Scottish Food Security Alliance Crops

climate change

Connecting climate science and policy in Scotland

UNIVERSITY OF ABERDEEN

Addressing the joint challenges of climate change and food security

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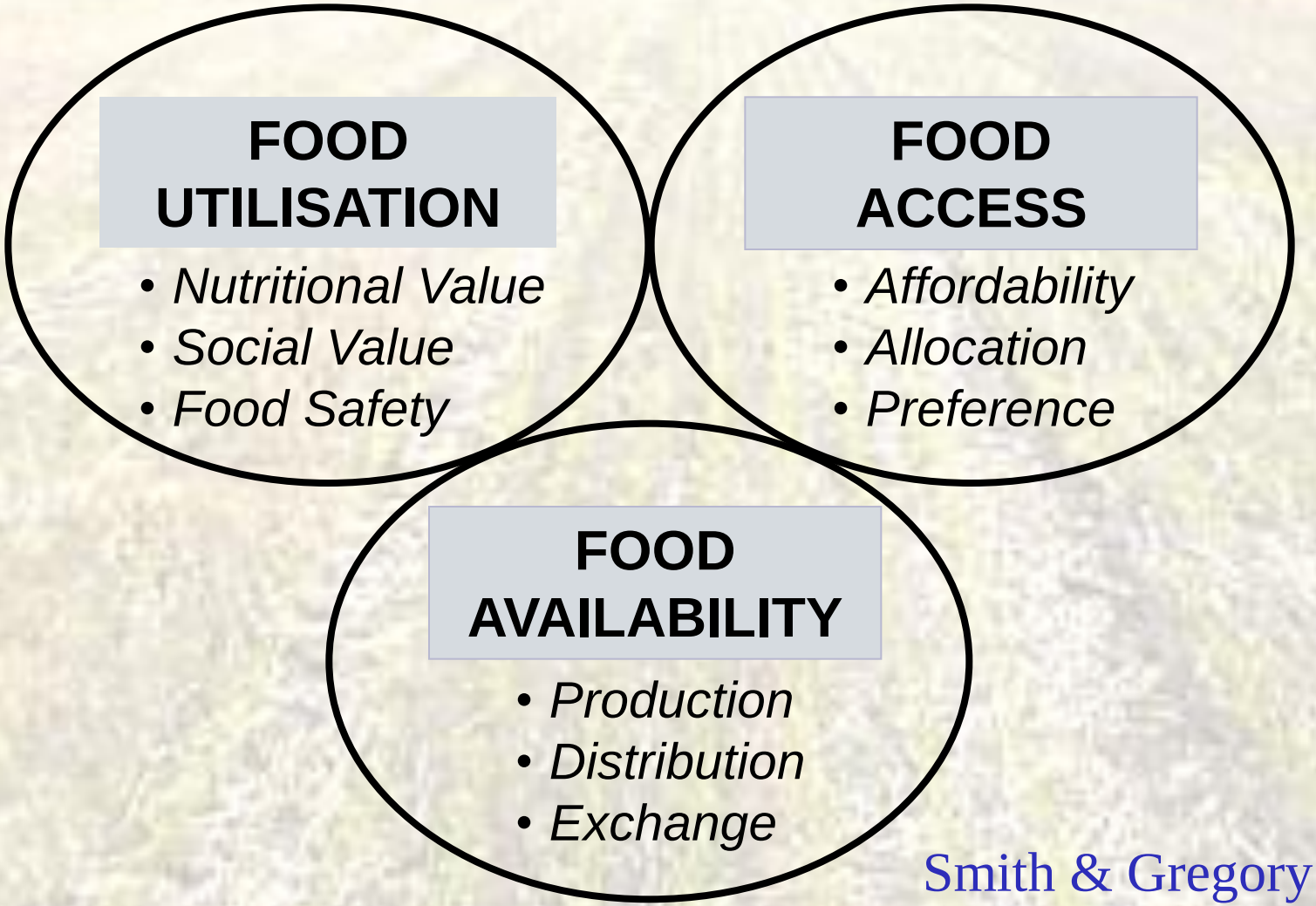
Food Security

"… exists when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life".

(definition from the 1996 World Food Summit)

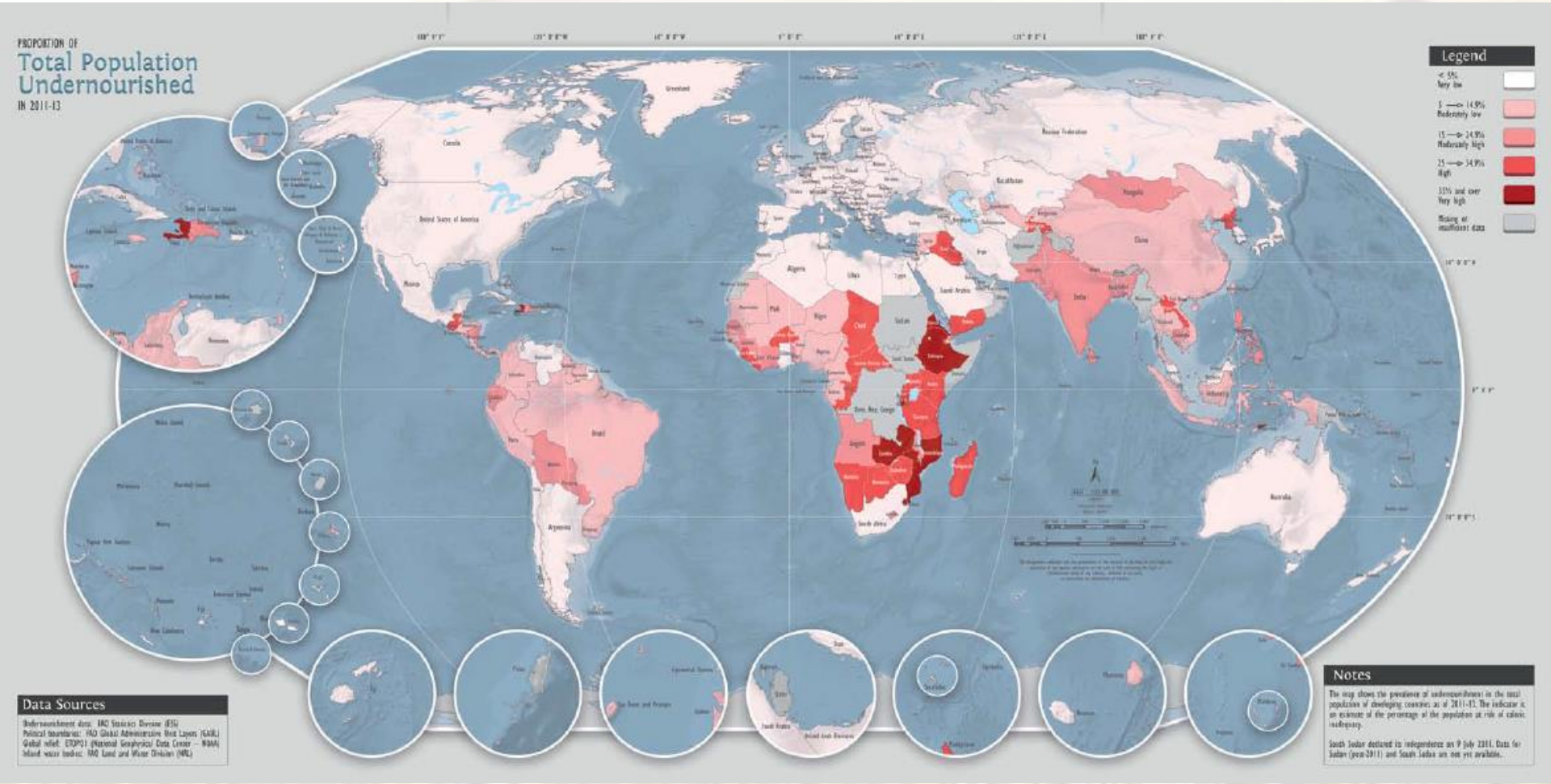
3 Components of Food Security

each with Key Elements



Smith & Gregory (2013)

World hunger



842 million people will go to bed hungry and undernourished tonight

FAO (2014)

Source: © 2005 PETER MENZ
PHOTOGRAPHY

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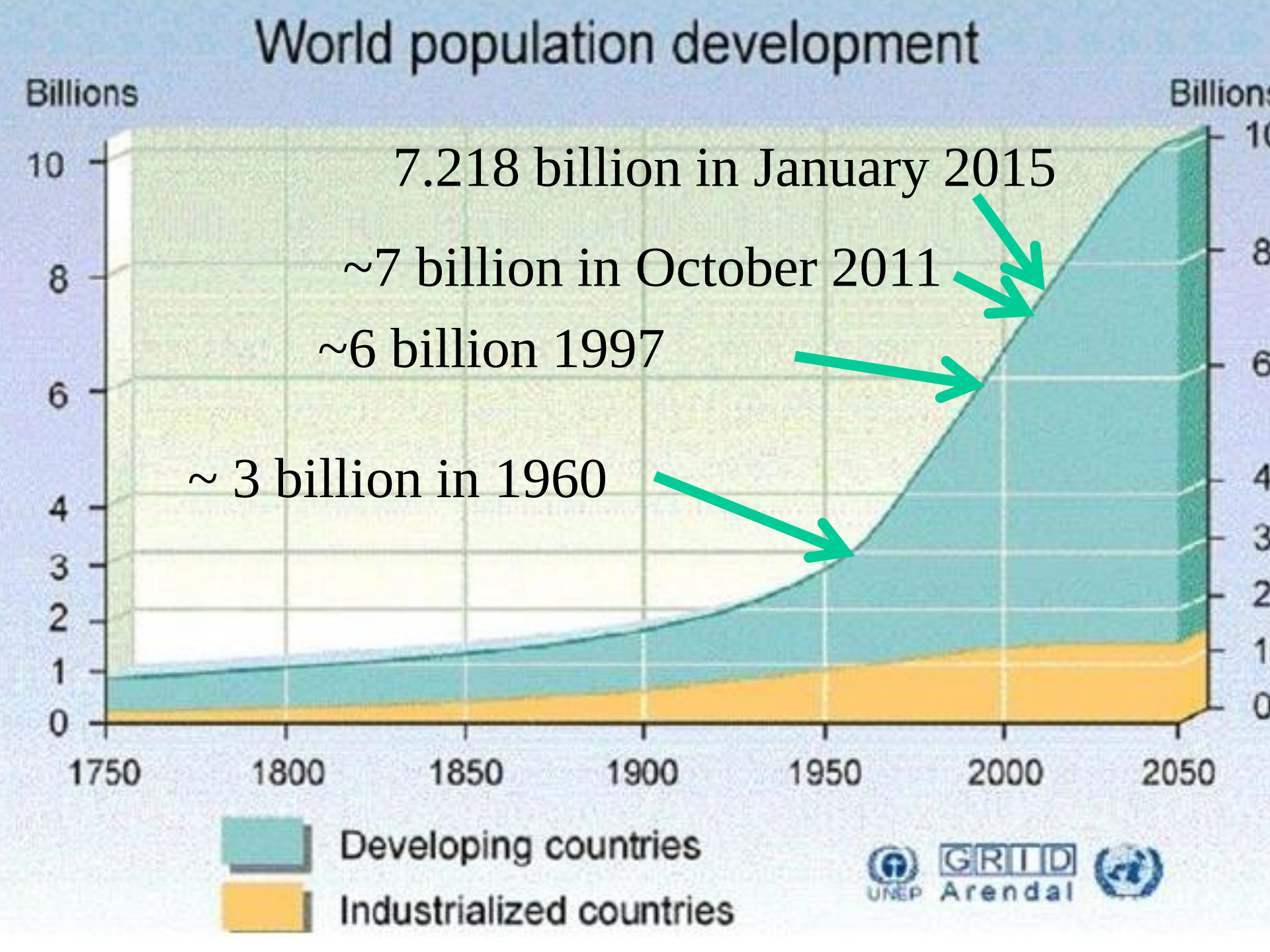
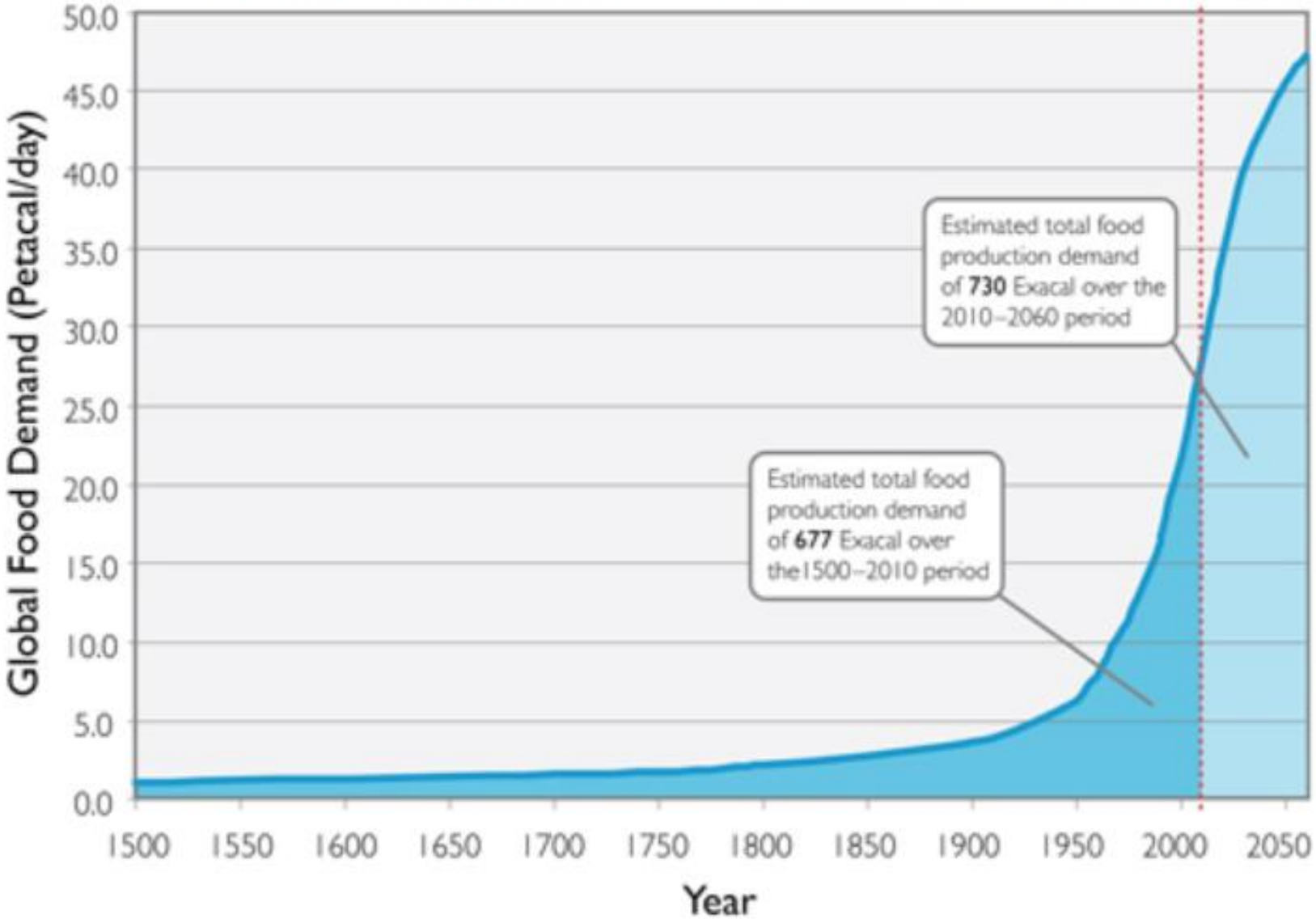
Population growth and dietary change

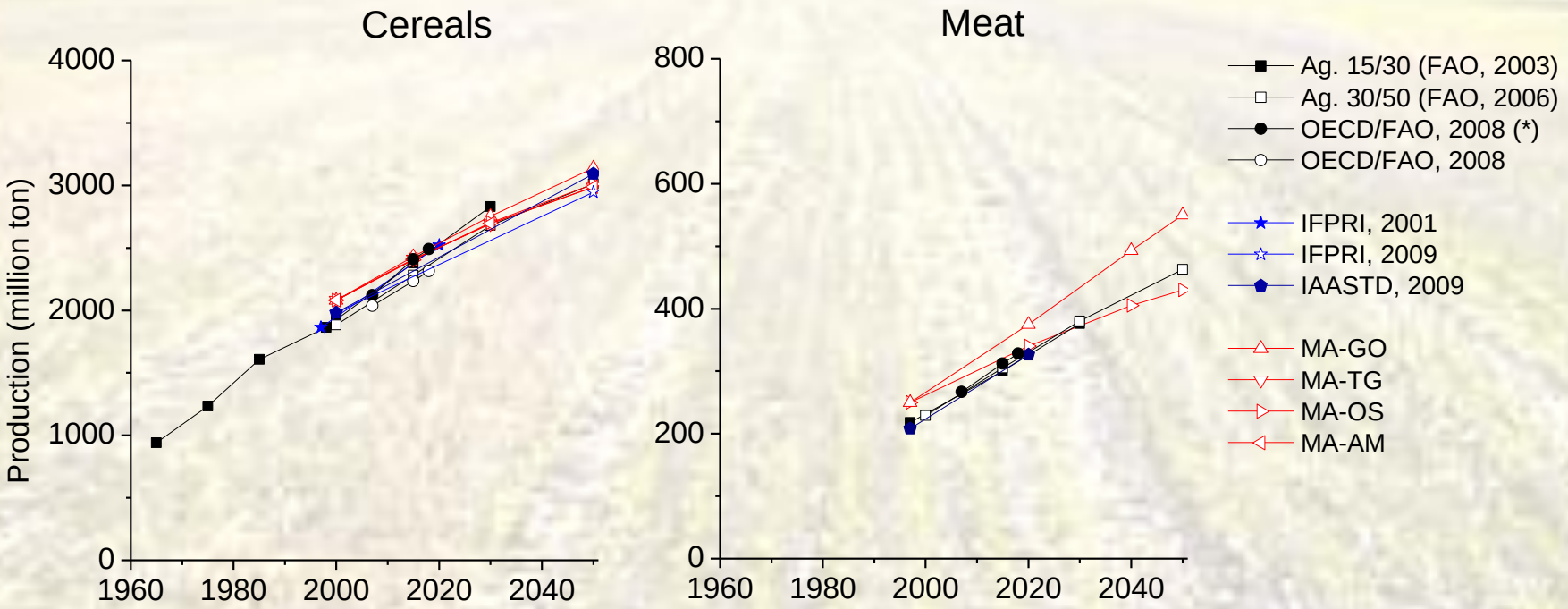

World population development
Billions
Billions
10
8
6
4
3
2
1
0
7.218 billion in January 2015
~7 billion in October 2011
~6 billion 1997
~ 3 billion in 1960
1750
1800
1850
1900
1950
2000
2050
Developing countries
Industrialized countries
UNEP
GRID
Arendal

The challenge to produce enough food will be greater over the next 50 years than in all human history



http://www.csiro.au/Portals/Multimedia/On-the-record/Sustainable-Agriculture-Feeding-the-World.aspx

Food demand increase

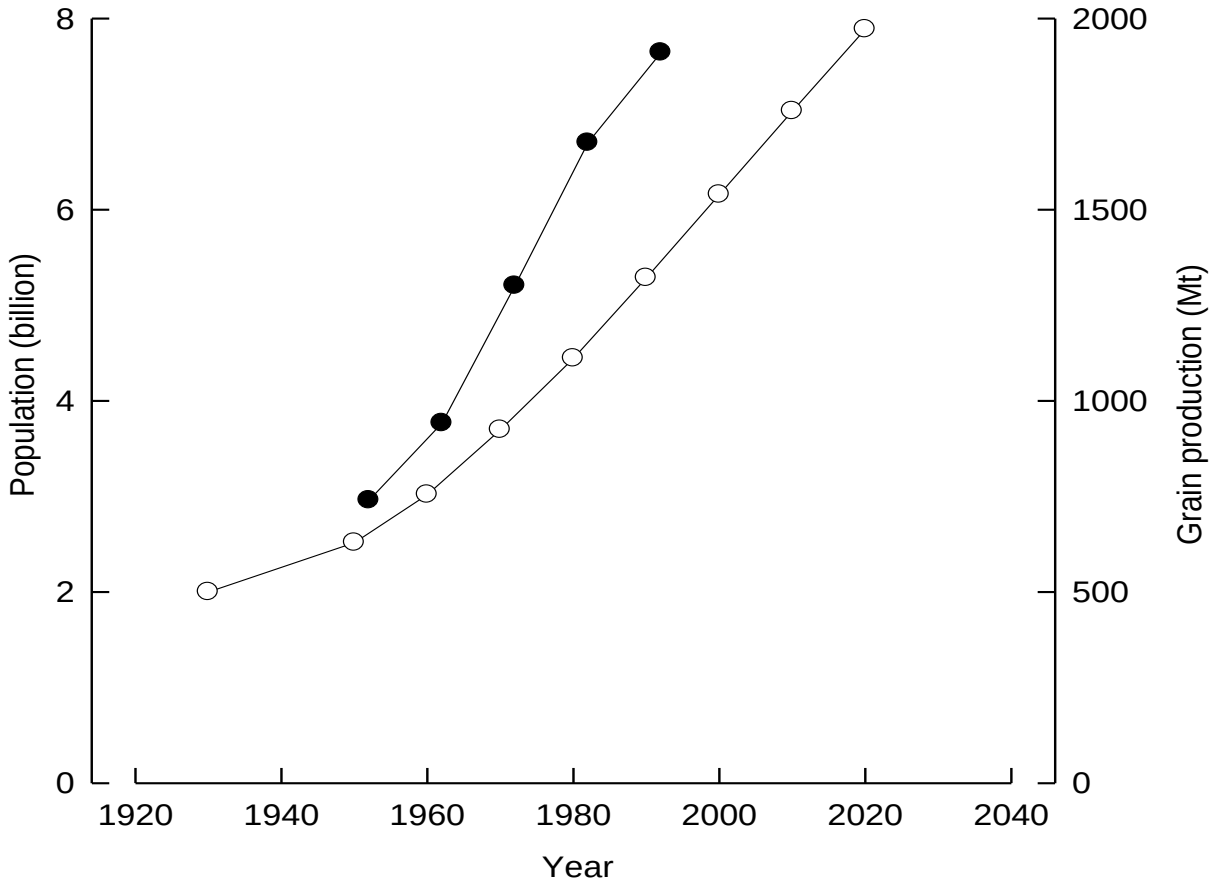


Developing country demand for livestock products projected to increase greatly over the next 40 years as the wealth gap between developed and developing countries reduces.

Smith et al. (2010)

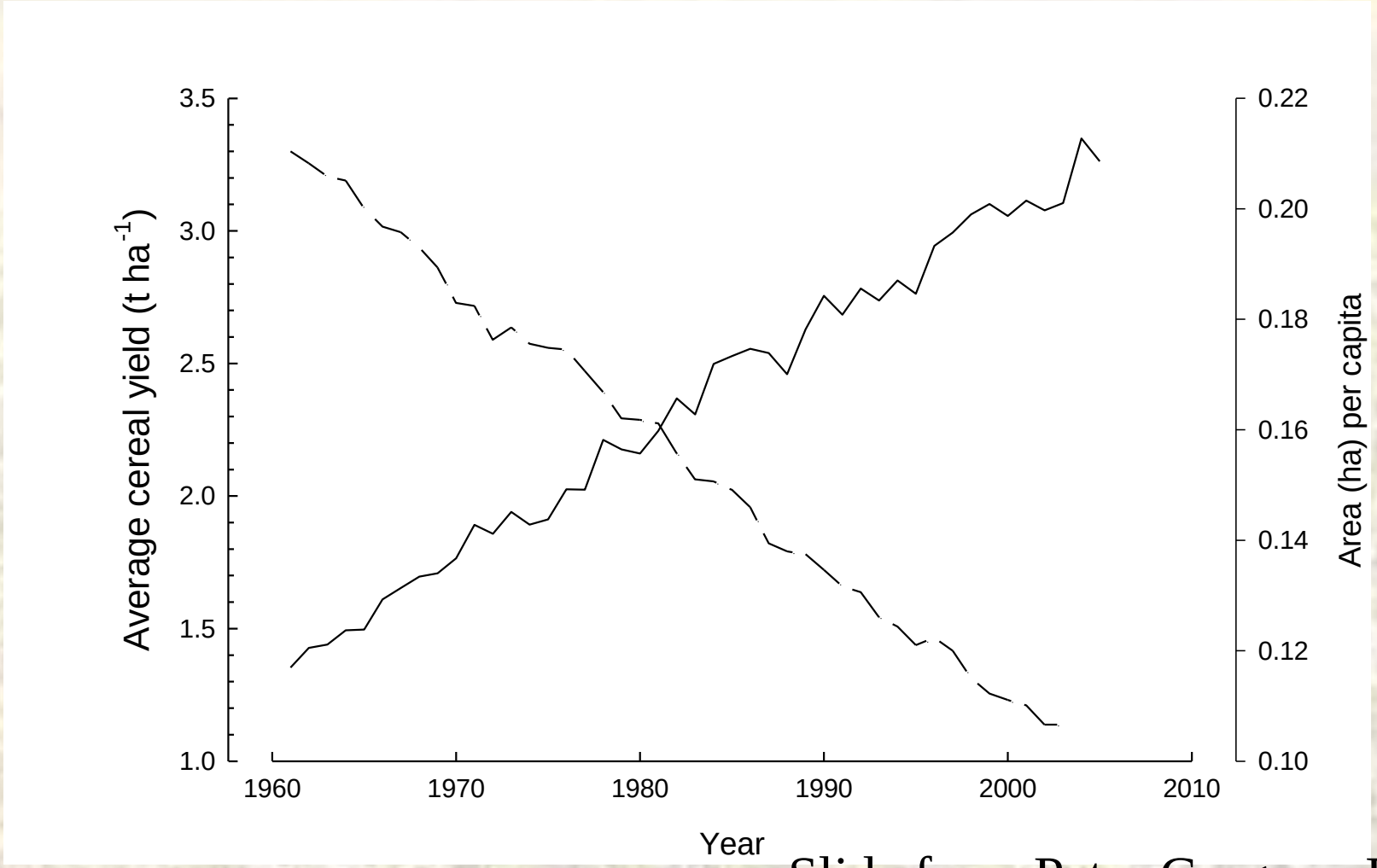
Recorded and projected population (o) and grain production (•)

(adapted from Dyson, 1996)



Slide from Peter Gregory, EMR

World cereal yield and area harvested per capita *(extended from Dyson, 1996)*



Slide from Peter Gregory, EMR

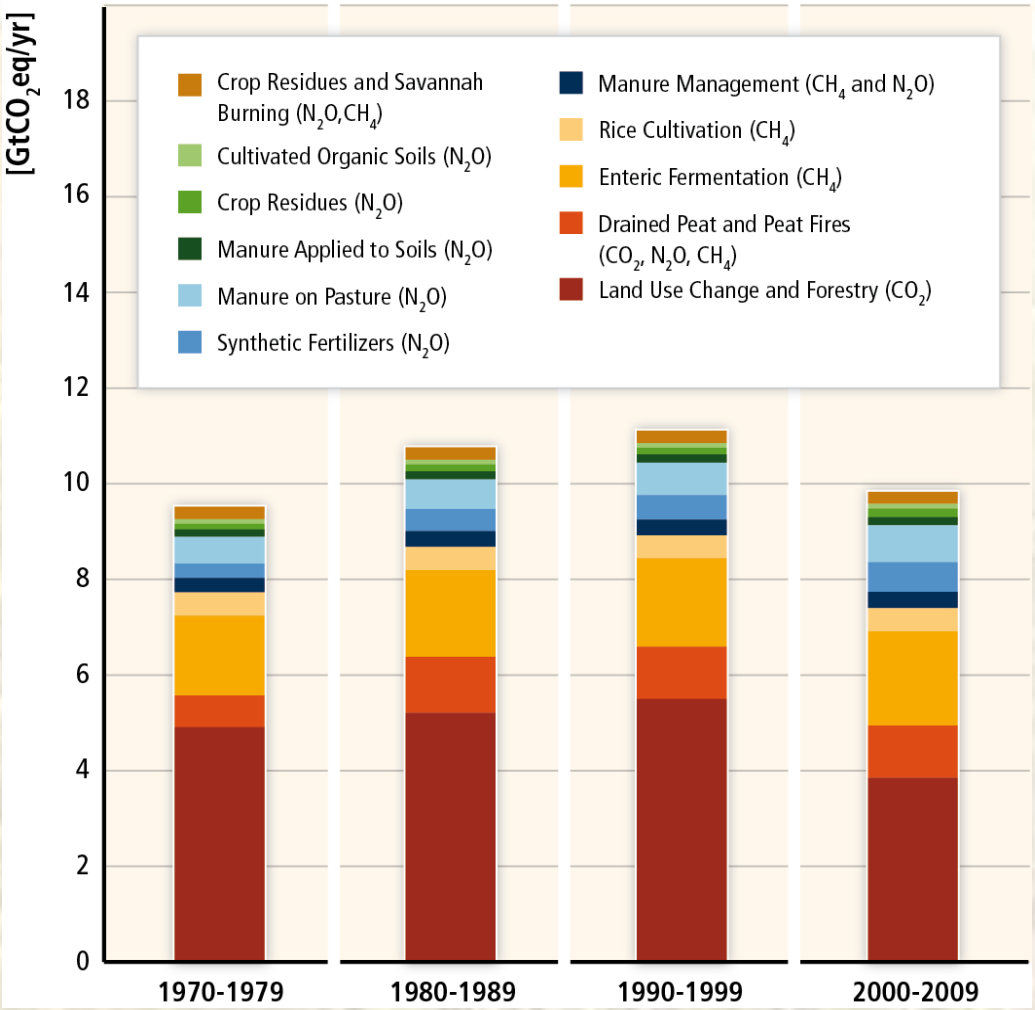
Productivity challenges for agriculture to 2050

- Need to increase per area productivity to avoid spreading agriculture on to other land (disastrous for GHG emissions, biodiversity and a range of other ecosystem services)
- Need to reduce inputs per unit product to minimise adverse environmental impacts
- Need to cope with future climate change

Smith (2013)

Agricultural GHG mitigation – supply-side measures

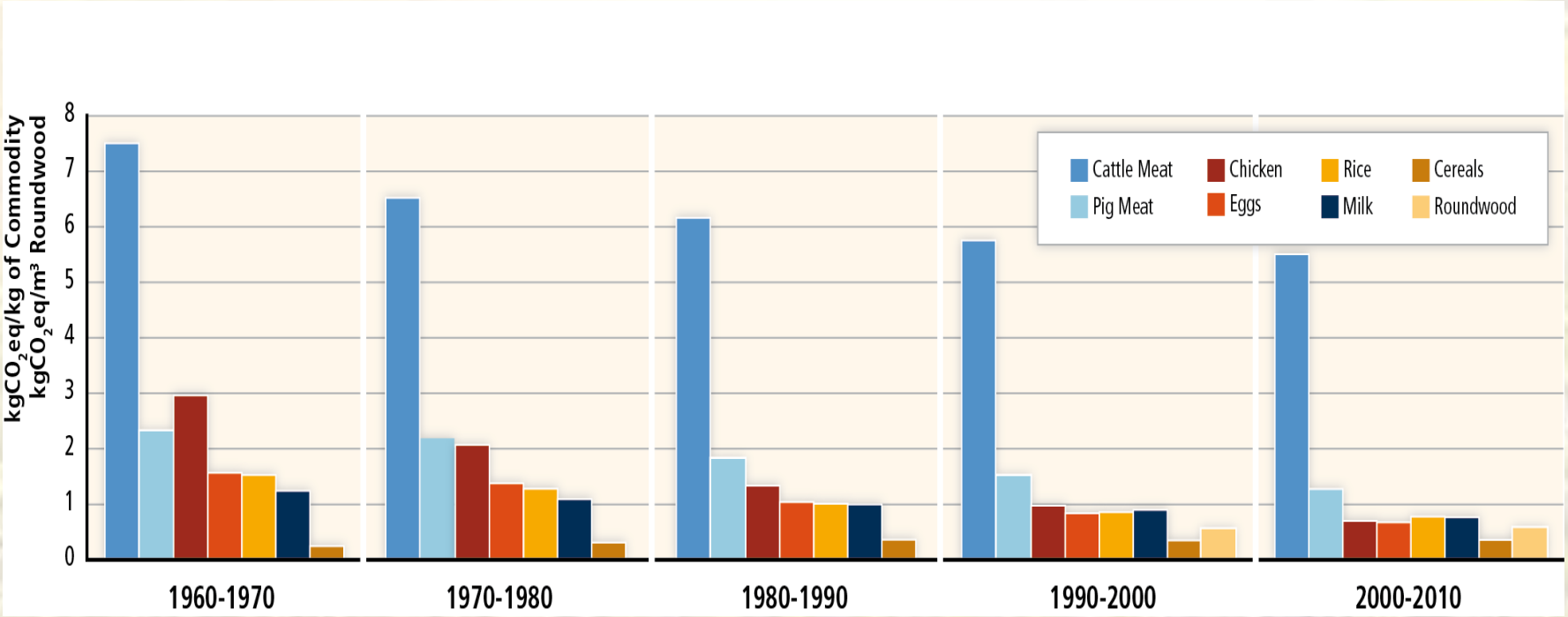
Agricultural emissions are increasing, but *net* forestry CO_2 emissions have fallen recently



- AFOLU accounts for 24% of total anthropogenic GHG emissions
- AFOLU is the only sector where net emissions fell in the most recent decade
- Whilst agricultural non-CO_2 GHG emissions increased, *net* CO_2 emissions fell, mainly due to decreasing deforestation, and increased afforestation rates

Smith *et al.* (2014) – IPCC WGIII AR5

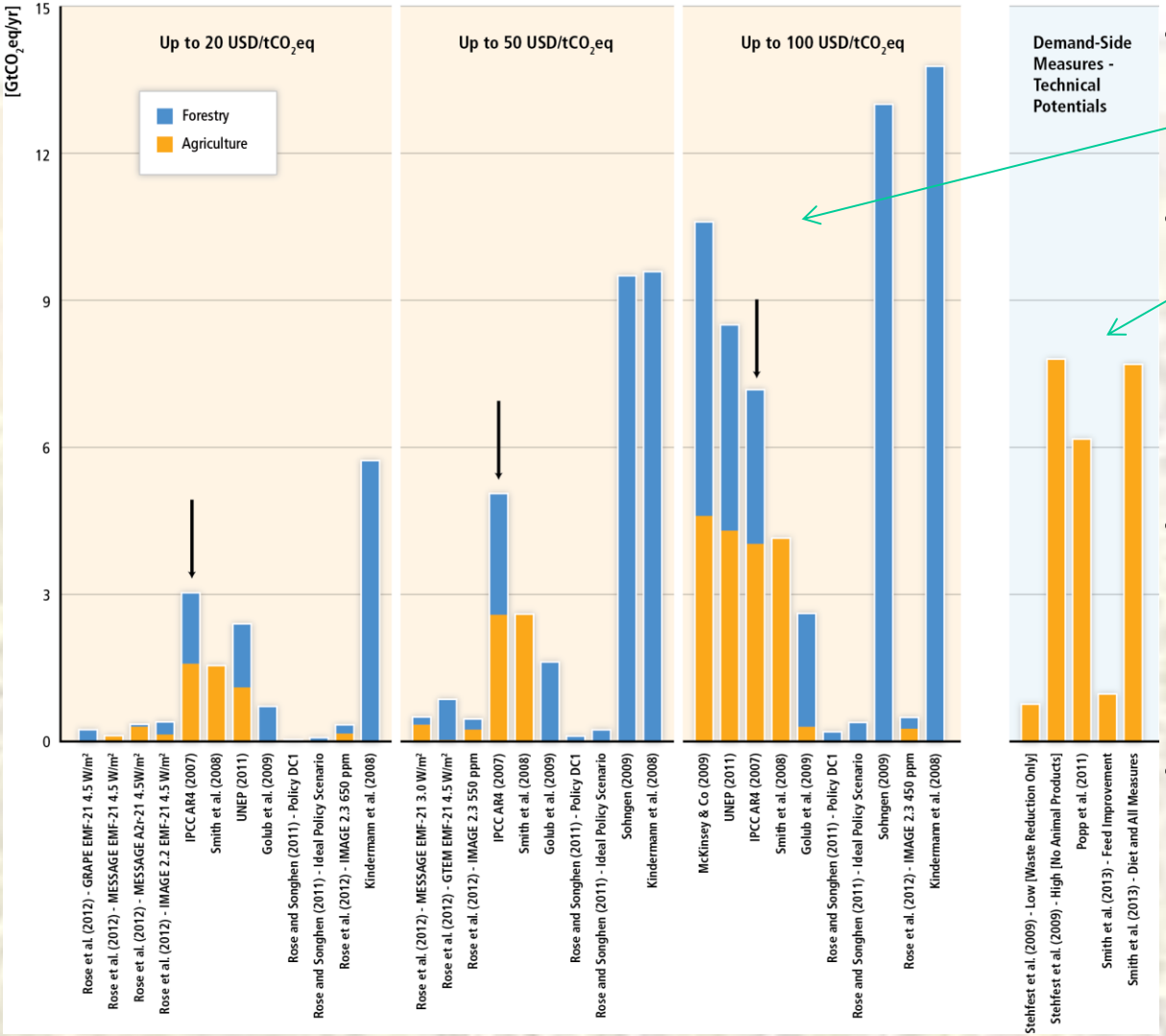
Emissions intensity of AFOLU products is falling as agriculture and forestry become more efficient



- Note that ruminant meat has a GHG intensity much higher than other agricultural products
- But also note that these are direct emissions only. If we include the emissions from the human-edible feed for mono-gastric animal products, they move closer to ruminant meat

Smith *et al.* (2014) – IPCC WGIII AR5

Demand- and supply-side measures need to be considered

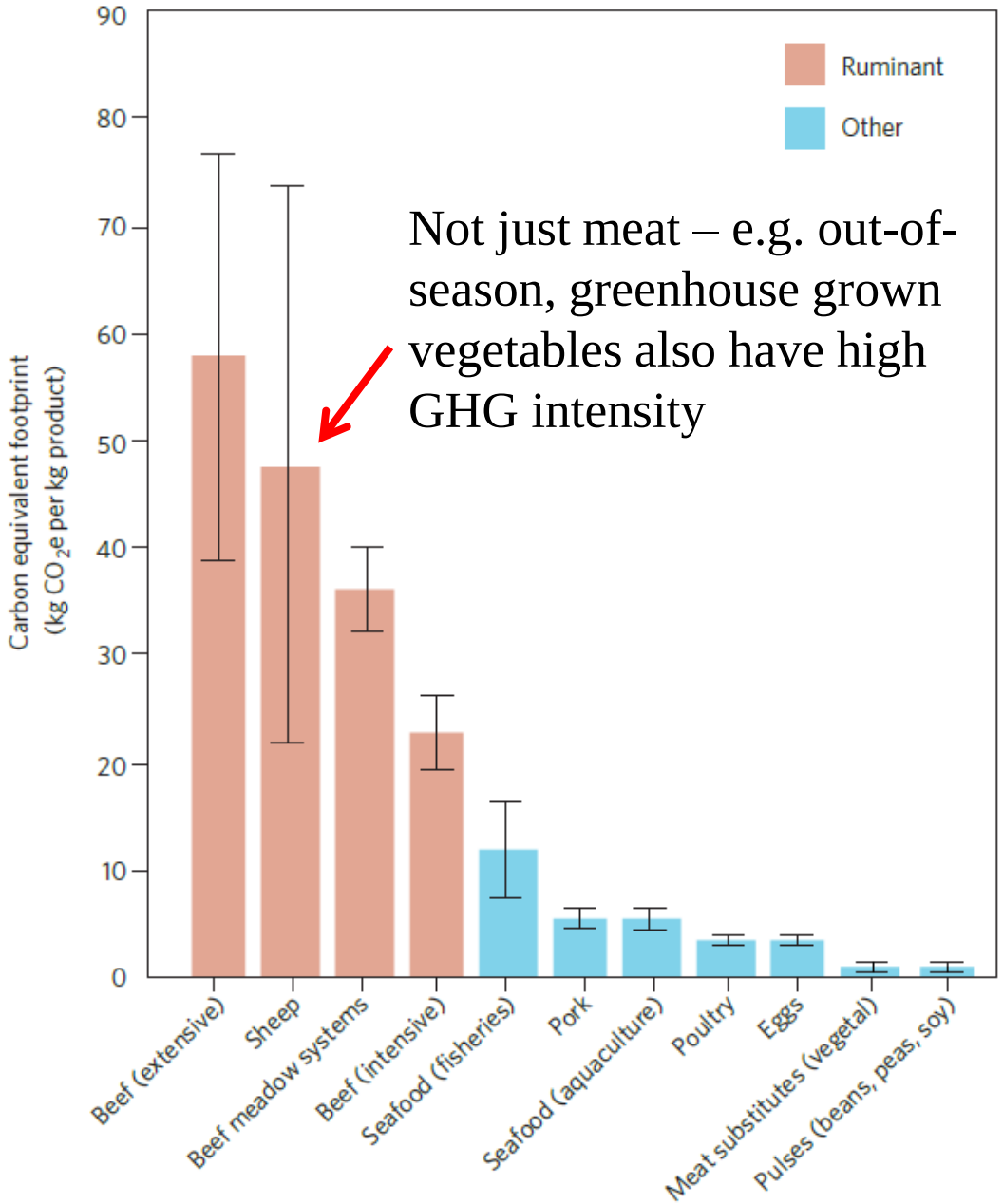


- Supply-side measures in the AFOLU sector are large & cost-competitive
- Demand-side measures such as dietary change and waste reduction also have large, but uncertain, mitigation
- Demand-side measures may be difficult to implement, but are worthy of further research
- Other options in the AFOLU sector include bioenergy

Smith *et al.* (2014) – IPCC WGIII AR5

Agricultural GHG mitigation – demand-side measures

Big differences in the GHG intensity of different foods



Not just meat – e.g. out-of-season, greenhouse grown vegetables also have high GHG intensity

Ripple *et al.*(2014)

Changed consumption patterns

Table 3 Description of the reference scenario and the four dietary variants

Variant	Description
Reference	Agricultural production for 2000–2030 (Bruinsma 2003) and 2030–2050 (FAO 2006). The 2000–2030 projections are country-scale and aggregated to the 24 world regions of the IMAGE model. The projections for 2030–2050 have a continental scale
No Ruminant Meat (NoRM)	As reference, but with complete substitution of proteins from ruminant meat (cattle, buffaloes, sheep and goats) by plant-proteins, starting in 2010 and completed by 2030. By-products such as wool and leather are also assumed to be substituted by other materials
No Meat (NoM)	As NoRM, with additional substitution of white meat (pork, poultry) by plant proteins, starting in 2010 and completed by 2030
No Animal Products (NoAP)	As NoM, with additional substitution of milk and eggs by plant proteins, starting in 2010 and completed by 2030
Healthy Diet (HDiet)	"Healthy Eating" recommendations from the Harvard Medical School (Willett 2001) implemented globally for meat and eggs, starting in 2010 and completed by 2030. See also Table 4

Fewer animal products in global diet allows everyone to be fed, and land is available for energy and nature conservation

Land based GHG emissions:

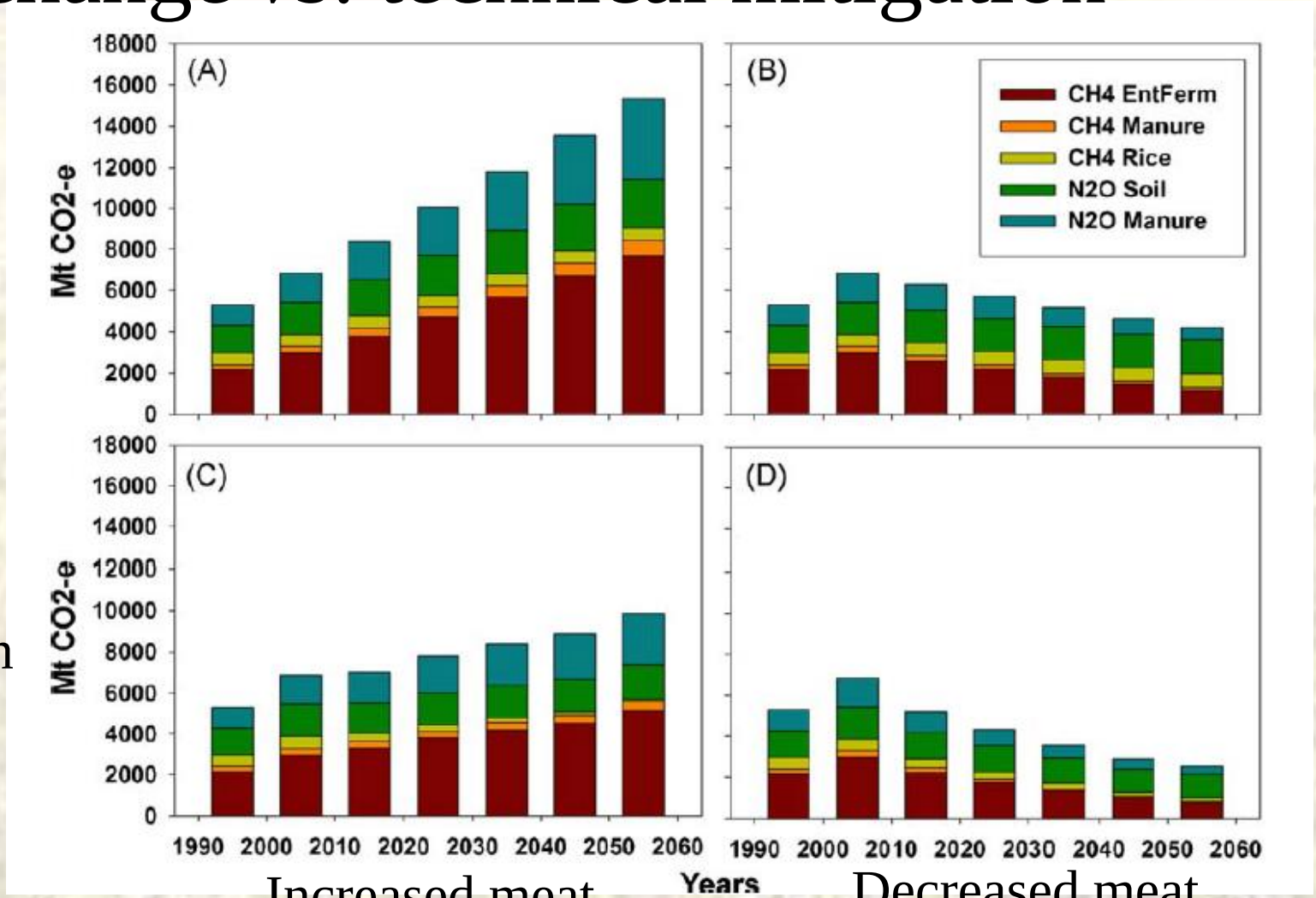
	GtC eq.
2000	3.0
2050-Reference	3.3
2050-NoRM	1.7
2050-NoM	1.5
2050-NoAP	1.1
2050-HDiet	2.1

Stehfest *et al.* (2009)

Reducing GHG emissions – dietary change *vs*. technical mitigation

Without technical mitigation

With technical mitigation



Increased meat

Decreased meat

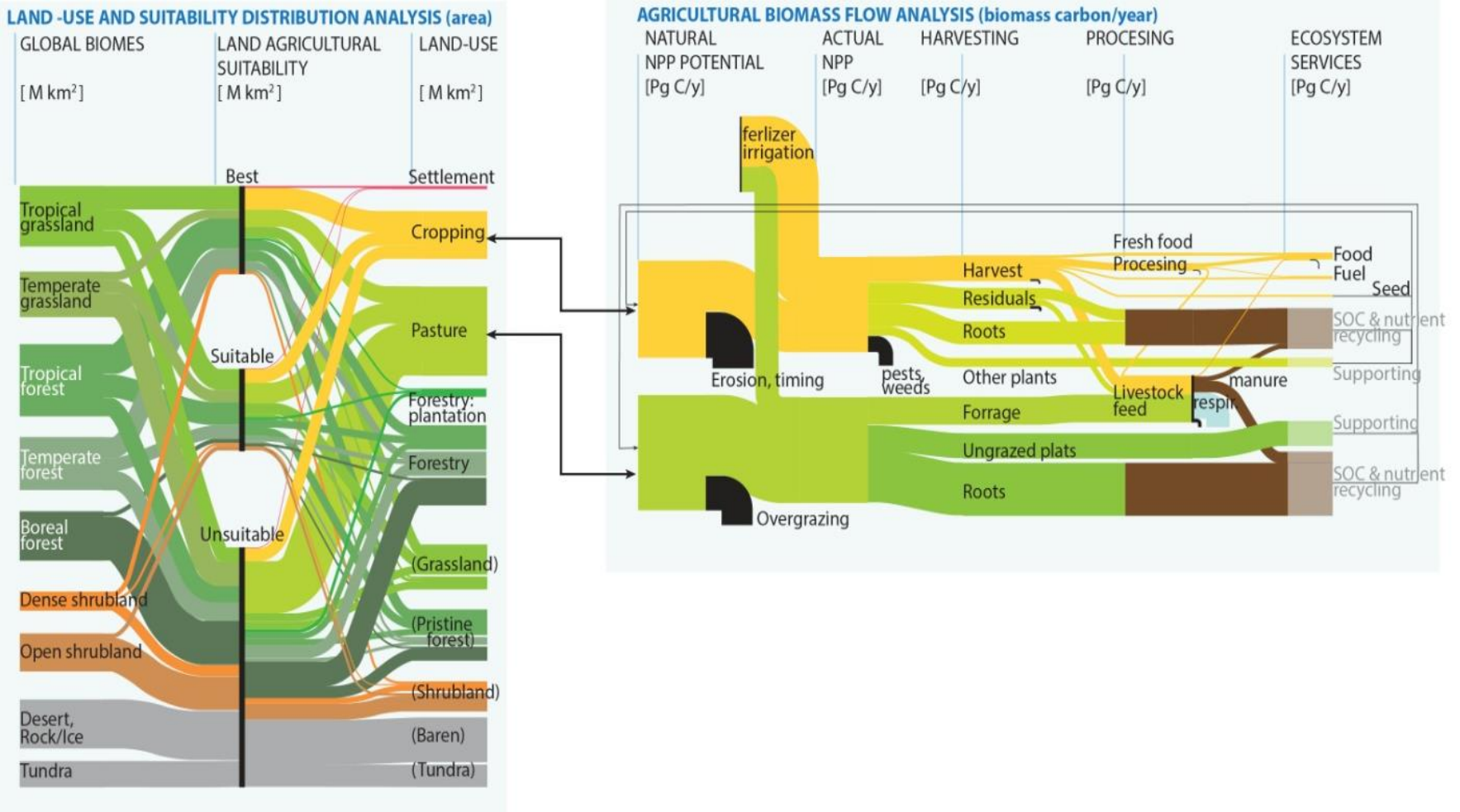
Popp *et al.* (2011)

Food demand must be managed because sustainable intensification alone will not suffice

Scenarios	Yields		Demand side reduction measures:	
	Current trends in yields	Yield gap closures (sustainable intensification)	50% Food waste reduction	Healthy diets
CT1	x			
CT2	x		x	
CT3	x		x	x
YG1		x		
YG2		x	x	
YG3		x	x	x

Bajželj *et al.* (2014) Nature CC

Food demand must be managed because sustainable intensification alone will not suffice



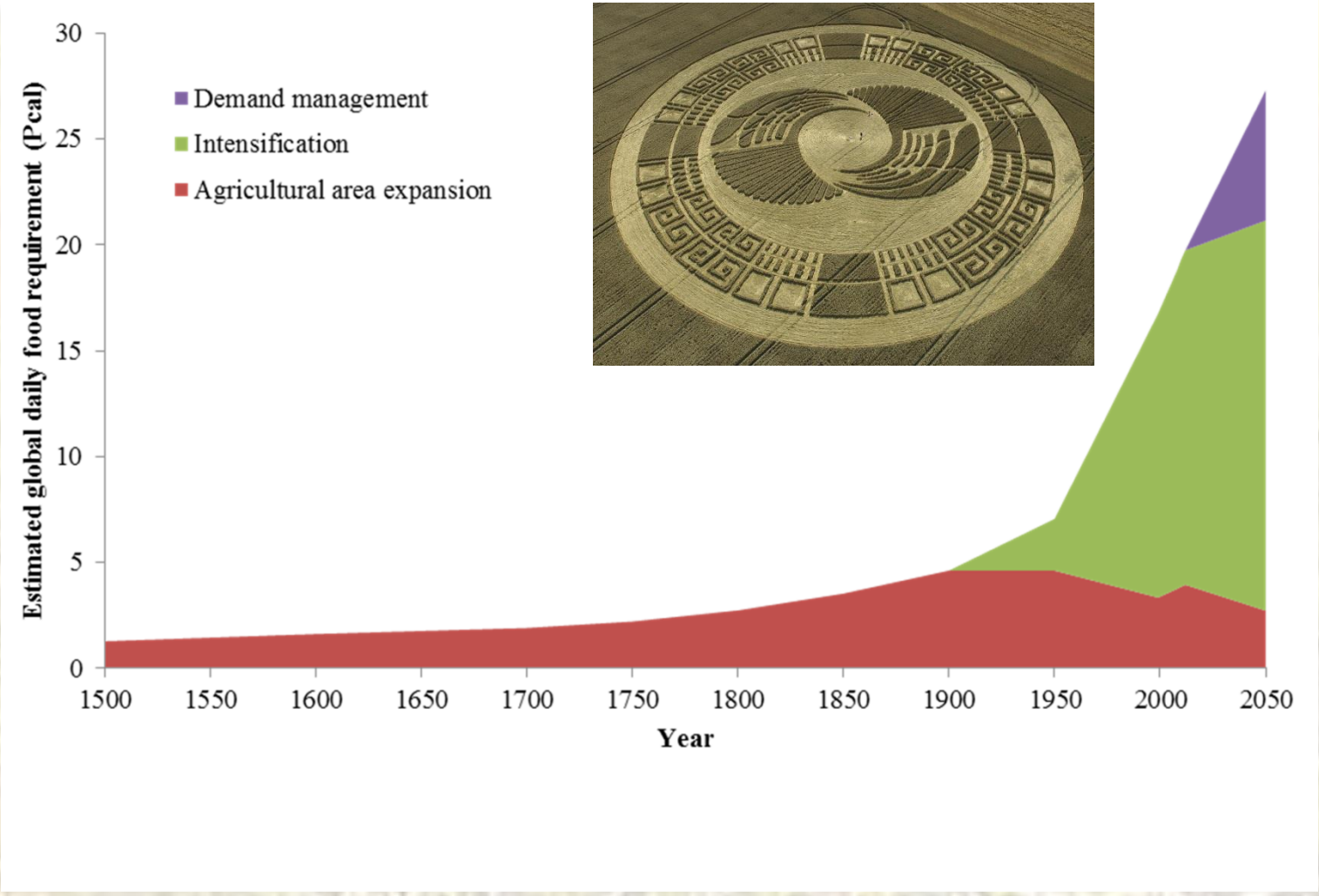
Bajželj *et al.* (2014) Nature CC

Food demand must be managed because sustainable intensification alone will not suffice

			Current yield trend				Yield gap closure only				Yield gap closure + demand options			
	units	2009*	CT1		CT2		CT3		YG1		YG2		YG3	
Cropland	Mkm^2	15.6	22.5	(+44%)	18.7	(+20%)	17.6	(+12%)	18.2	(+16%)	16.0	(+2%)	14.6	(-6%)
Pasture	Mkm^2	32.8	35.2	(+7%)	32.6	(-1%)	26.8	(-18%)	36.0	(+10%)	33.1	(+1%)	27.1	(-17%)
Net Forest cover	Mkm^2	26.1	23.1	(-12%)	24.7	(-6%)	26.1	(+0%)	24.2	(-7%)	25.6	(-2%)	27.1	(+4%)
Tropical Pristine Forests	Mkm^2	7.9	7.2	(-9%)	7.4	(-7%)	7.4	(-6%)	7.4	(-6%)	7.6	(-4%)	7.6	(-4%)
Total GHG emissions	$GtCO_2/y$	13.5	22.2	(+64%)	16.1	(+20%)	11.7	(-13%)	19.2	(+42%)	15.0	(+11%)	10.2	(-25%)
Carbon sink potential	$GtCO_2/y$	14.7	14.5	(-1%)	14.6	(-0%)	14.8	(+0%)	14.6	(-1%)	14.7	(+0%)	14.7	(+0%)
Fertiliser use	Mt/y	103	166	(+61%)	136	(+32%)	125	(+22%)	226	(+120%)	196	(+90%)	175	(+70%)
Irrigation water use	km^3/y	2889	6496	(+125%)	5328	(+84%)	5075	(+76%)	5051	(+75%)	4413	(+53%)	4157	(+44%)

Bajželj *et al.* (2014) Nature CC

How will food demand be met in future?



Smith (2014b)

Other papers arriving at similar conclusions……

ARTICLE

doi:10.1038/nature13959

Global diets link environmental sustainability and human health

David Tilman[1,2] & Michael Clark[1]

Diets link environmental and human health. Rising incomes and urbanization are driving a global dietary transition in which traditional diets are replaced by diets higher in refined sugars, refined fats, oils and meats. By 2050 these dietary trends, if unchecked, would be a major contributor to an estimated 80 per cent increase in global agricultural greenhouse gas emissions from food production and to global land clearing. Moreover, these dietary shifts are greatly increasing the incidence of type II diabetes, coronary heart disease and other chronic non-communicable diseases that lower global life expectancies. Alternative diets that offer substantial health benefits could, if widely adopted, reduce global agricultural greenhouse gas emissions, reduce land clearing and resultant species extinctions, and help prevent such diet-related chronic non-communicable diseases. The implementation of dietary solutions to the tightly linked diet–environment–health trilemma is a global challenge, and opportunity, of great environmental and public health importance.

Taxes on food by GHG emissions?

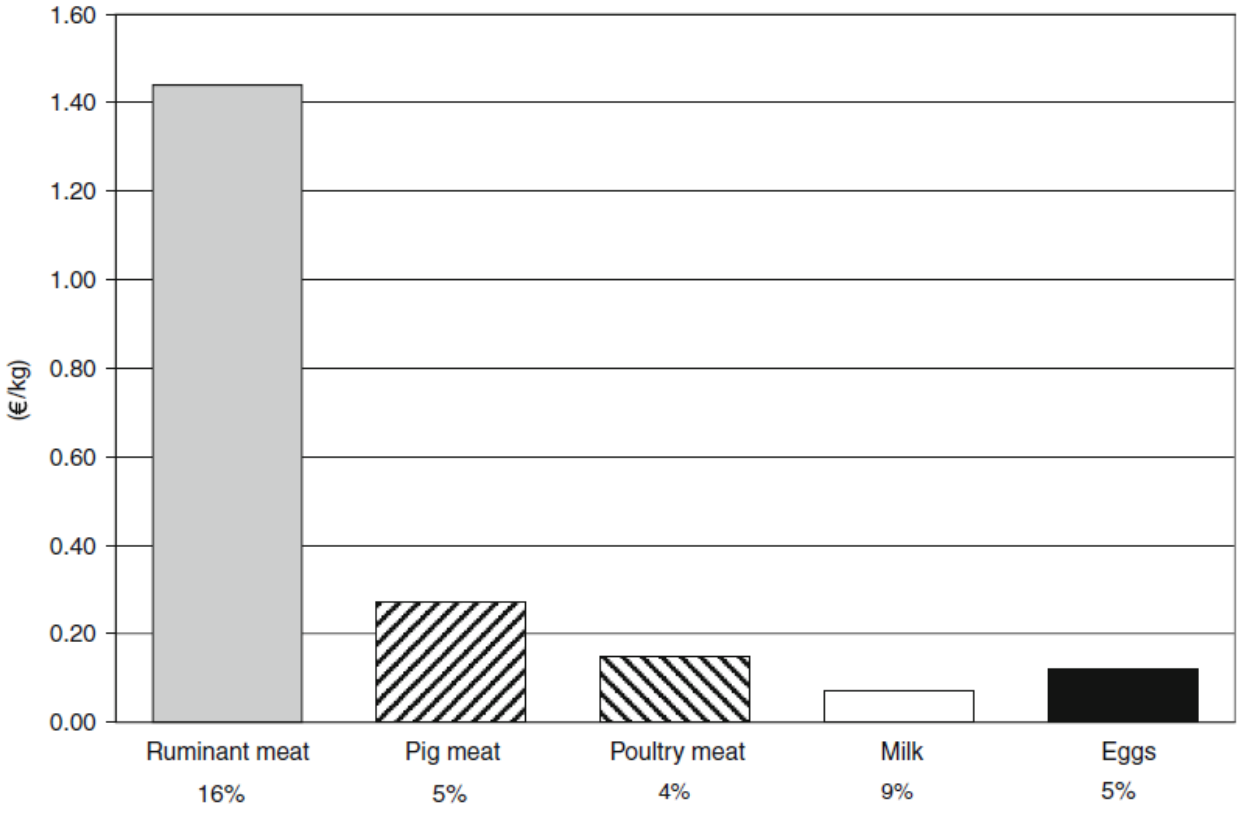


Fig. 9 Taxes per kg (fresh weight) food product for GHG weighted consumption taxes on animal food equivalent to €60 per ton CO_2-eq. *Percentages on top of bars* show the corresponding relative increase in consumer price

Wirsenius *et al.* (2011)

Other aspects to consider

- Not all grassland is suitable for conversion to cropland (too wet/dry) – best way to get human edible food from this land is *via* ruminants. But concentrate feed must be reduced
- Food is immensely socially and culturally important – deeply embedded in all cultures and self-identities
- Resistance to interference in personal choice – could be political suicide!
- Resistance from the meat, livestock and dairy industries – and e.g. organic movement
- Food taxes are a blunt instrument and lead to a range of other issues (e.g. food access / social justice / equity)
- Greenhouse gases are not the only relevant measure of sustainability
- Opportunity for high-quality, grass fed beef/lamb to fill a niche as a more occasional, luxury product (with high premium)

Conclusions

- We can feed 9-10 billion people
- Food supply needs to be increased whilst reducing environmental impact of agriculture
- Need to find options and policies that co-deliver improved food security and improved environmental outcomes
- Some promising supply-side measures (e.g. efficiency improvements) improve food security and reduce environmental impact
- Demand-side measures (e.g. changing diets, waste reduction) are under-researched, for food security and for potential to reduce environmental impact
- We need to change consumption patterns (demand-side measures) – techno-fixes are not enough to make the necessary changes

Smith (2014a)

Implications for policy

- Supply-side measures should be implemented immediately with focus on sustainable intensification
- Demand-side measures – it will take time for behaviour change to occur - policy should be introduced quickly, and should aim to co-deliver to other policy agendas
- Joined-up policy to address multiple objectives is required now more than ever.

Smith (2014)

Thank you for your attention