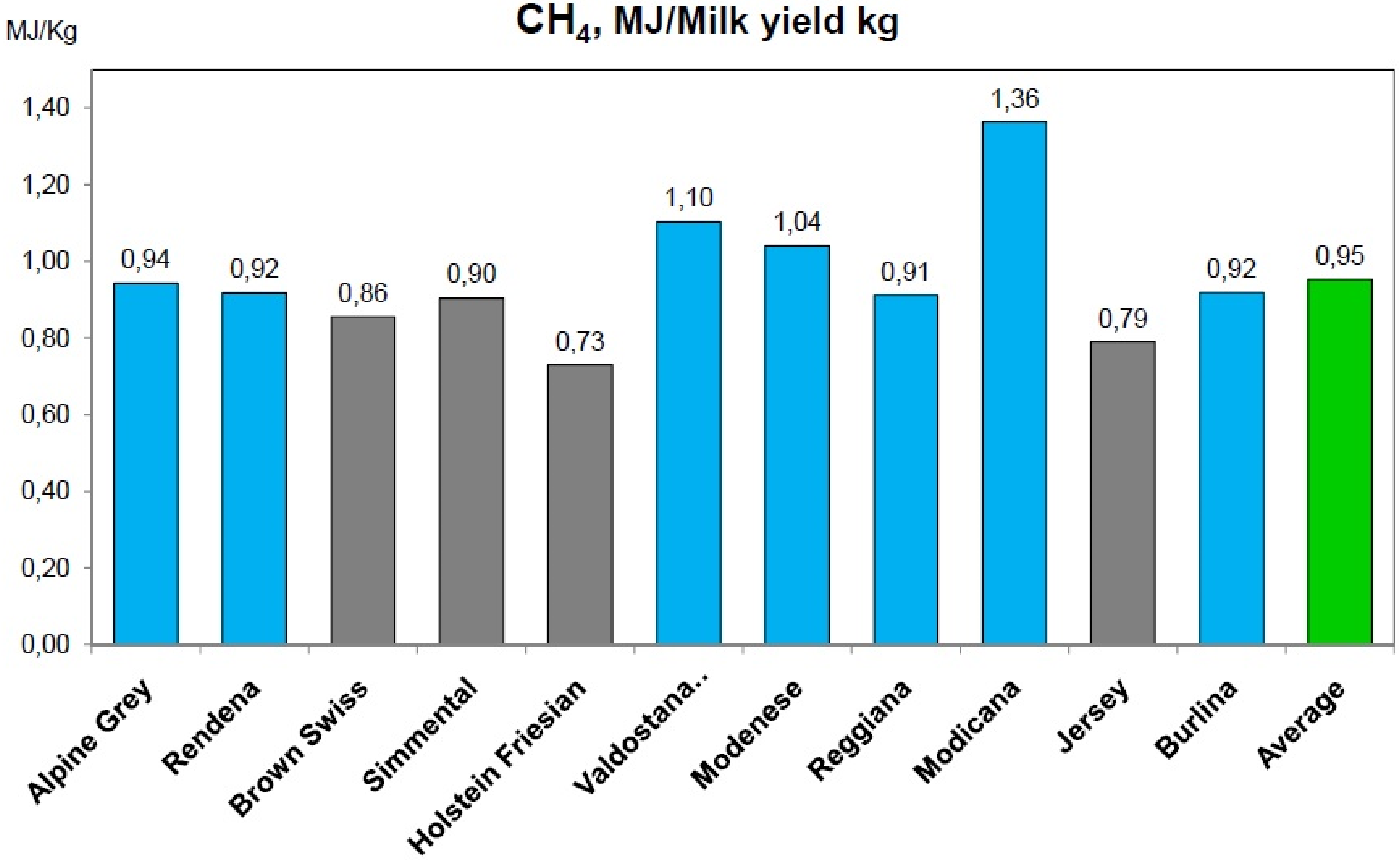
**Cosmopolitan vs Local Breeds: 18.29 vs 14.32 MJ/d (+28%)**



Cassandro, et al. WCGALP, 2010

# Predicted Methane Production / unit of output

**Cosmopolitan vs Local Breeds: 0.82 vs 1.03 MJ/ Milk yield, kg (-20 %)**



# Inventory analysis

- Animal in the farm, feed, manure management, …
- Fuel to produce fertilizer, seed, for transport,…
- Many LCA databases exist and can normally be used (enteric fermentation, ammonia from fertilizer, data on transport, extraction of raw materials, processing of materials…)

# Impact assessment

The inventory results are assigned to different impact categories, based on the expected types of impacts on the environment.

↓

Classification, characterization, normalization and valuation

Roy, 2009; Schmidt 2008

# Interpretation

- Final phase of an LCA
- Is to verify whether the conclusions drawn from the analysis are supported by the data collected and the procedure adopted
- The tests include: representativeness of the sample analyzed, sensitivity, real meaning

# Advantages

- Knowledge of the consequences of the entire process
- Contrasting effects
- Definition of best practices
- Benchmarking
- Trade promotion
- Powerful tool for planning both corporate and political, which lends itself very well to establish development goals, to outline strategies and define performance indicators

Pirlo, 2012

# Disadvantages

- Data quality often made in very different contexts
- Modest uniformity of methods
- Difficulty in obtaining data from companies/ farms (distrust, disorganization,...)
- Predominantly diffuse pollution

Pirlo, 2012

Impact assessment results per 1 liter of HQ milk and percentage contribution of each life cycle phase

| Impact categories | Units | Total | From cradle to farm gate | Transports to dairies | Dairies | To distribution centres |
|---|---|---|---|---|---|---|
| **GW** | kg $CO_2$ eq | 1.5 | 85% | 1% | 11% | 3% |
| **Ozone layer depletion** | kg CFC-11 eq | 6.7E-08 | 62% | 2% | 27% | 9% |
| **Photochemical oxidation** | kg $C_2H_4$ eq | 2.7E-04 | 84% | 1% | 12% | 3% |
| **Acidification** | kg $SO_2$ eq | 9.9E-03 | 92% | 1% | 5% | 2% |
| **Eutrophication** | Kg $PO_4^{3-}$eq | 7.2E-03 | 97% | <1% | 2% | <1% |

(Fantin et al. 2012)

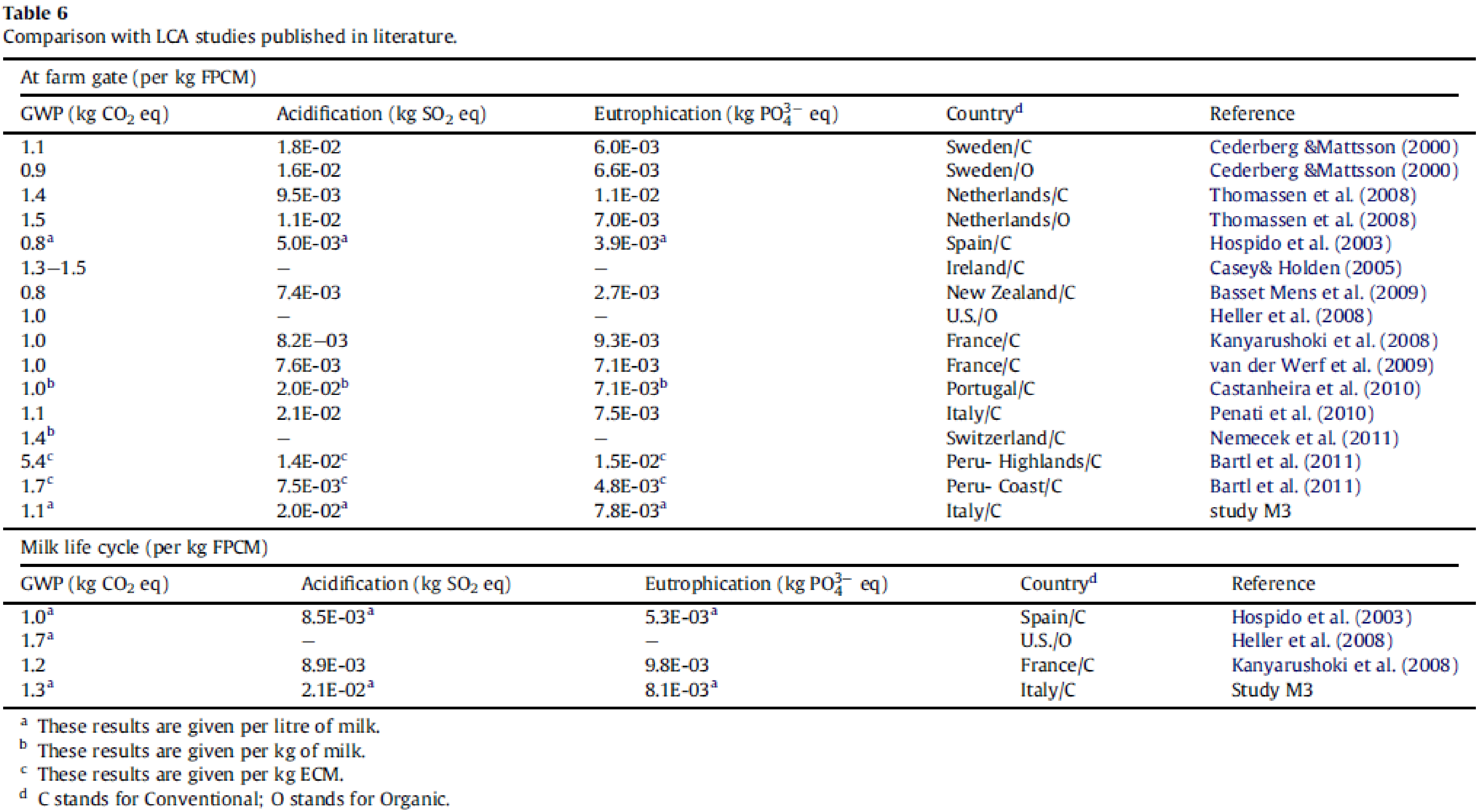


**Table 6**
Comparison with LCA studies published in literature.

At farm gate (per kg FPCM)

| GWP (kg $CO_2$ eq) | Acidification (kg $SO_2$ eq) | Eutrophication (kg $PO_4^{3-}$ eq) | Country[d] | Reference |
|---|---|---|---|---|
| 1.1 | 1.8E-02 | 6.0E-03 | Sweden/C | Cederberg &Mattsson (2000) |
| 0.9 | 1.6E-02 | 6.6E-03 | Sweden/O | Cederberg &Mattsson (2000) |
| 1.4 | 9.5E-03 | 1.1E-02 | Netherlands/C | Thomassen et al. (2008) |
| 1.5 | 1.1E-02 | 7.0E-03 | Netherlands/O | Thomassen et al. (2008) |
| 0.8[a] | 5.0E-03[a] | 3.9E-03[a] | Spain/C | Hospido et al. (2003) |
| 1.3–1.5 | – | – | Ireland/C | Casey& Holden (2005) |
| 0.8 | 7.4E-03 | 2.7E-03 | New Zealand/C | Basset Mens et al. (2009) |
| 1.0 | – | – | U.S./O | Heller et al. (2008) |
| 1.0 | 8.2E–03 | 9.3E-03 | France/C | Kanyarushoki et al. (2008) |
| 1.0 | 7.6E-03 | 7.1E-03 | France/C | van der Werf et al. (2009) |
| 1.0[b] | 2.0E-02[b] | 7.1E-03[b] | Portugal/C | Castanheira et al. (2010) |
| 1.1 | 2.1E-02 | 7.5E-03 | Italy/C | Penati et al. (2010) |
| 1.4[b] | – | – | Switzerland/C | Nemecek et al. (2011) |
| 5.4[c] | 1.4E-02[c] | 1.5E-02[c] | Peru- Highlands/C | Bartl et al. (2011) |
| 1.7[c] | 7.5E-03[c] | 4.8E-03[c] | Peru- Coast/C | Bartl et al. (2011) |
| 1.1[a] | 2.0E-02[a] | 7.8E-03[a] | Italy/C | study M3 |

Milk life cycle (per kg FPCM)

| GWP (kg $CO_2$ eq) | Acidification (kg $SO_2$ eq) | Eutrophication (kg $PO_4^{3-}$ eq) | Country[d] | Reference |
|---|---|---|---|---|
| 1.0[a] | 8.5E-03[a] | 5.3E-03[a] | Spain/C | Hospido et al. (2003) |
| 1.7[a] | – | – | U.S./O | Heller et al. (2008) |
| 1.2 | 8.9E-03 | 9.8E-03 | France/C | Kanyarushoki et al. (2008) |
| 1.3[a] | 2.1E-02[a] | 8.1E-03[a] | Italy/C | Study M3 |

[a] These results are given per litre of milk.
[b] These results are given per kg of milk.
[c] These results are given per kg ECM.
[d] C stands for Conventional; O stands for Organic.

(Fantin et al. 2012)

# LCA and mountain area

- The scenario of the alps has never been studied and considered in in the study of the LCA or carbon footprint. Therefore the aims of my Ph.D. are to investigate the environmental impact in mountain areas in terms of sustainability, resource consumption, procurement of feed (self-sufficiency), input / output, etc.

# Cow plus

Sampling of the dairy and dual purpose cows reared in mixed breed farms in Trentino and collecting all the data to estimate the environmental impact.

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PROVINCIA AUTONOMA DI TRENTO

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Ph.D. SCHOOL ANIMAL & FOOD SCIENCE
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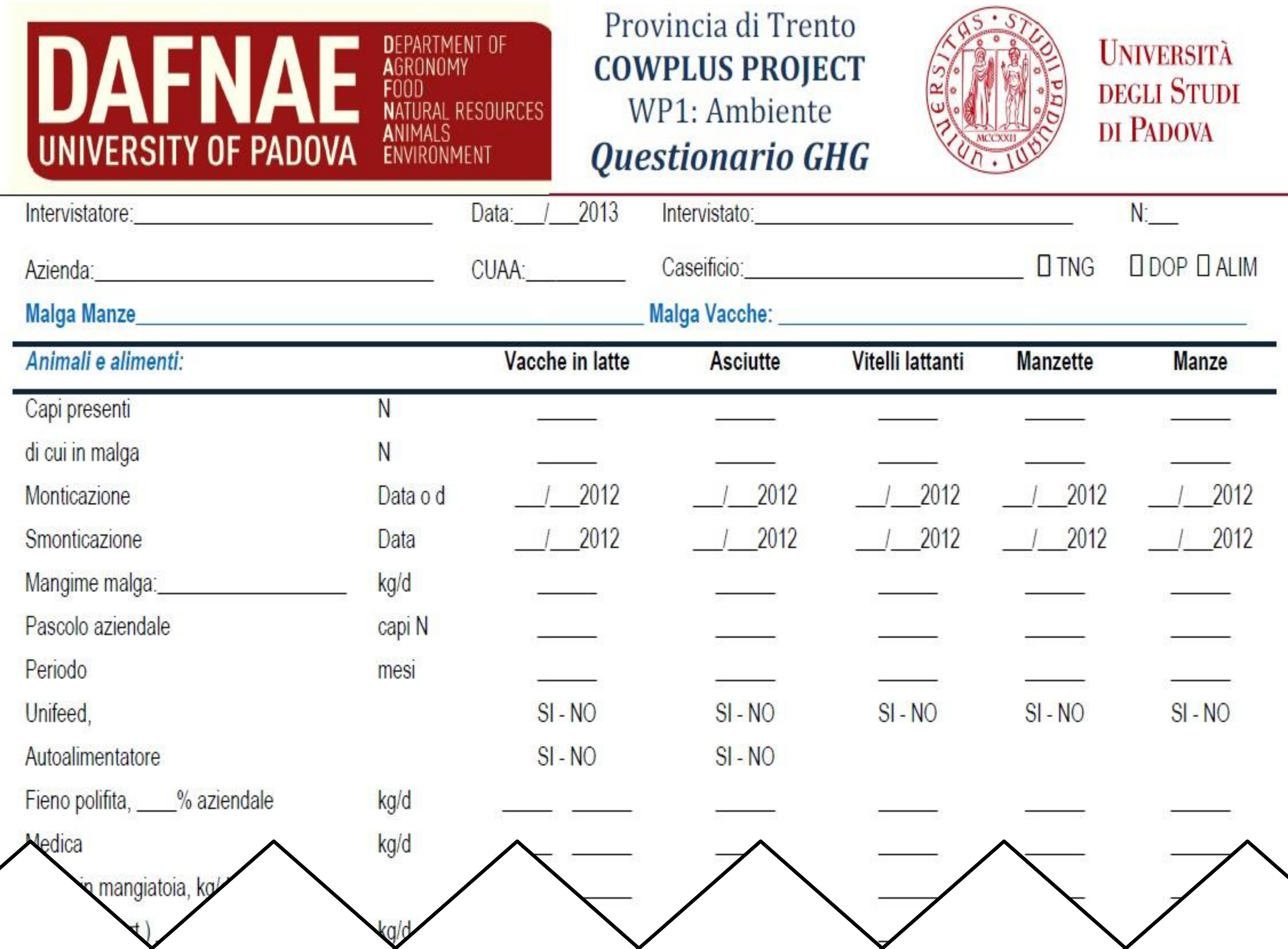

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Provincia di Trento
**COWPLUS PROJECT**
WP1: Ambiente
***Questionario GHG***

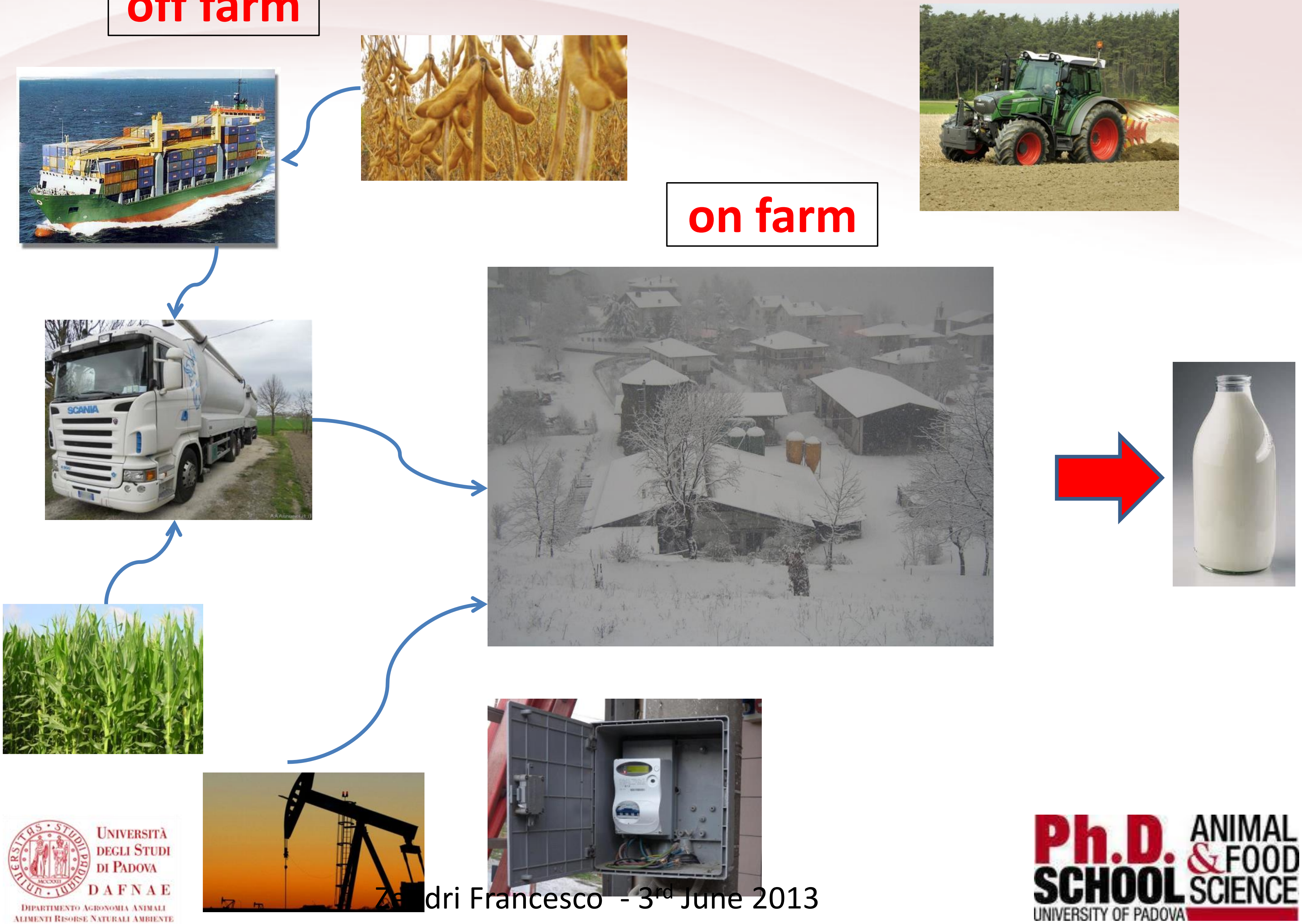
UNIVERSITÀ DEGLI STUDI DI PADOVA

Intervistatore:________________ Data:___/___2013 Intervistato:________________ N:___

Azienda:________________ CUAA:________ Caseificio:________________ ☐ TNG ☐ DOP ☐ ALIM

**Malga Manze**________________ **Malga Vacche:** ________________

| ***Animali e alimenti:*** | | **Vacche in latte** | **Asciutte** | **Vitelli lattanti** | **Manzette** | **Manze** |
|---|---|---|---|---|---|---|
| Capi presenti | N | _____ | _____ | _____ | _____ | _____ |
| di cui in malga | N | _____ | _____ | _____ | _____ | _____ |
| Monticazione | Data o d | __/__2012 | __/__2012 | __/__2012 | __/__2012 | __/__2012 |
| Smonticazione | Data | __/__2012 | __/__2012 | __/__2012 | __/__2012 | __/__2012 |
| Mangime malga:__________ | kg/d | _____ | _____ | _____ | _____ | _____ |
| Pascolo aziendale | capi N | _____ | _____ | _____ | _____ | _____ |
| Periodo | mesi | _____ | _____ | _____ | _____ | _____ |
| Unifeed, | | SI - NO | SI - NO | SI - NO | SI - NO | SI - NO |
| Autoalimentatore | | SI - NO | SI - NO | | | |
| Fieno polifita, ____% aziendale | kg/d | ____ _____ | _____ | _____ | _____ | _____ |
| Medica | kg/d | | | _____ | | _____ |
| in mangiatoia, kg/ | | | | _____ | | |
| t.) | kg/ | | | | | |



off farm

on farm

DEGLI STUDI
DI PADOVA
DAFNAE
DIPARTIMENTO AGRONOMIA ANIMALI
ALIMENTI RISORSE NATURALI AMBIENTE

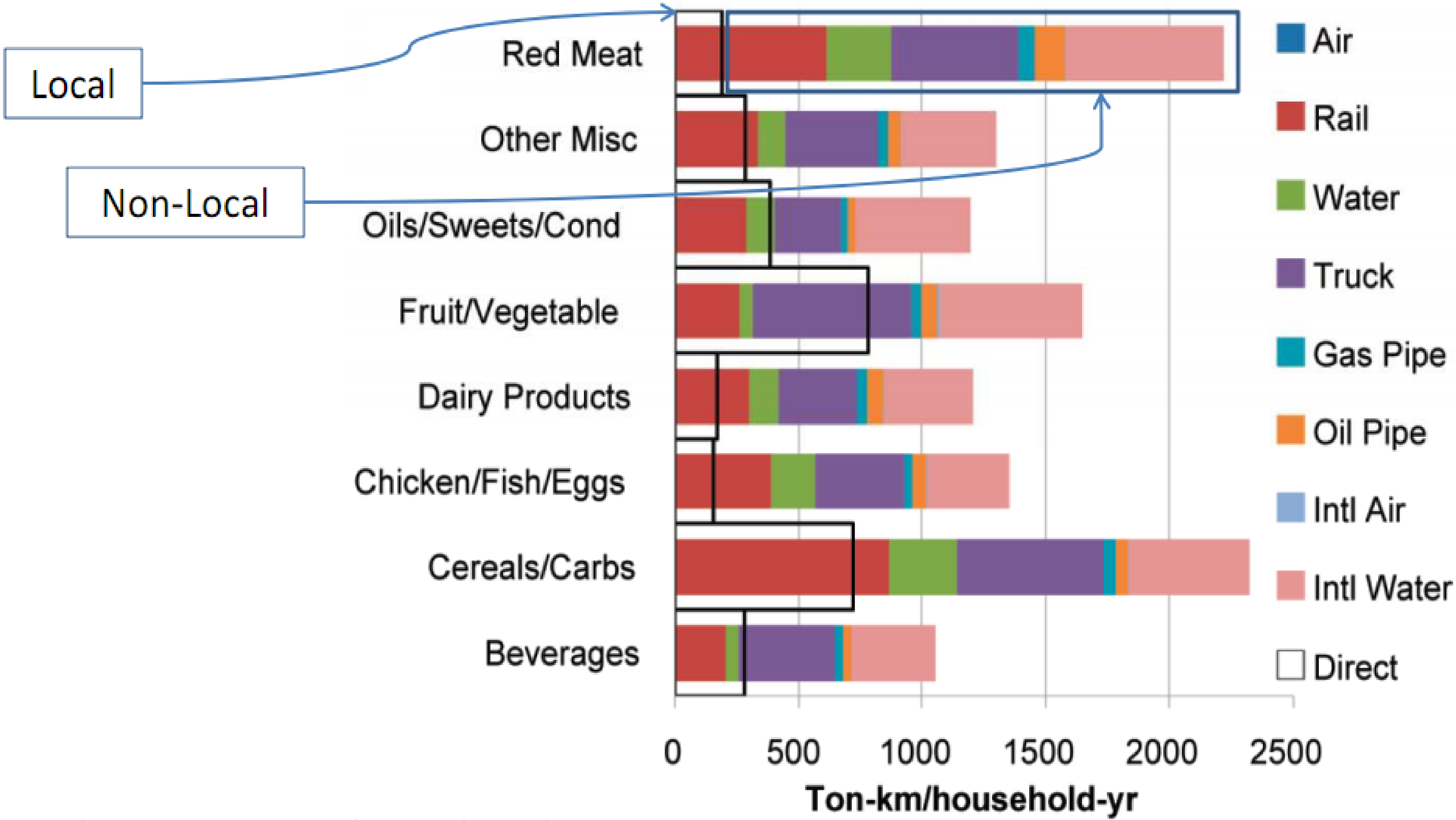
# Conclusions

Everyone can do something in terms of the environment, not only large farms or industries.

For example, consume local products (zero km), fruit and vegetables in season, slow food, etc.

Slow Food®

# Carbon Footprint of Food Choices in US

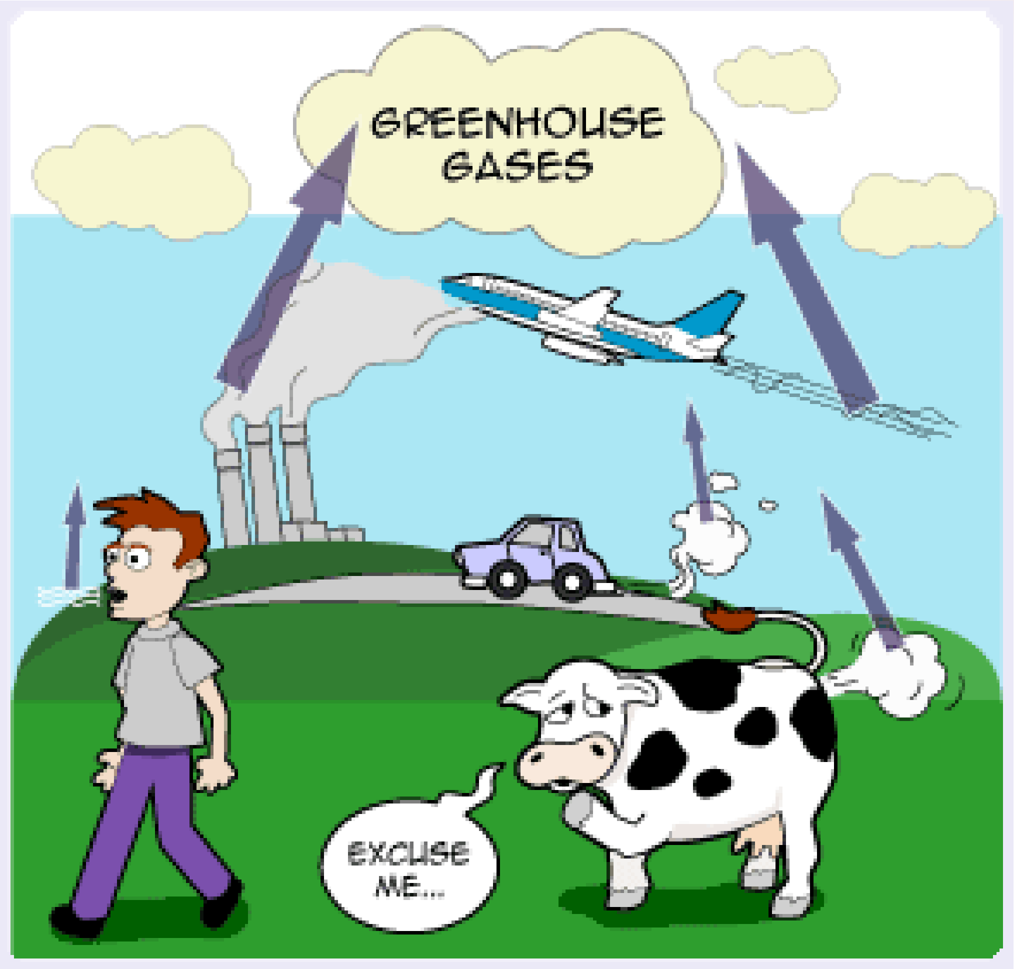


- Red meat is primarily produced non-locally
- Fruit/Vegetable is produced more locally

Total ton-kilometer of freight by mode per year per household

Weber and Matthews (2008)

# Thanks for your attention



Zendri Francesco - 3rd June 2013