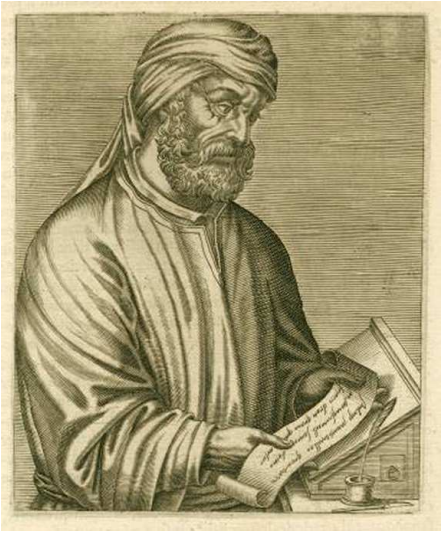
Four Scenarios for How to Feed the World in 2050

By Prof Dr Peer Ederer

Who is right ?



The scourges of pestilence, famine, wars, and earthquakes have come to be regarded a blessing to overcrowded nations, since they serve to prune away the luxuriant growth of the human race

Tertullian, Historian of Roman Republic AD 209

Men make history and not the other way around. In periods where there is no leadership, society stands still. Progress occurs when courageous, skillful leaders seize the opportunity to change things for the better

Harry S Truman, President USA 1945 – 1953

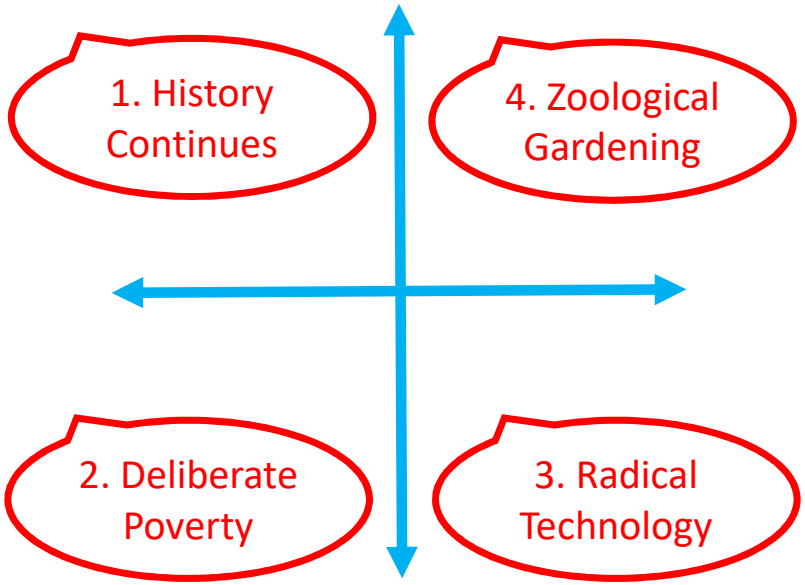
CEIBS

Rates of Innovation (X) and Land Utilization (Y) Create Four Global Food Scenarios for 2050

INcrease
Global Ag Land by 10%*

* This is the same expansion as since the year 1960 according to FAO-Data

Innovation Proceeds at Current Pace



Innovation Speed Doubles

DEcrease
Global Ag Land by 10%

CEIBS

Source: Ederer et al, CEIBS / Wageningen University and Research

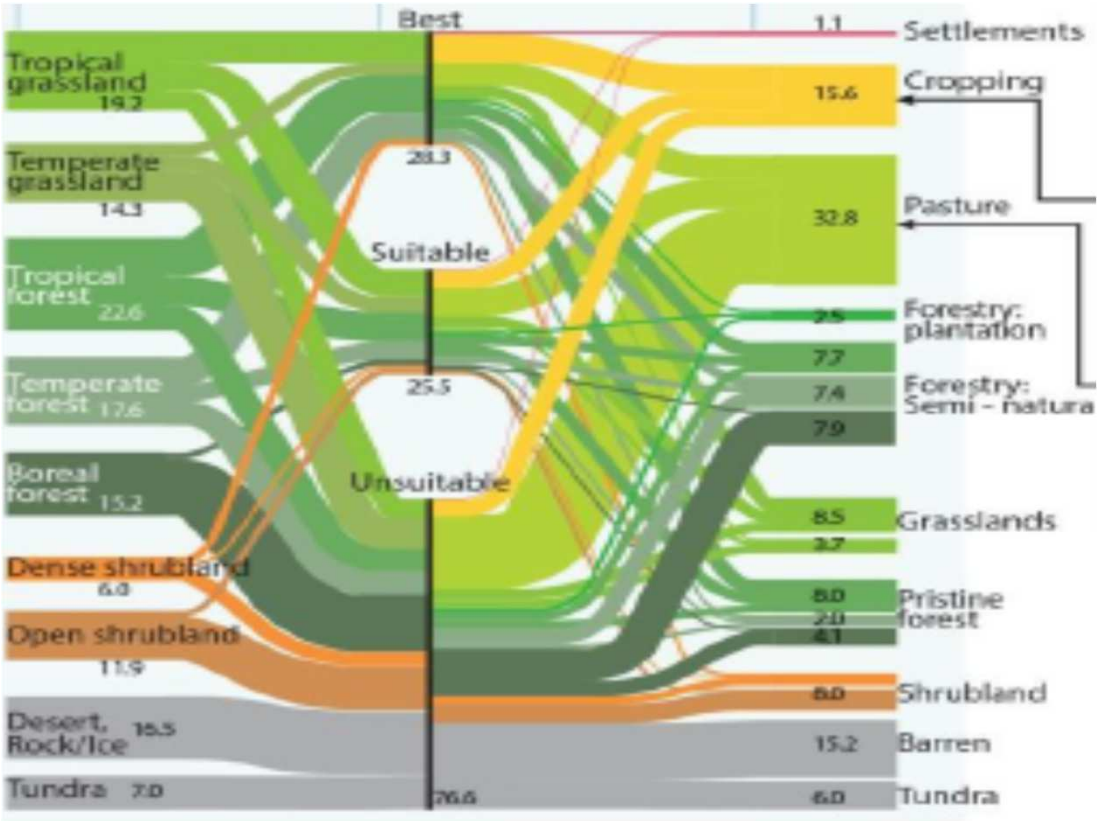
Our Starting Point 1/6: Global Land Utilization

130.4 million sq km of land

28.3 excellent

25.5 suitable

76.6 unsuitable



1.1 settlements

15.6 croplands

28.1 pastures

17.6 forestry

68.0 unused

of which 17.2 good ag land

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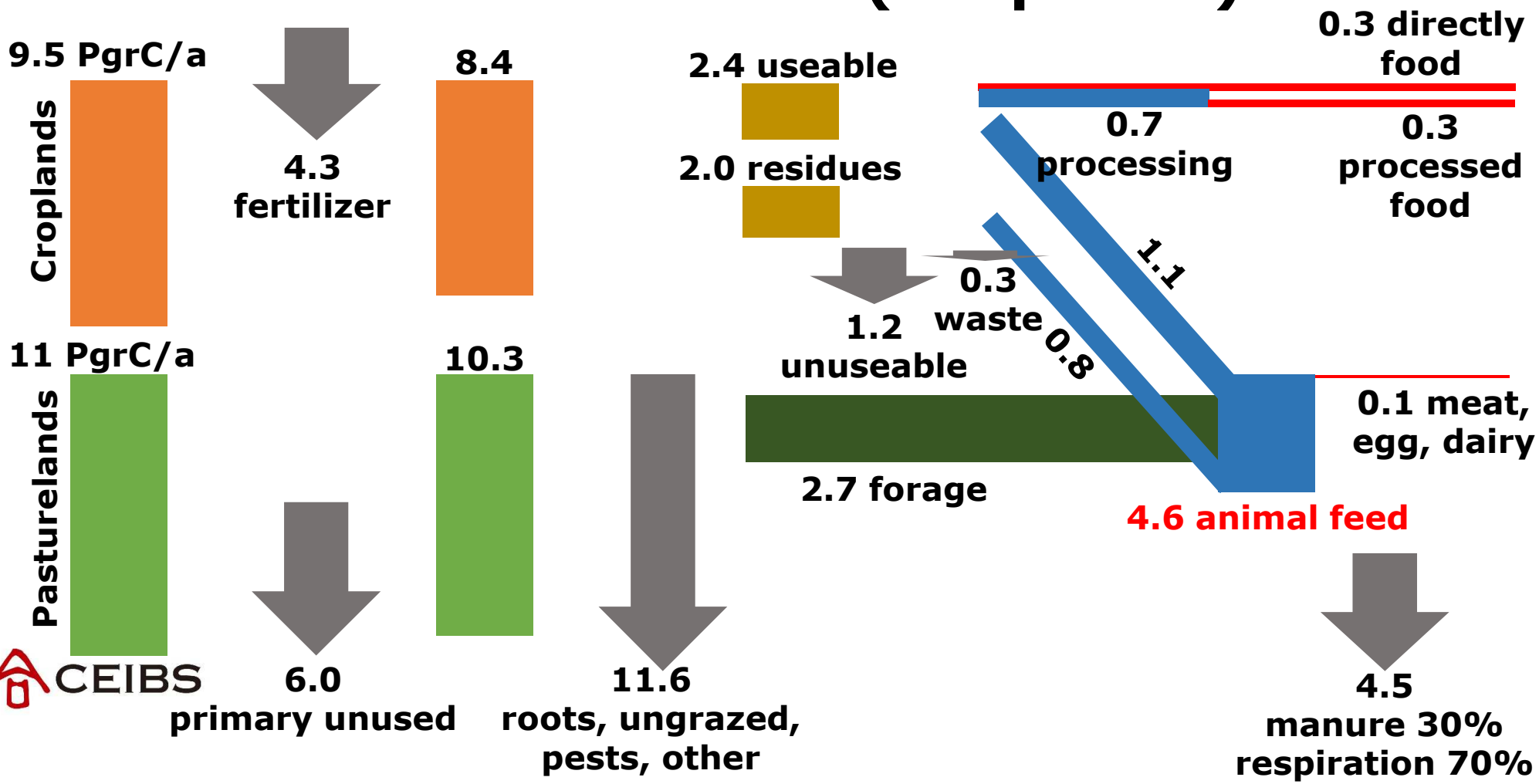
Source: Bajželj et al, Univ. of Cambridge 2014 based on FAO and IIASA GAEZ v3.0

Our Starting Point 2/6: Global Biomass Streams (simplified)



Source: Bajželj et al, Univ. of Cambridge 2014 own modelling analysis

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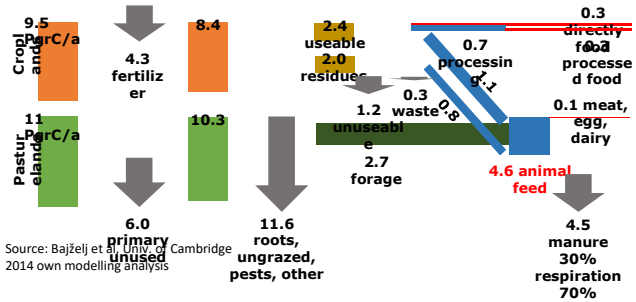


Source: Bajželj et al, Univ. of Cambridge 2014 own modelling analysis

=> 0.6 PgrC/a human food

+

=> 4.6 PgrC/a animal feed

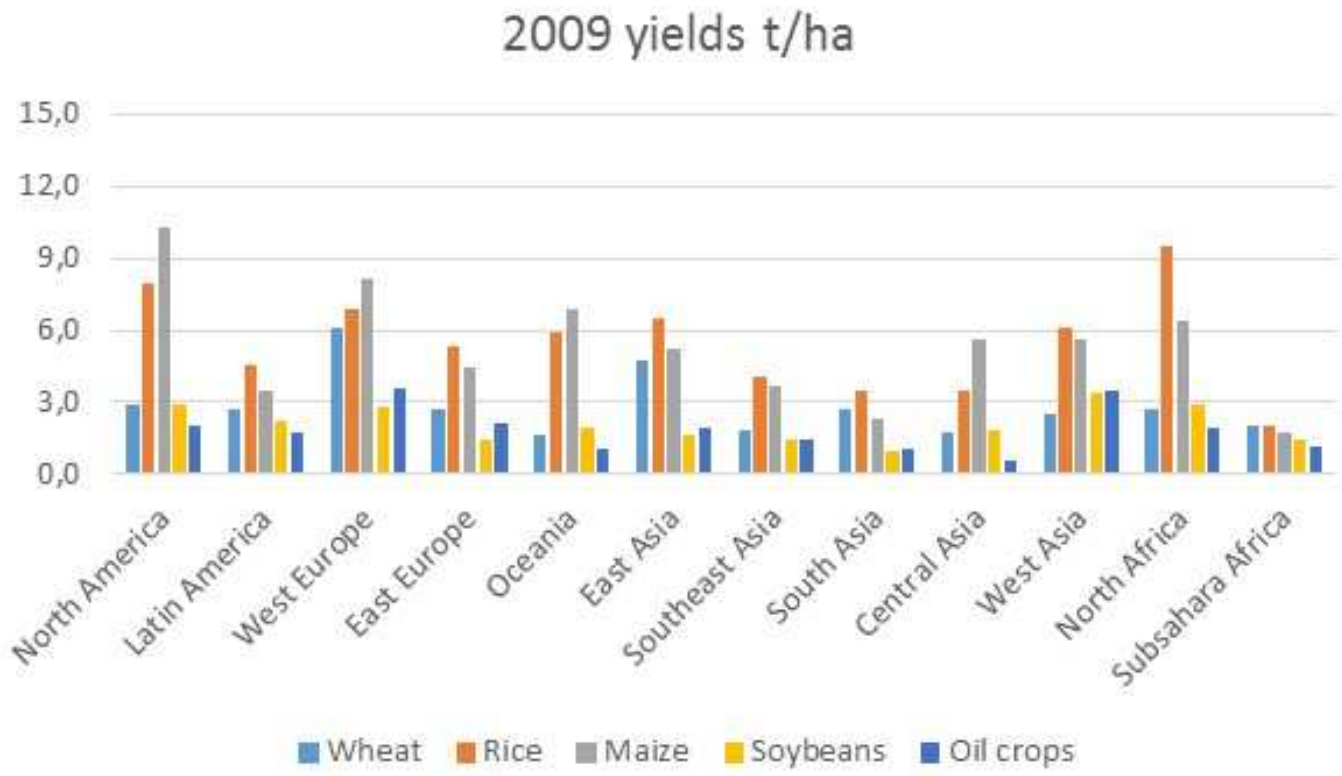
=> 0.1 PgrC/a human food

CEIBS

Source: Bajželj et al, Univ. of Cambridge 2014 own modelling analysis

Our Starting Point 3/6: Agricultural Yields

Average Growth Rate of 1,2% per year
(non-compounded since 1960)



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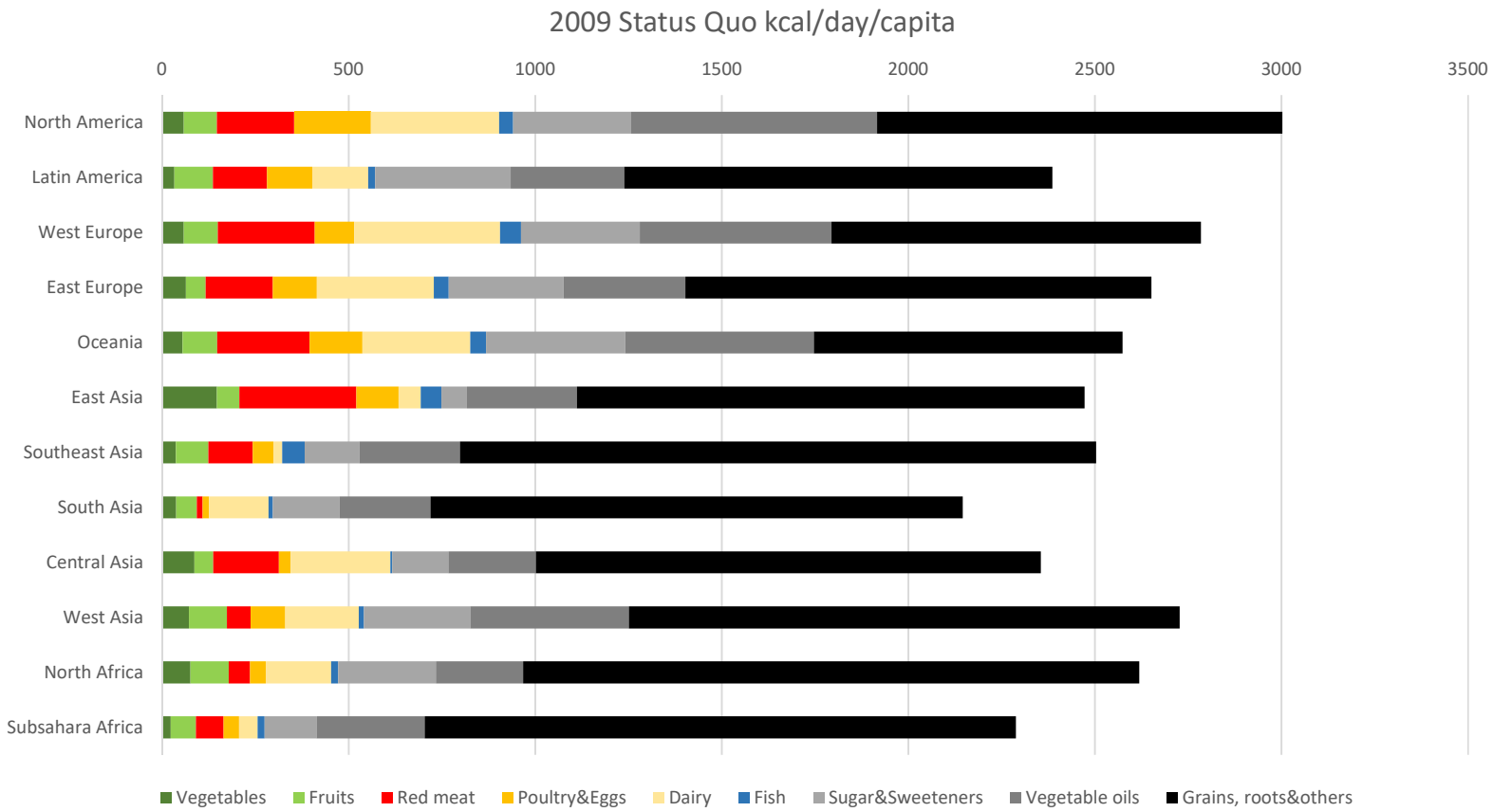
Source: Bajželj et al, Univ. of Cambridge 2014 based in FAOStat 2009

Our Starting Point 4/6: The Global Diet

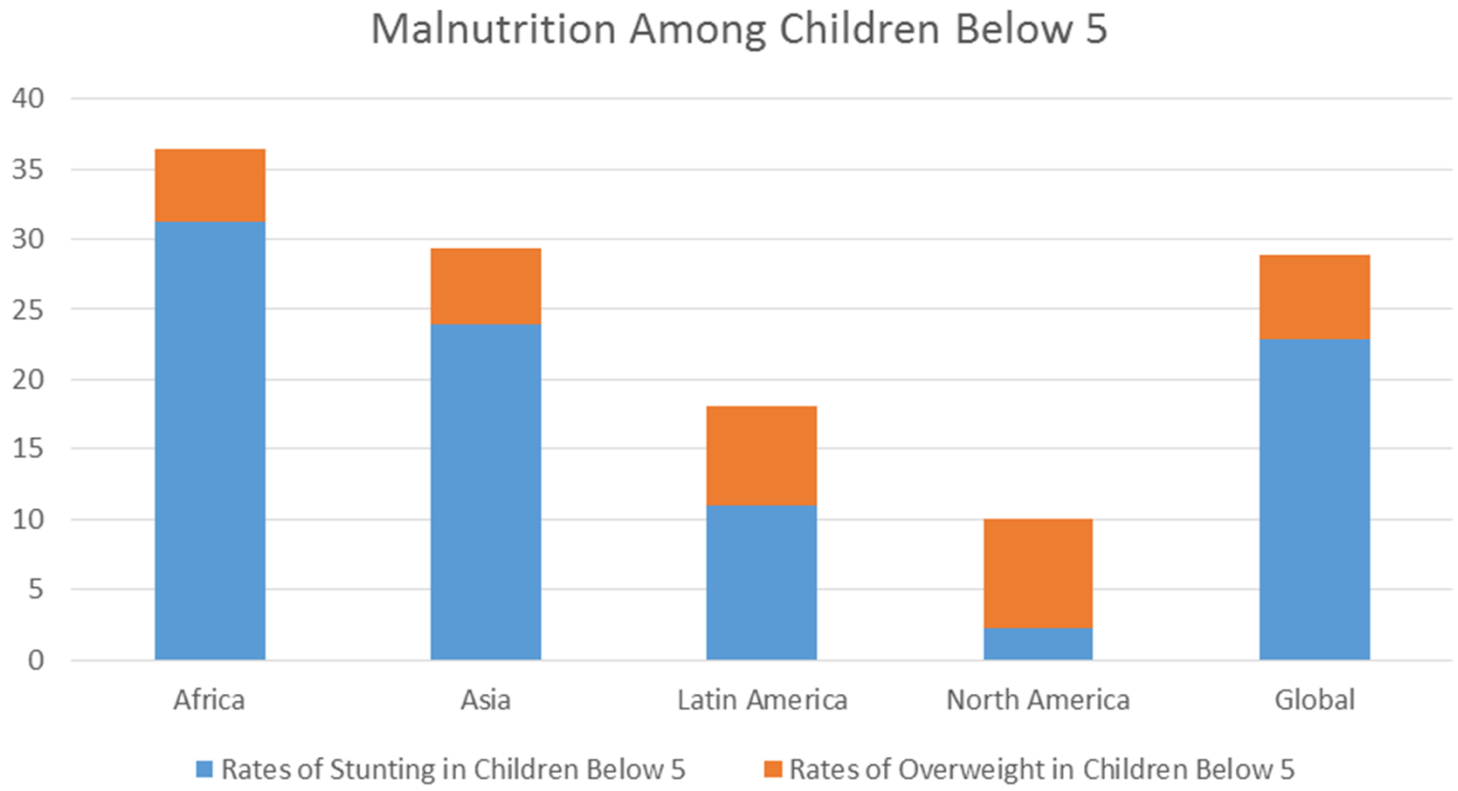
~1/2 as much as red meat despite higher efficiency



CEIBS

Source: Bajželj et al, Univ. of Cambridge 2014 based in FAO Food Balance Sheets 2009

Our Starting Point 5/6:
Almost 30% of All Children in the World Below 5, Suffer from Malnutrition



CEIBS

Source: UNICEF and FAO reports on malnutrition 2017

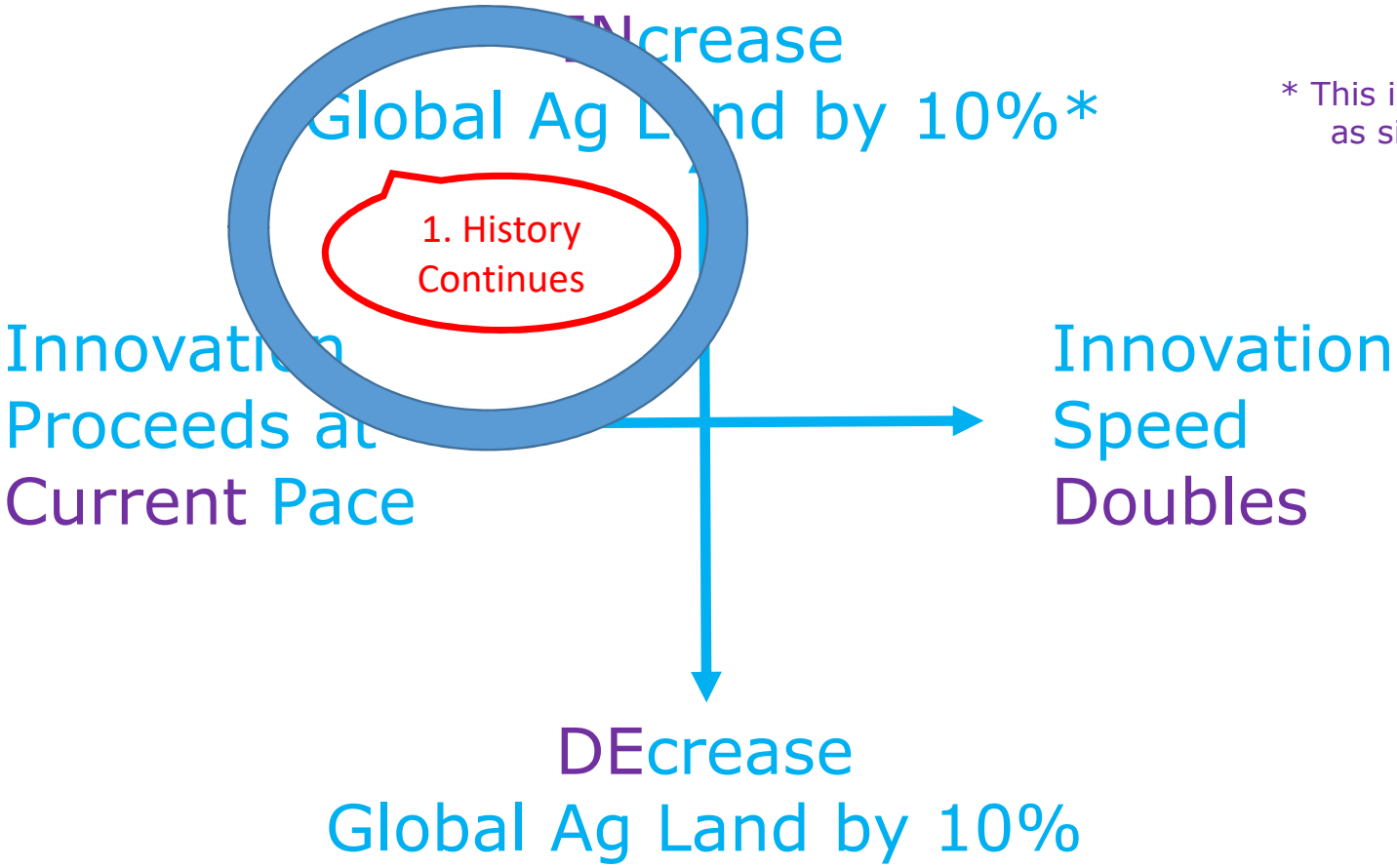
Our Starting Point 6/6: Not sustainable as of today – a reduction of ag land might be desirable

- Water shortages
- Deforestation
- Species decline
- Climate change
- Urban pollution

CEIBS

Source: UNICEF and FAO reports on malnutrition 2017

Innovation and Land Utilization Create Four Technology Outcome Scenarios for 2050



* This is the same expansion as since the year 1960

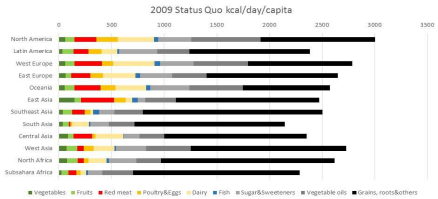
CEIBS

Source: Ederer et al, CEIBS / Wageningen University and Research

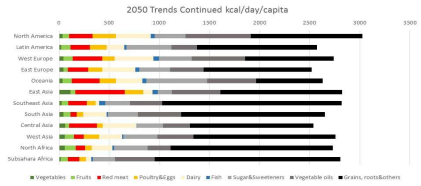
Scenario 1: History Continues – Key Features

Population

- Increases
- UN medium scenario rate



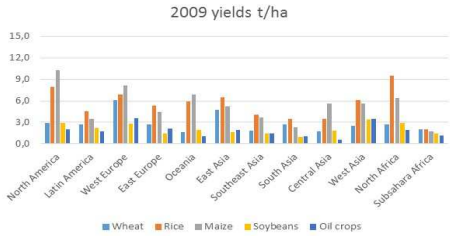
x 6.96 billion

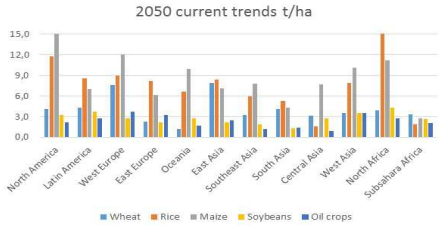


x 9.78 billion

Yield

- Improvements
- Same pace since 1960s.





Diet

- Increases in quantity / calories +
- Increases quality
- Animal protein increases

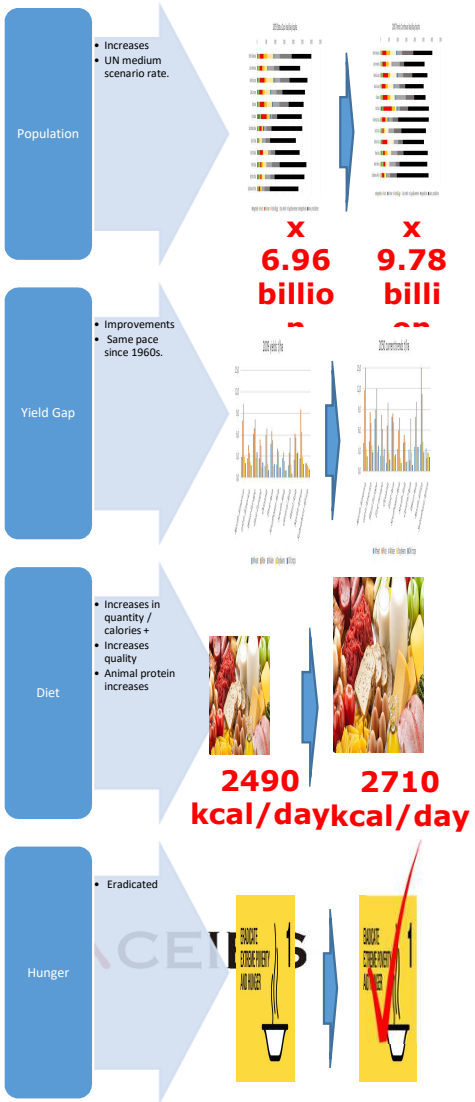
2490 kcal/day
410 livestock

2710 kcal/day
470 livestock

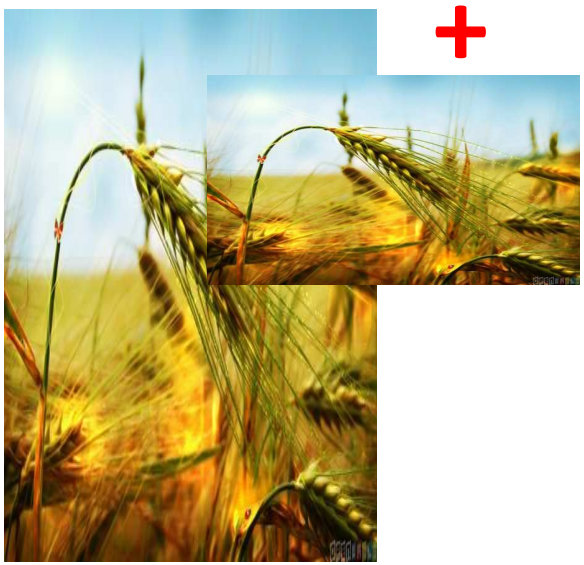
Hunger

- Eradicated

Scenario 1: History Continues – Means…



Land use goes up by 28%



Source: Bajželj et al, Univ. of Cambridge 2014 own modelling analysis

+ 42 % cropland / (6.6 million km2)

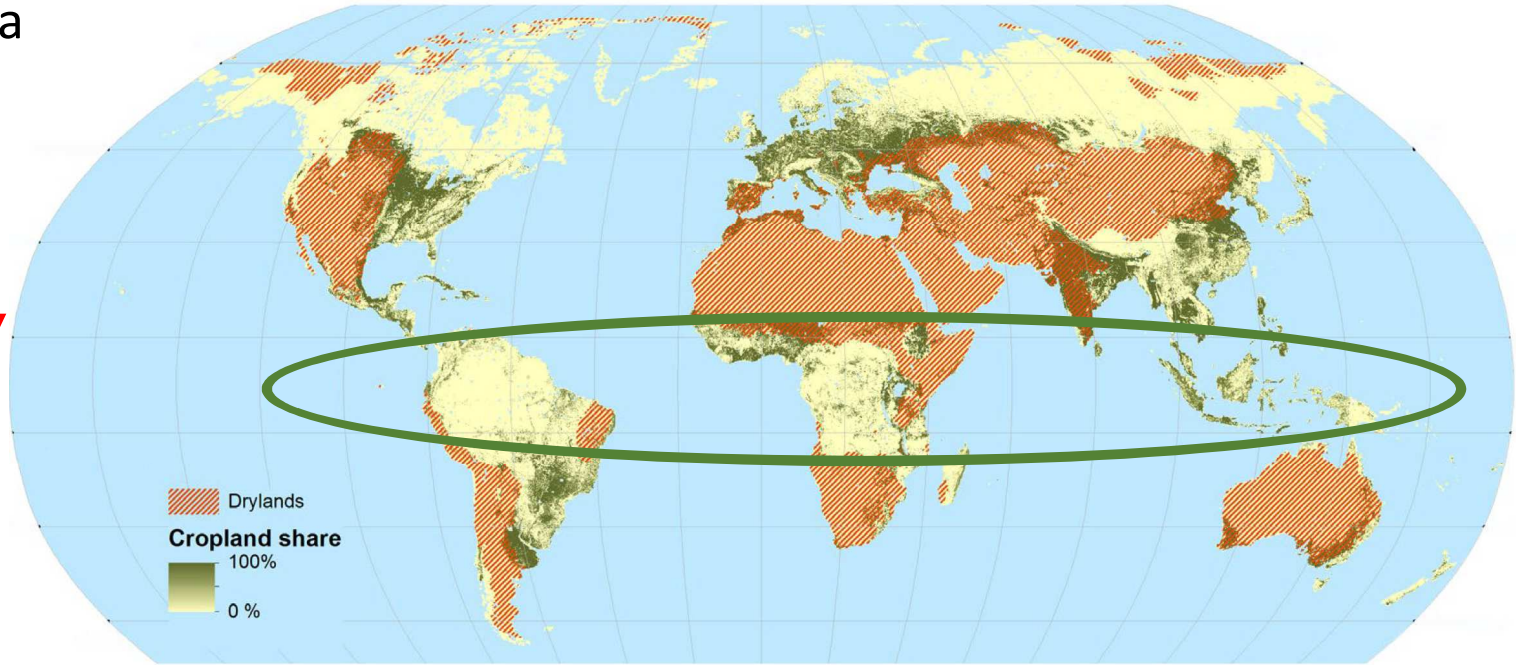
+ 13 % pasture/ (4.3 million km2)

Scenario 1: History Continues – Options?

…Jungle/Savanna.

Mostly all in tropical belt of central Africa
and South America

Amazon, Cerrado, Congo, Borneo



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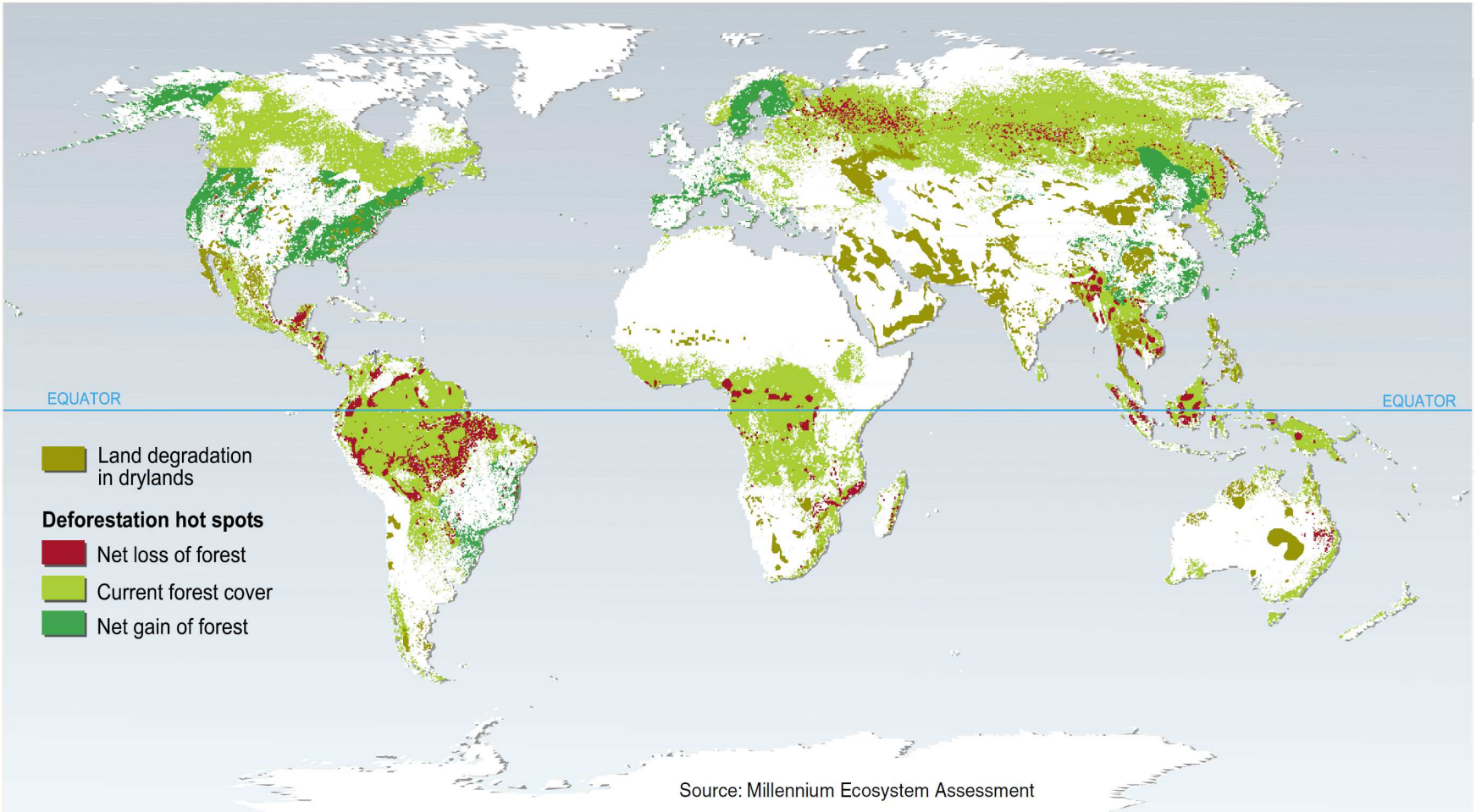
8.5 million km2 of prime and 8.7 million km2 of good agricultural land available for utilization

Source: UNCCD The Global Land Outlook, First Edition 2017 / FAO and IIASA GAEZ v 3.0

Scenario 1: History Continues – Where Deforestation Happens



Source: Unired Nations Millenium Ecosystem Assessment

Scenario 1: History Continues – Plough it Under

Irreversible destruction of the three global lungs of tropical forest and biodiversity
Destruction of an unprecedented scale

Amazon, Cerrado, Congo, Borneo

CEIBS

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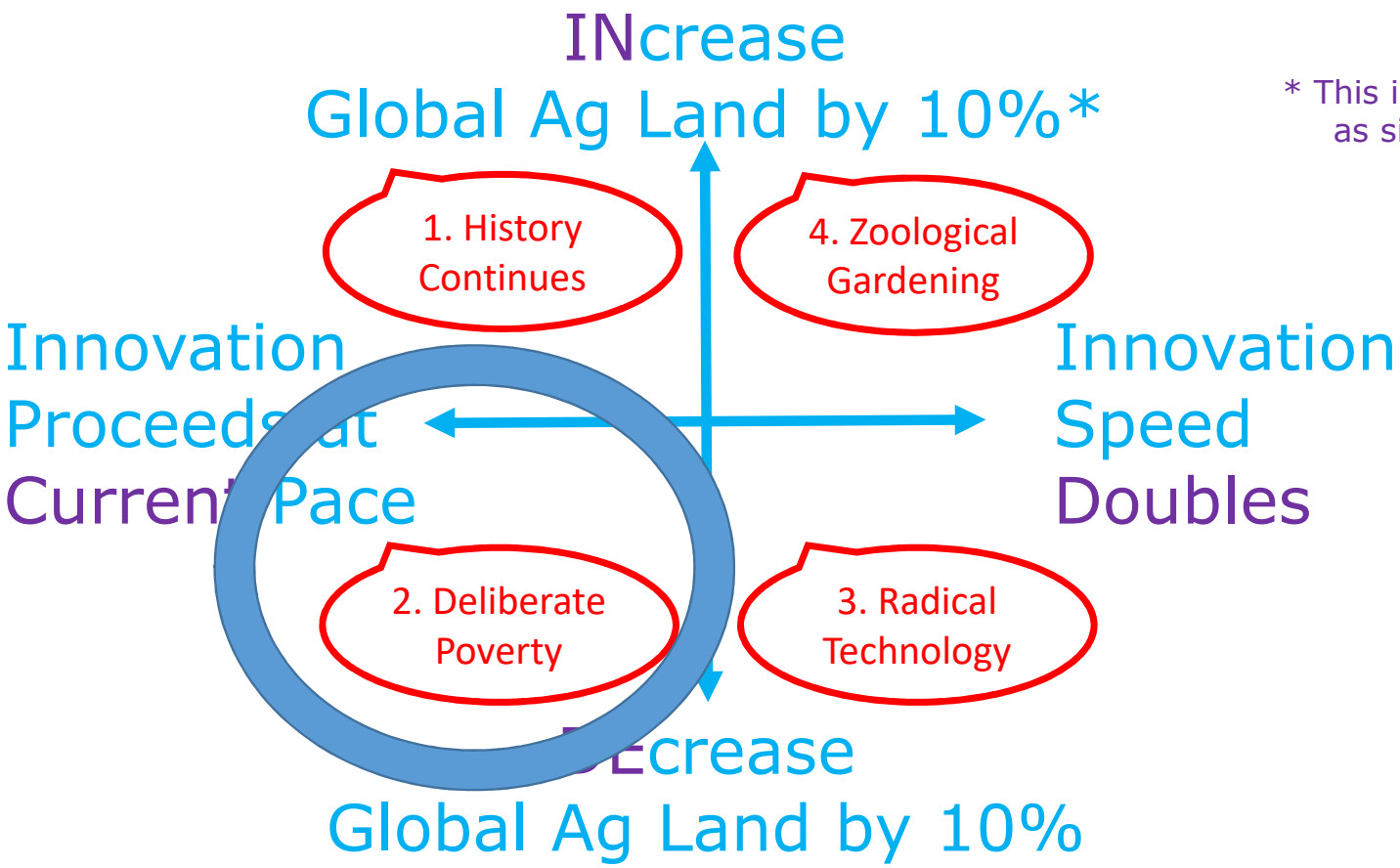
Innovation and Land Utilization Create Four Technology Outcome Scenarios for 2050



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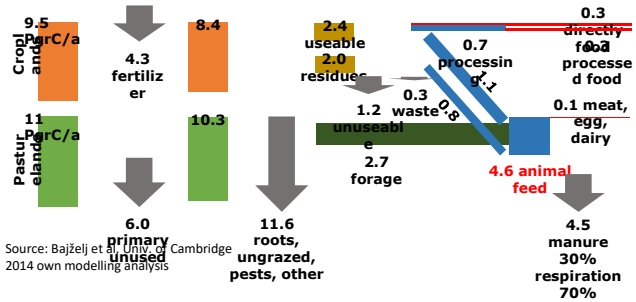
Our Starting Point 2/6: Global Biomass Streams



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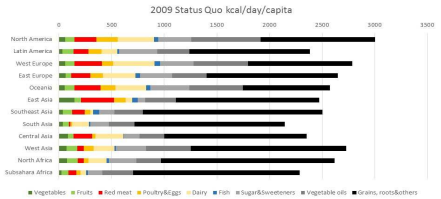
Scenario 2: Deliberate Poverty – Key Features

Population

- Increases
- UN medium scenario rate.



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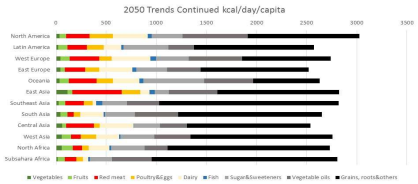

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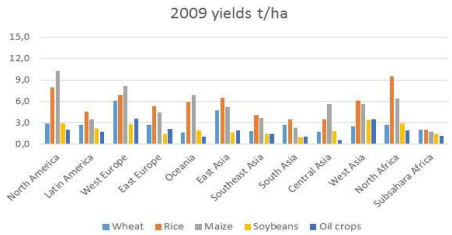
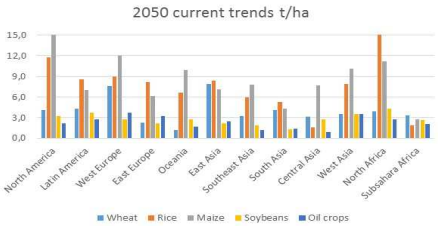




Diet

- Red meat: reduce & cap as least efficient
- Fruits / Veg: increase
- Sugar: reduce & cap

207 N.A. & 314 E.A. red meat kcal/day

Veg 43 kcal/day
Fruit 75 kcal/day

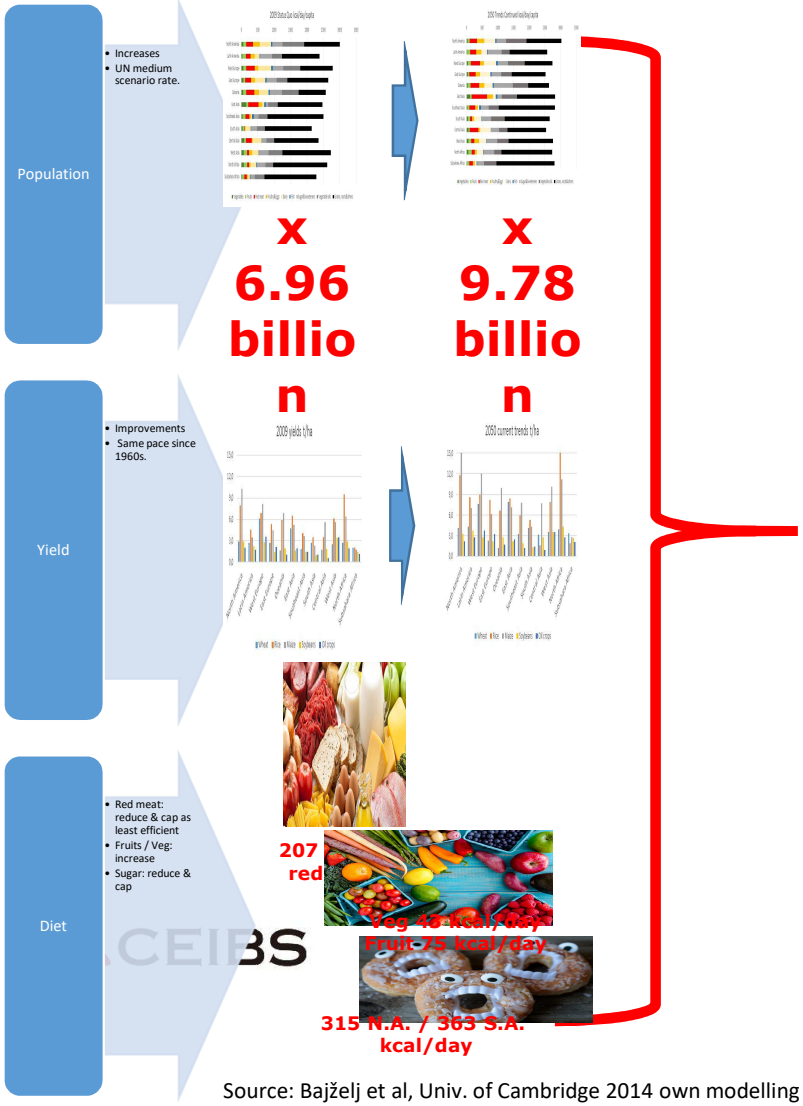
315 N.A. / 363 S.A. kcal/day

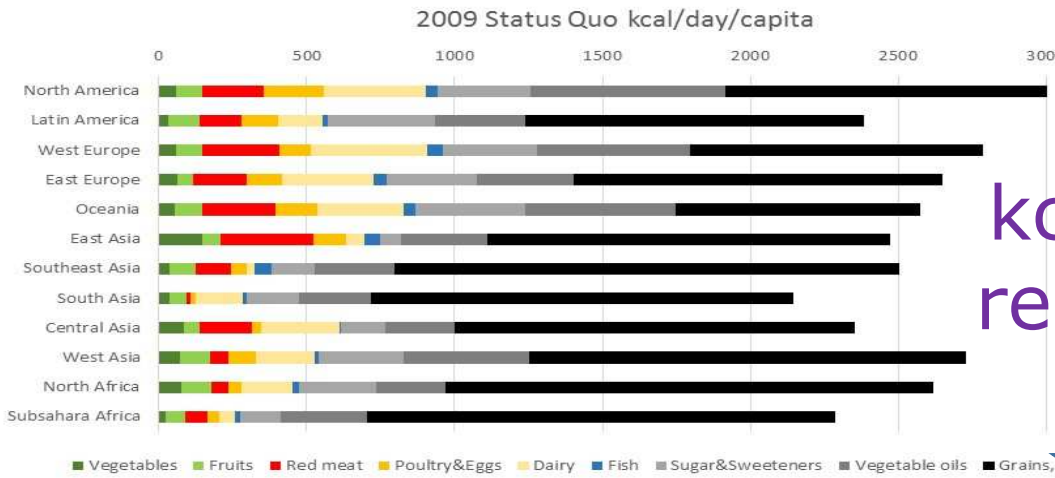
57 red meat kcal/day

Veg 136 kcal/day
Fruit 119 kcal/day

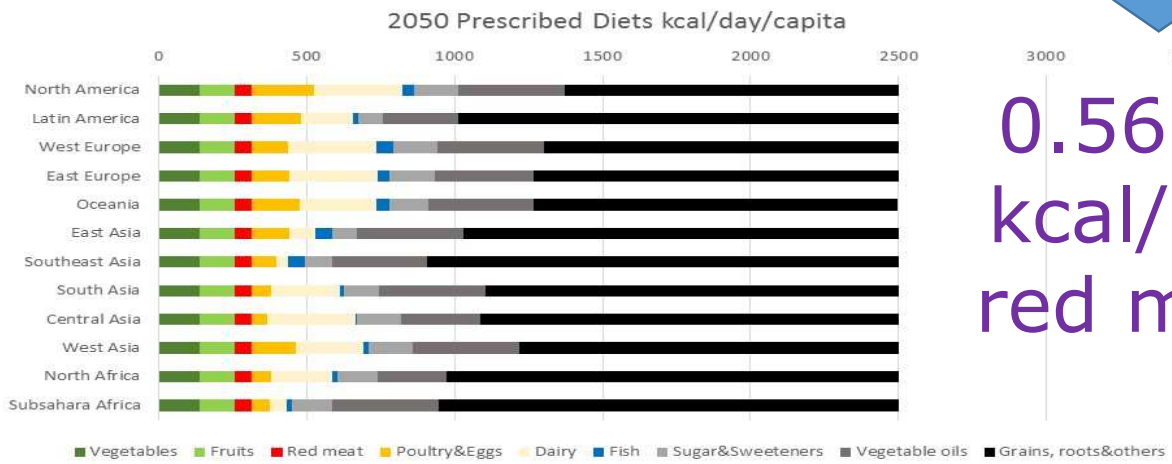
150 kcal/day

Scenario 2: Deliberate Poverty – Means…





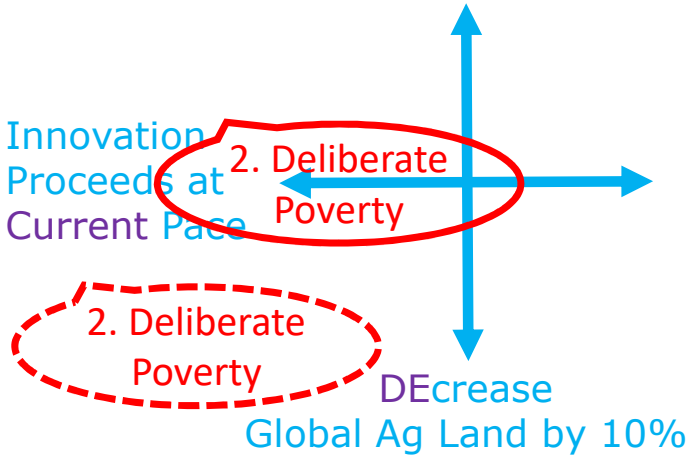
1 tril kcal/day red meat

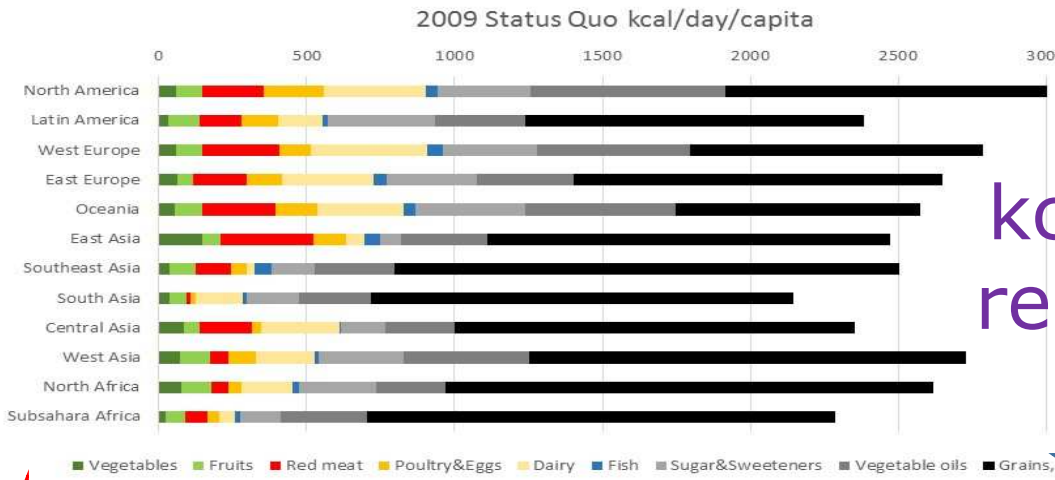


0.56 tril kcal/day red meat

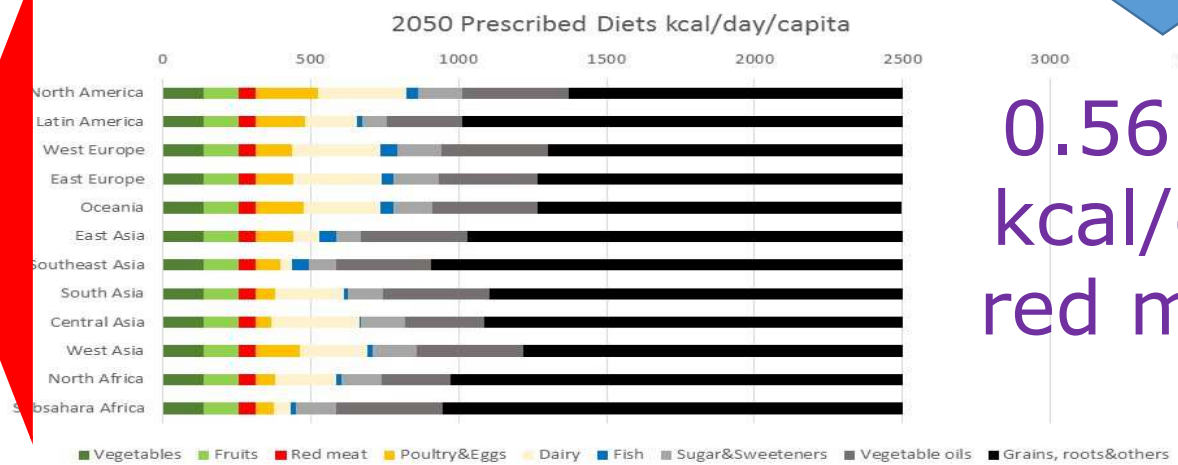
Source: Bajželj et al, Univ. of Cambridge 2014 own modelling analysis

Scenario 2: Deliberate Poverty





1 tril kcal/day red meat



0.56 tril kcal/day red meat

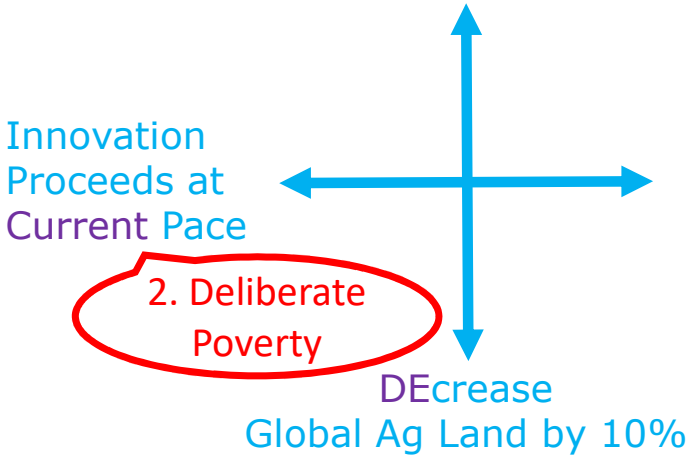
Land Use Could Stay Same*

***reducing poultry/dairy as well, will reduce land use**

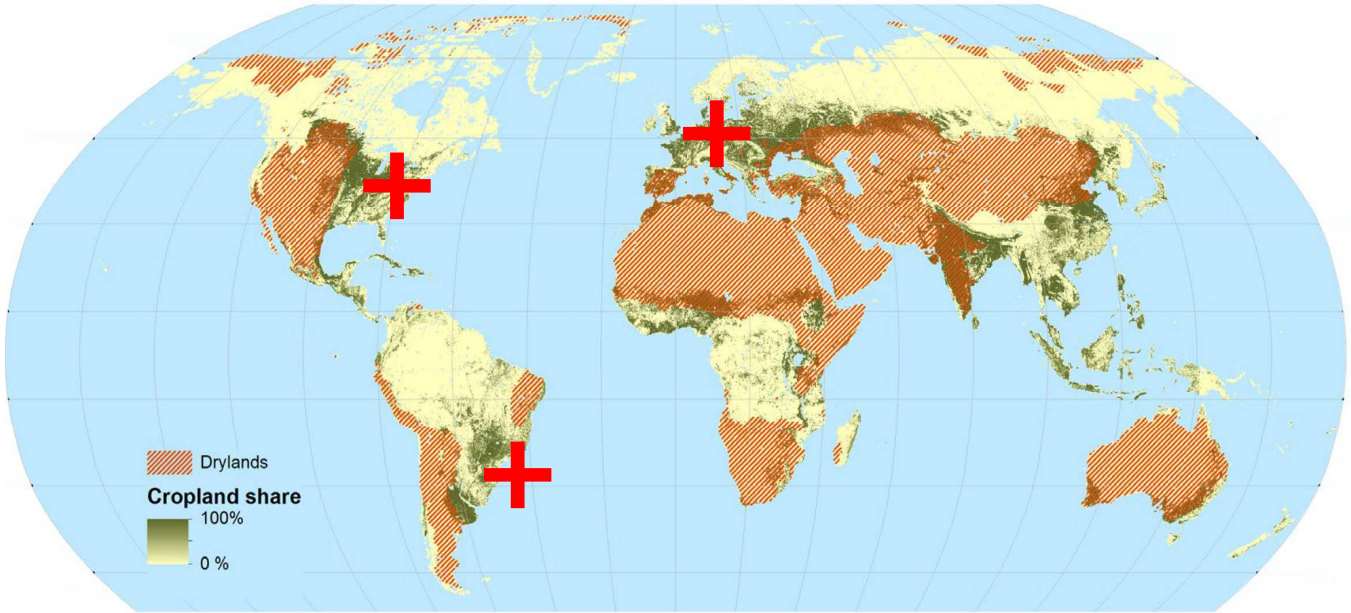
CEIBS

Source: Bajželj et al, Univ. of Cambridge 2014 own modelling analysis

Scenario 2: Deliberate Poverty Will Not Work



Reduction of meat could increase food production in Americas and Europe…



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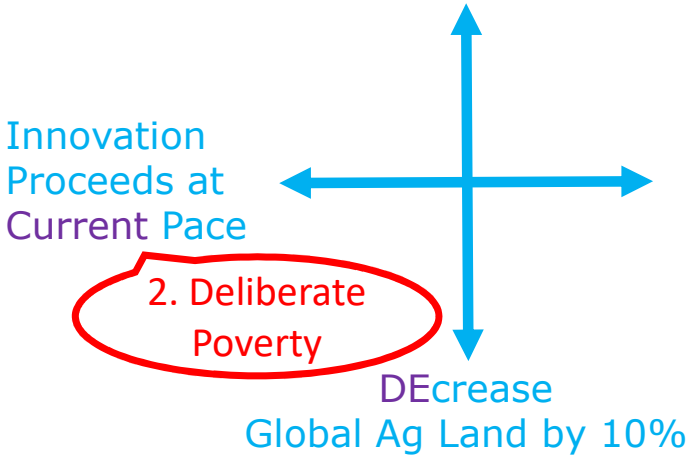
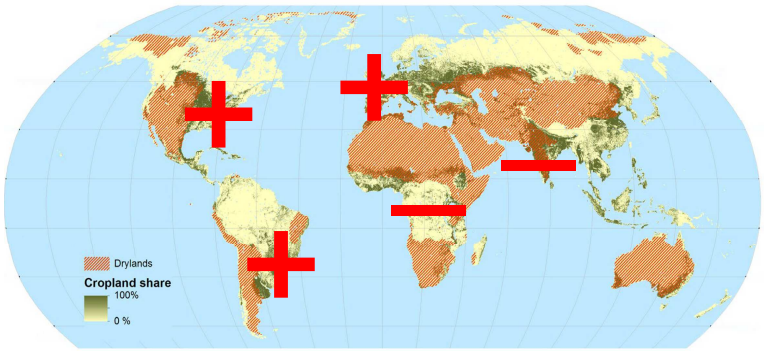
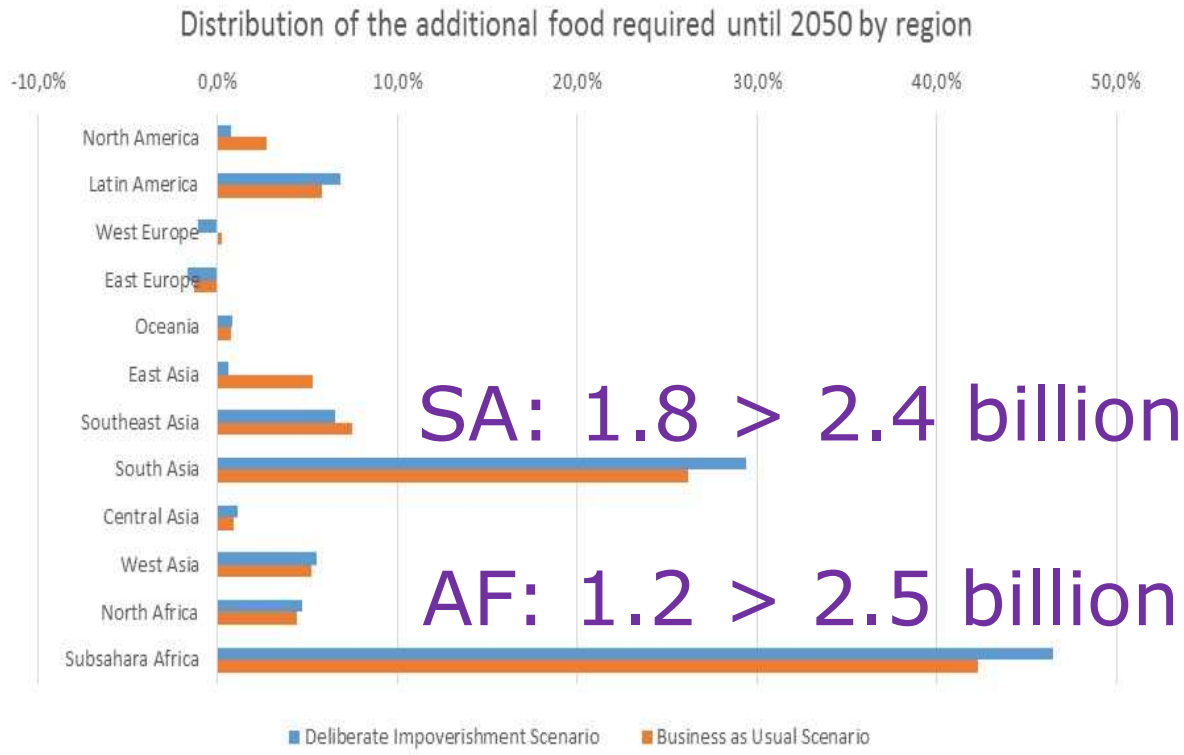
Scenario 2: Deliberate Poverty Will Not Work



… but needed in Africa/South Asia > Food flows are not financeable



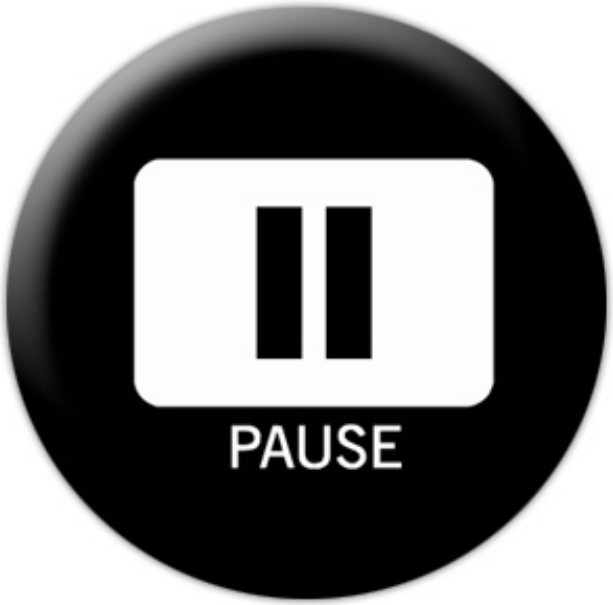


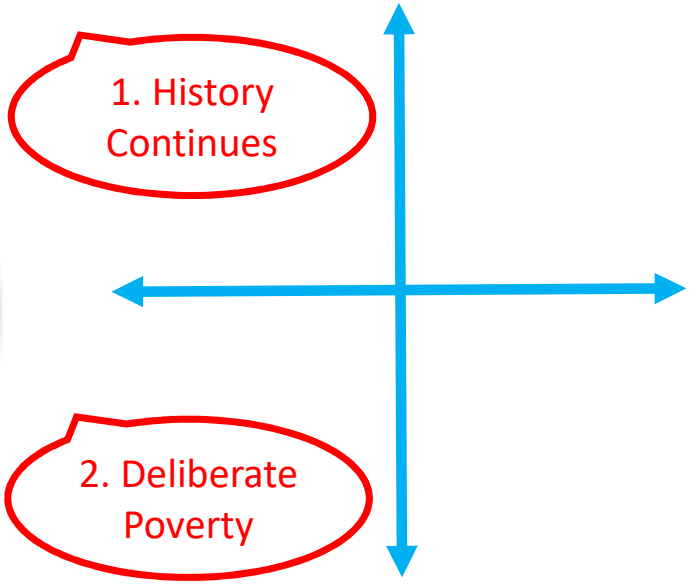
CEIBS

Source: Ederer et al, CEIBS / Wageningen University and Research, based on UN Population Revision 2017 edition and FAO global food diets

Scenario 2: Deliberate Poverty Will Not Work

… for lots of other reasons too





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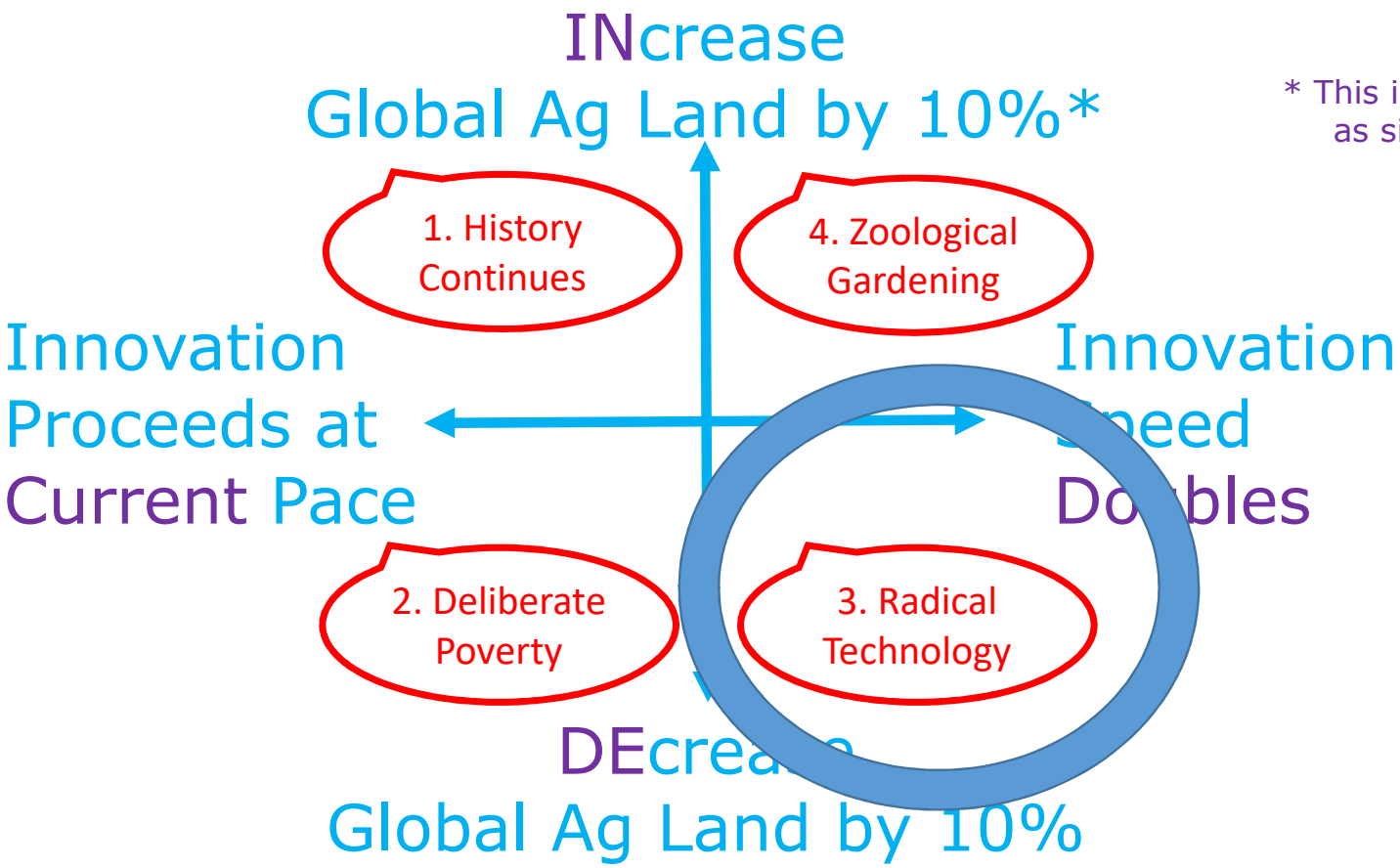


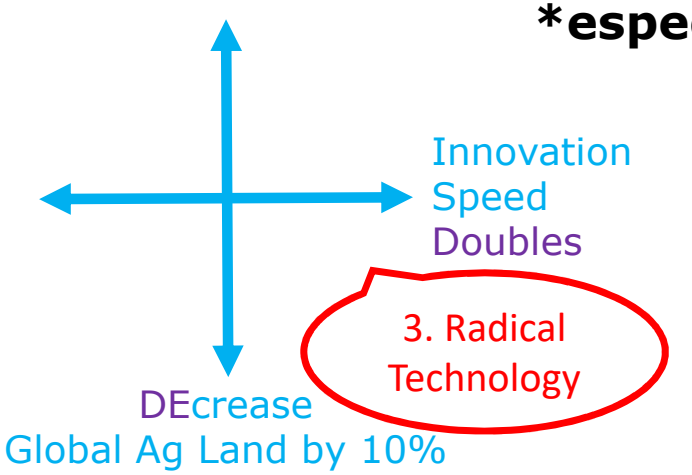
* This is the same expansion as since the year 1960

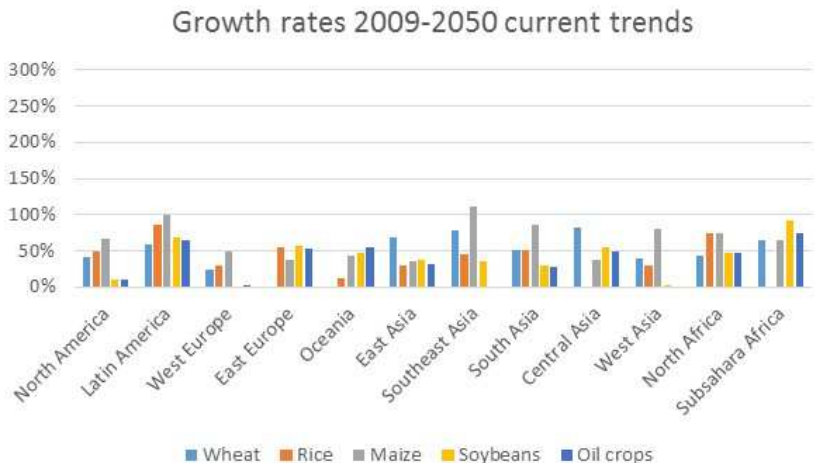
CEIBS

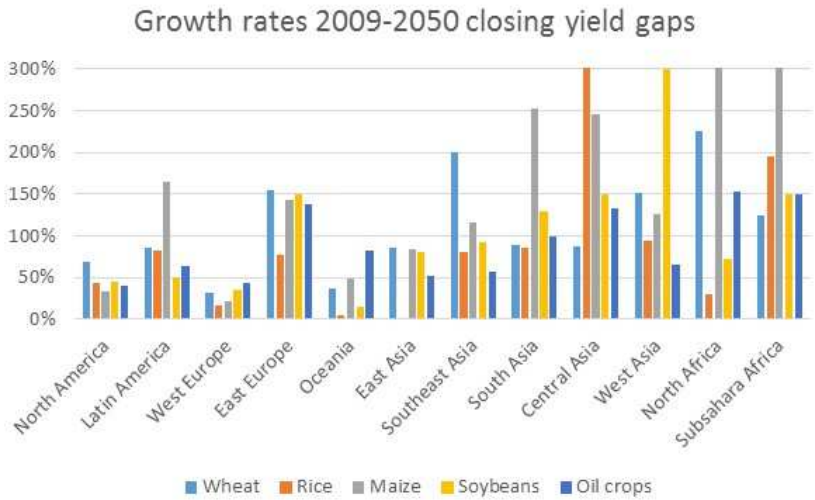
Source: Ederer et al, CEIBS / Wageningen University and Research

Scenario 3: Radical Technology Deployment*

***especially in Africa and Asia**







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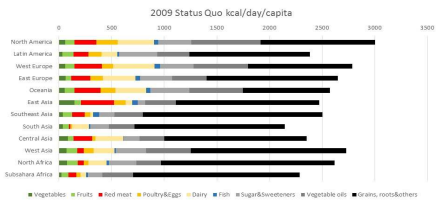
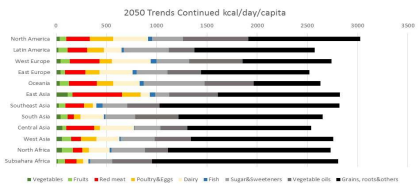
Scenario 3: Radical Technology Deployment – Key Features

Population

- Increases
- UN medium scenario rate.



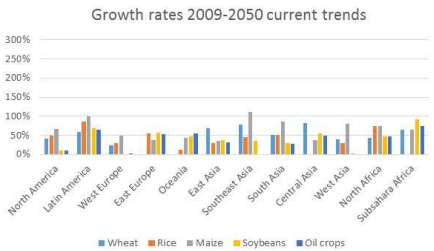
x 6.96 billion

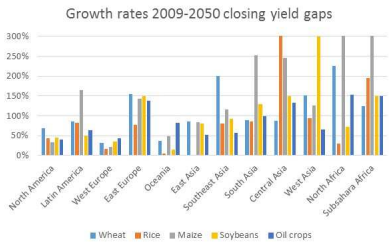


x 9.78 billion

Yield

- Doubles: land use intensifies
- Africa: agronomic practices revolutionized
- Land use intensifies
- Opportunity to protect biodiversity





Technology

- Reduce waste via track & trace
- Crop yield enhancement
- Robotization & automation
- Data analysis
- Animal health enhancement
- Financing technologies

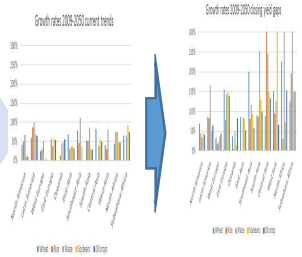
30% food waste

15% food waste

Scenario 3: Radical Technology Deployment – Means…

Population

- Increases
- UN medium scenario rate.



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Technology

- Reduce waste via track & trace
- Crop yield enhancement
- Robotization & automation
- Data analysis
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- Financing technologies

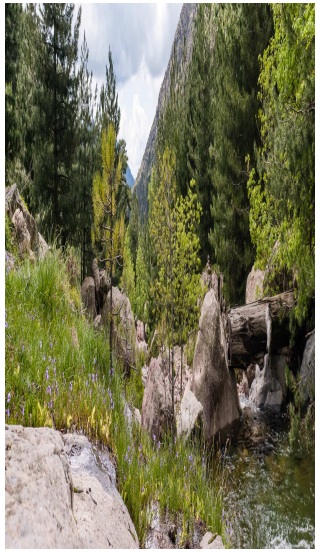
30% food waste

15% food waste

Land use goes down ---> Re-claim / Protect

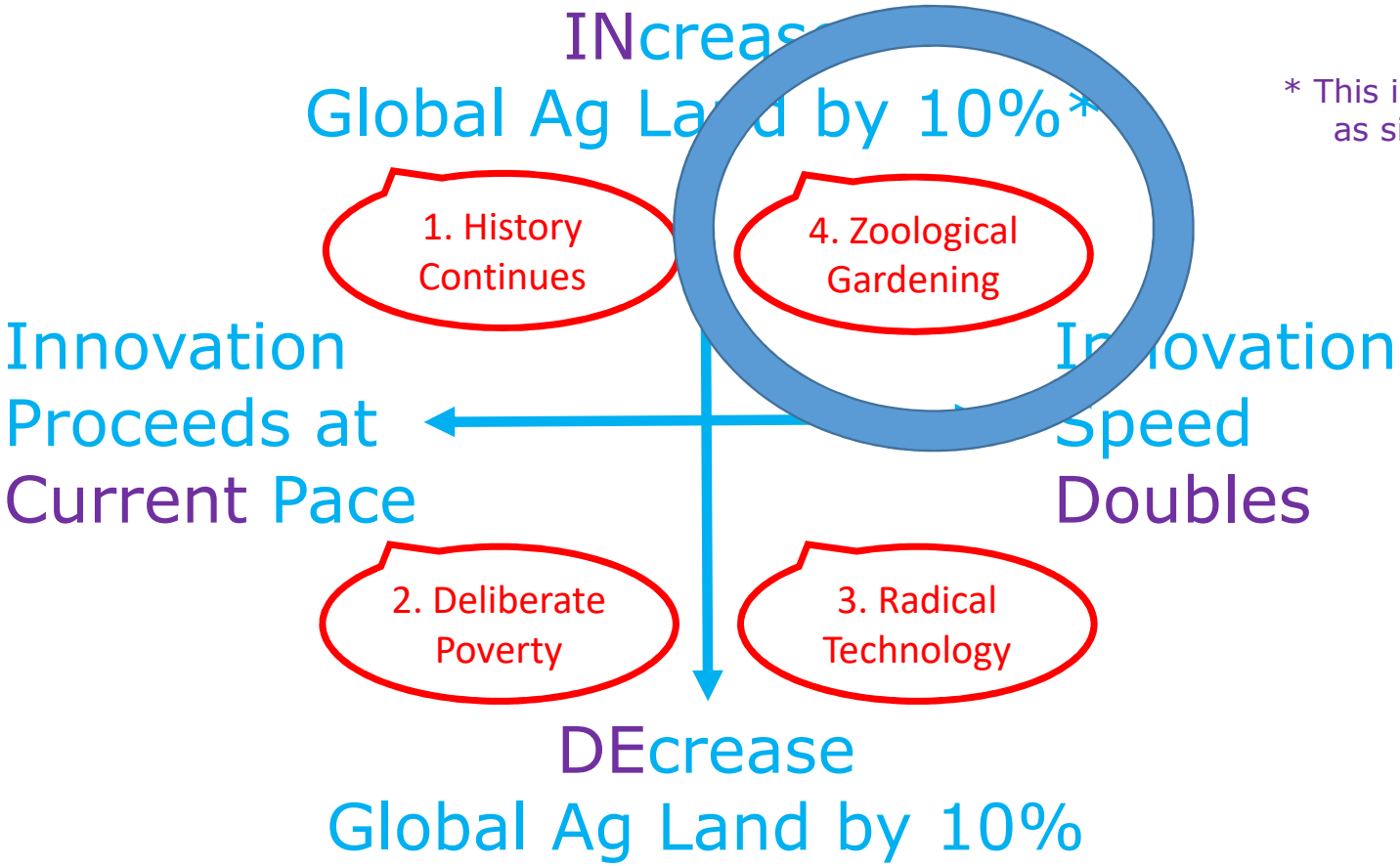
9% of cropland reduced

3% of pasture increased



Source: Bajželj et al, Univ. of Cambridge 2014 own modelling analysis

Innovation and Land Utilization Create Four Technology Outcome Scenarios for 2050



* This is the same expansion as since the year 1960

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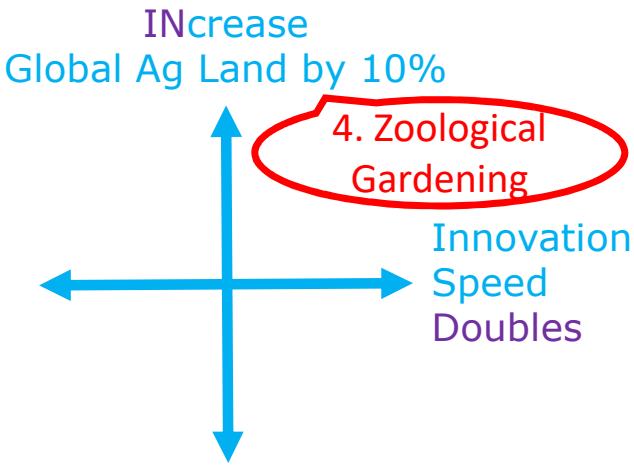
Source: Ederer et al, CEIBS / Wageningen University and Research

Scenario 4: Zoological Gardening



eg: bio-organic farming of animals (the natural way)

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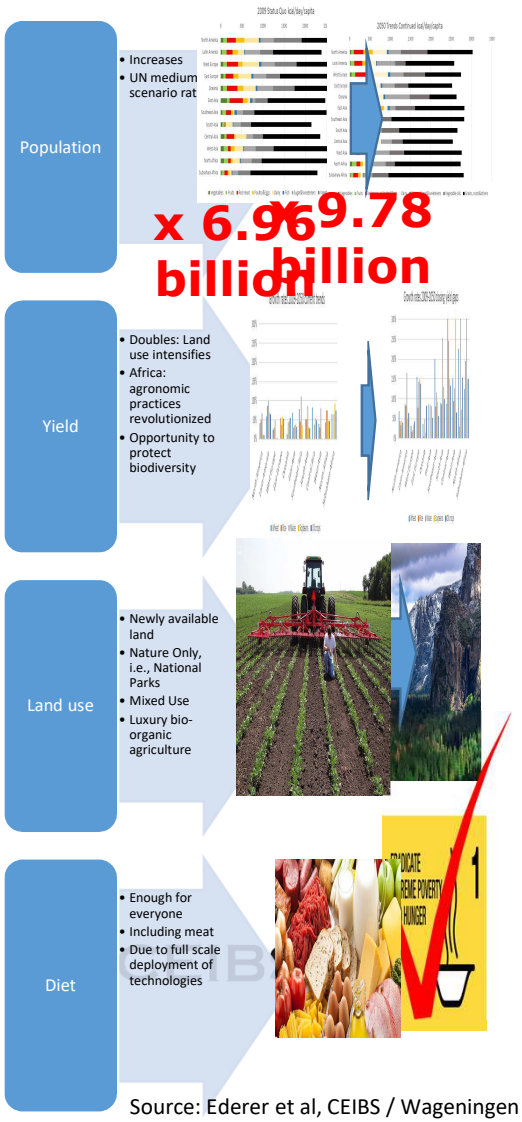
Source: Ederer et al, CEIBS / Wageningen University and Research

Scenario 4: Zoological Gardening – Means…



Source: Ederer et al, CEIBS / Wageningen University and Research

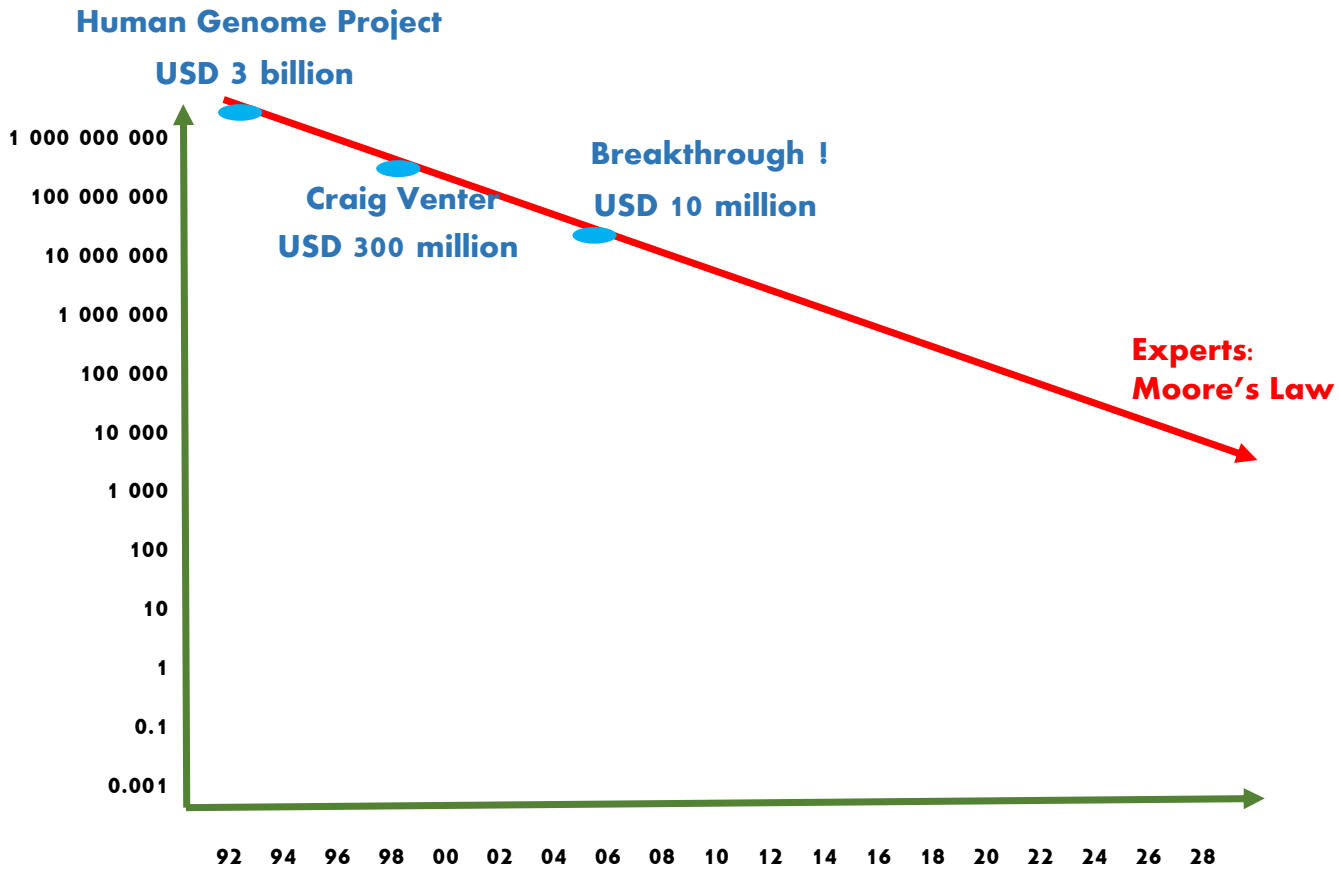
> we can spare land in Americas and Europe for organic agricultural practices

> or we can return this land to nature…

> or we can use it for zoological agricultural purposes…

BUT NONE OF THIS WILL MAKE A DIFFERENCE TO THE FOOD CRISIS IN AFRICA AND SOUTH ASIA

Cost of Human Genome Sequencing



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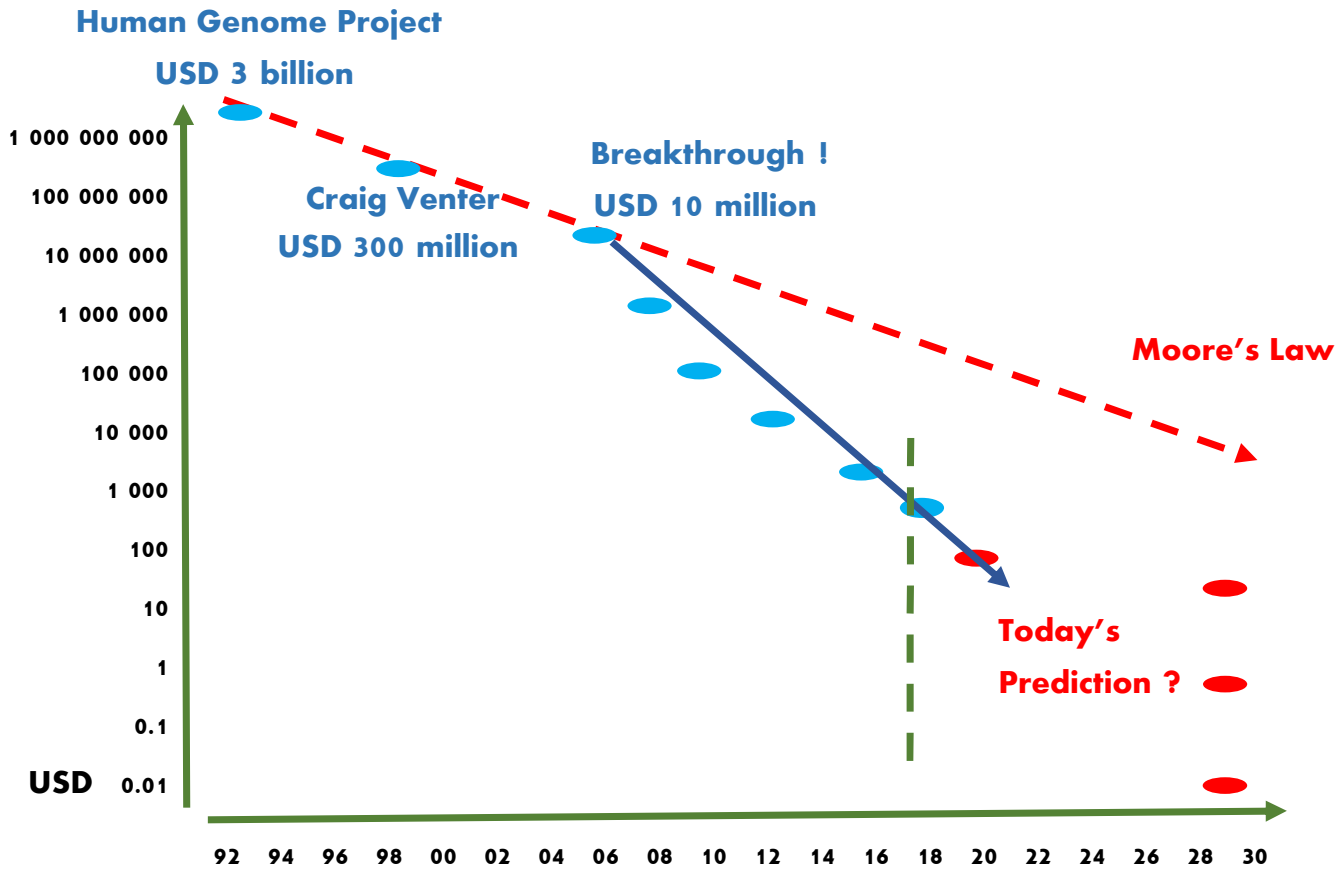
Source: Ederer et al, CEIBS / Wageningen University and Research

Cost of Human Genome Sequencing 1992-2027



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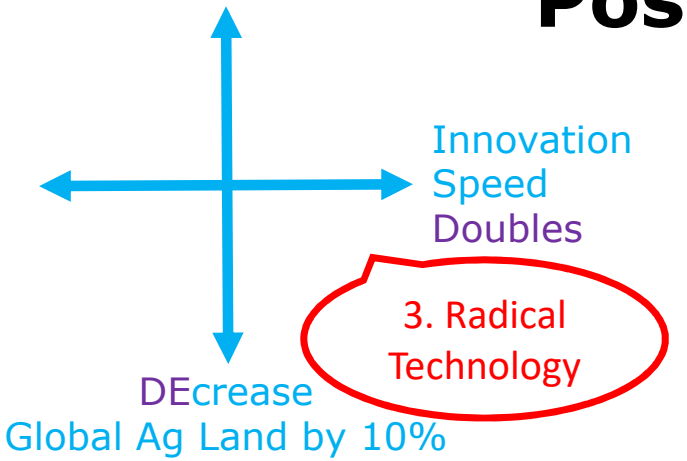
Source: Ederer et al, CEIBS / Wageningen University and Research

Scenario 3: Radical Technology Deployment Possibilities:



STINE HAS YIELD

Harry Stine of Stine Seeds:*
"We're going to be able to double corn yields very easily"

*Mr Stine from Ohio is estimated to be the wealthiest entrepreneur in US agriculture

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Source: Fortune Magazine 2014

Recent Milestones
Mapping all Life – announced in 2017

EARTH BIOGENOME PROJECT

Powerful advances in genome sequencing technology, informatics, automation, and artificial intelligence, have propelled humankind to the threshold of a new beginning in understanding, utilizing, and conserving biodiversity. For the first time in history, it is possible to efficiently sequence the genomes of all known species, and to use genomics to help discover the remaining 80 to 90 percent of species that are currently hidden from science
(Ucal Davis, Univ. Illinois, Smithsonian Institution)

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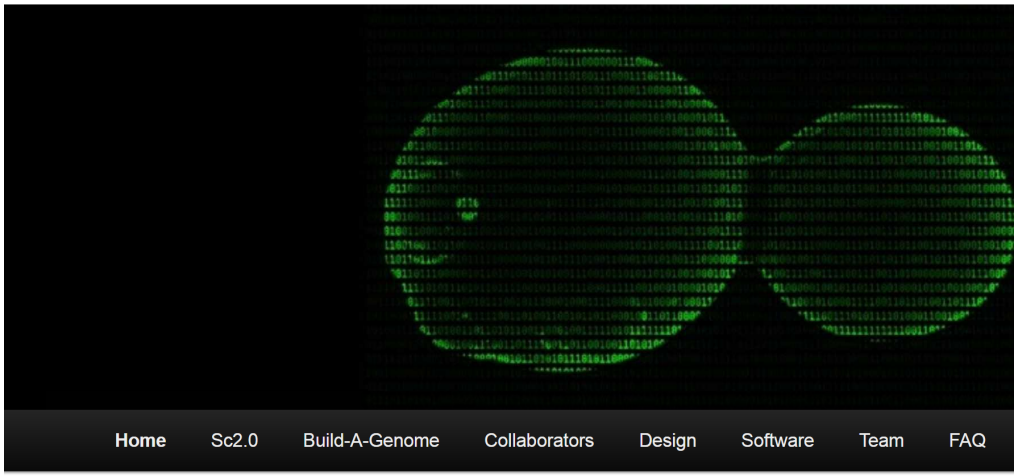
Recent Milestones
The first synthetic eukaryotic life form - 2018

Synthetic Yeast 2.0

Building the world's first synthetic eukaryotic genome together



CATEGORY ARCHIVES: NEWS

6th Annual Sc2.0 Meeting, Singapore

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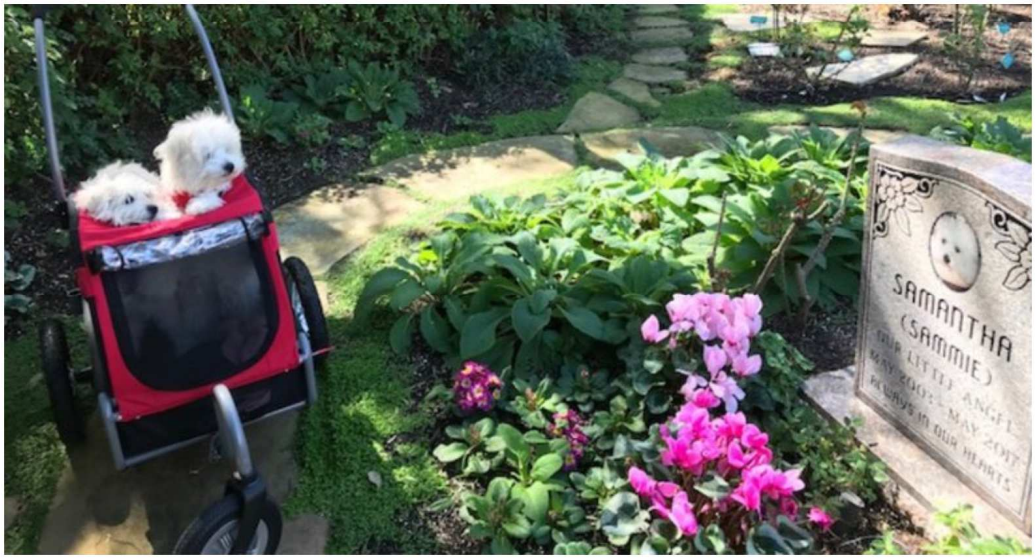
Recent Milestones
The New York Times 02 March 2018

Barbra Streisand Explains: Why I Cloned My Dog

By BARBRA STREISAND MARCH 2, 2018



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The Osc
Gerwig,
Gadot

Barbra
$50,000
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Setting
Straight
'60s Pix

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Becoming God –
Adolfo Cambiaso and his polo team
Crestview Genetics: *Perpetuating the Finest*

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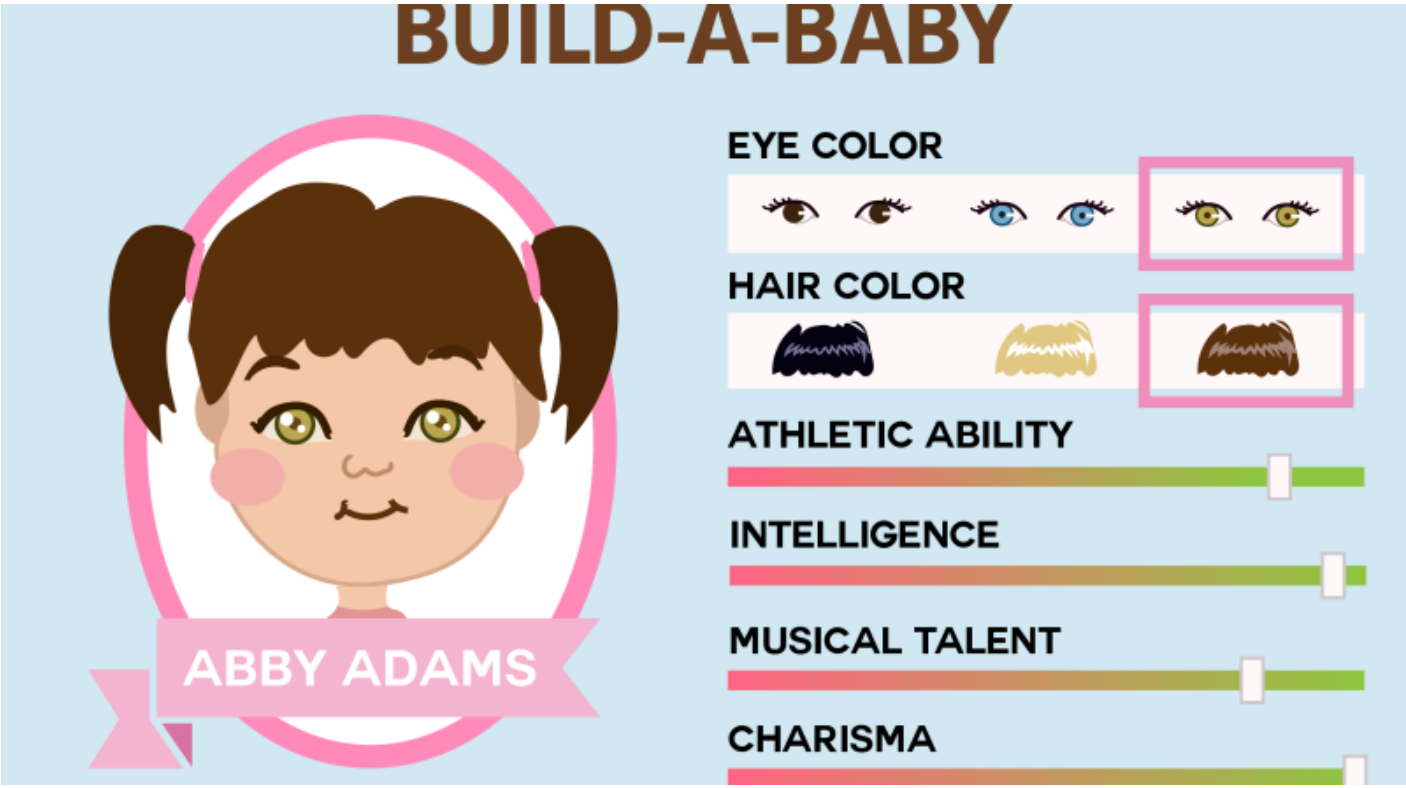
Design-a-Life is a Strategic Reality Today



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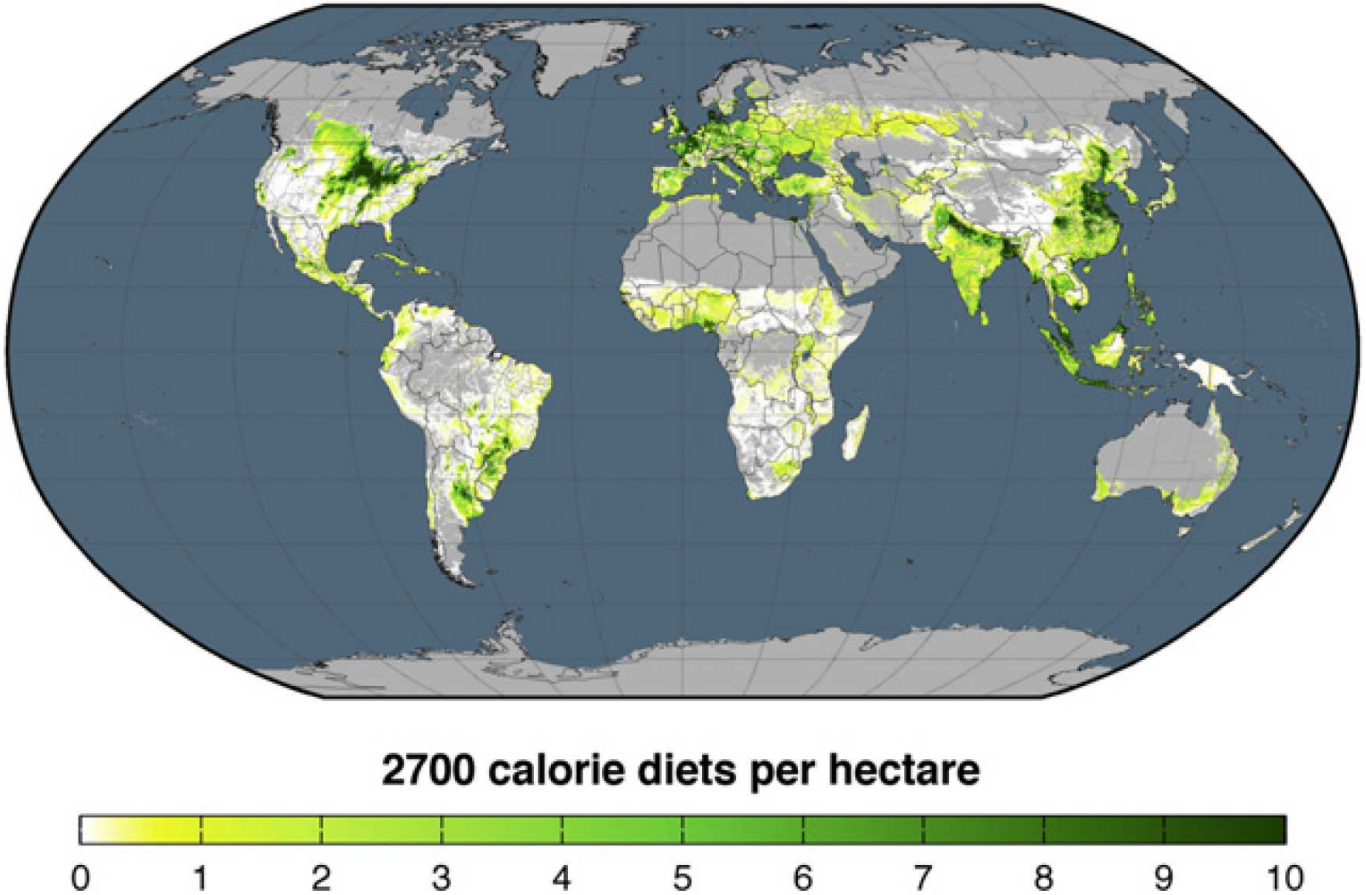
Where we produce our food today



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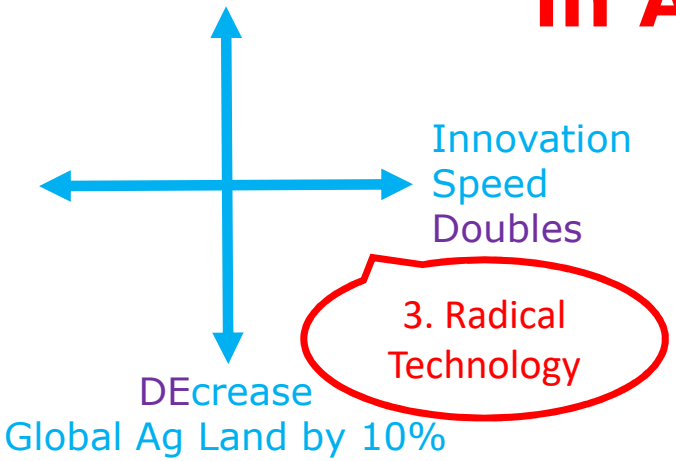
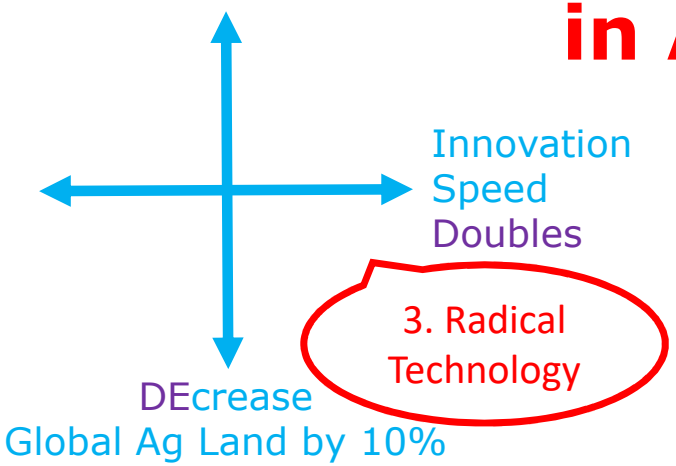
Scenario 3: Radical Technology Deployment in Africa must include livestock



CEIBS

Source: Ederer et al, CEIBS / Wageningen University and Research

Scenario 3: Radical Technology Deployment in Africa must include livestock



According to the International Livestock Research Institute, Nairobi and Kampala, 2015:

"Across the food-challenged regions of sub-Saharan Africa, the sustenance provided by livestock and seafood - milk, meat, eggs, and fish - is far more important than it is in wealthy countries. For most Africans, particularly the poor, there are no alternatives that can supply anywhere near the same level of protein and micronutrients."

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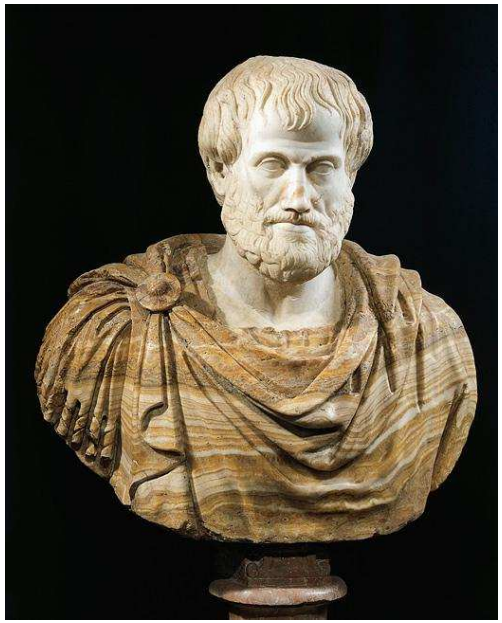
Source: International Livestock Research Institute, Nairobi and Kampala, 2015, Delia Grace and Kristina Roesel

Ethical Norm 1/3:
From the Bible to Aristotle

Genesis 1:28
Dominium Terrae



"Nature has intrinsic purpose and therefore value"

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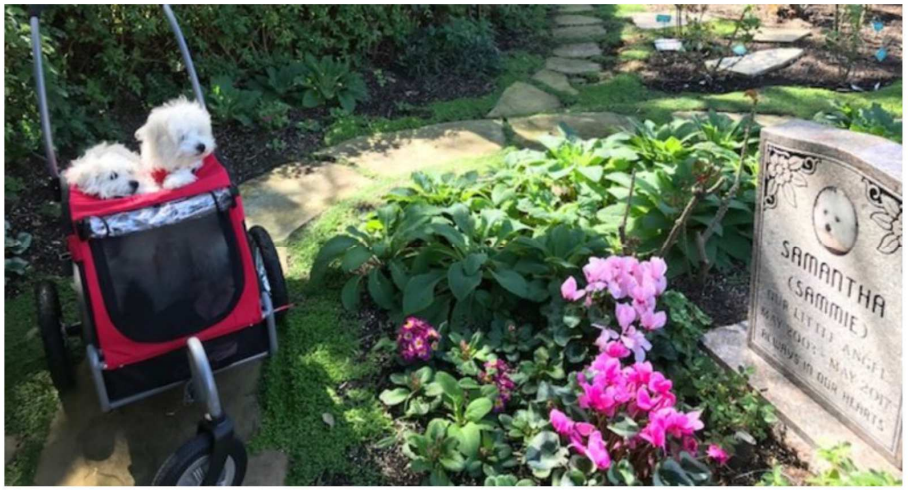
Ethical Norms 2/3:
The Humanization of Nature



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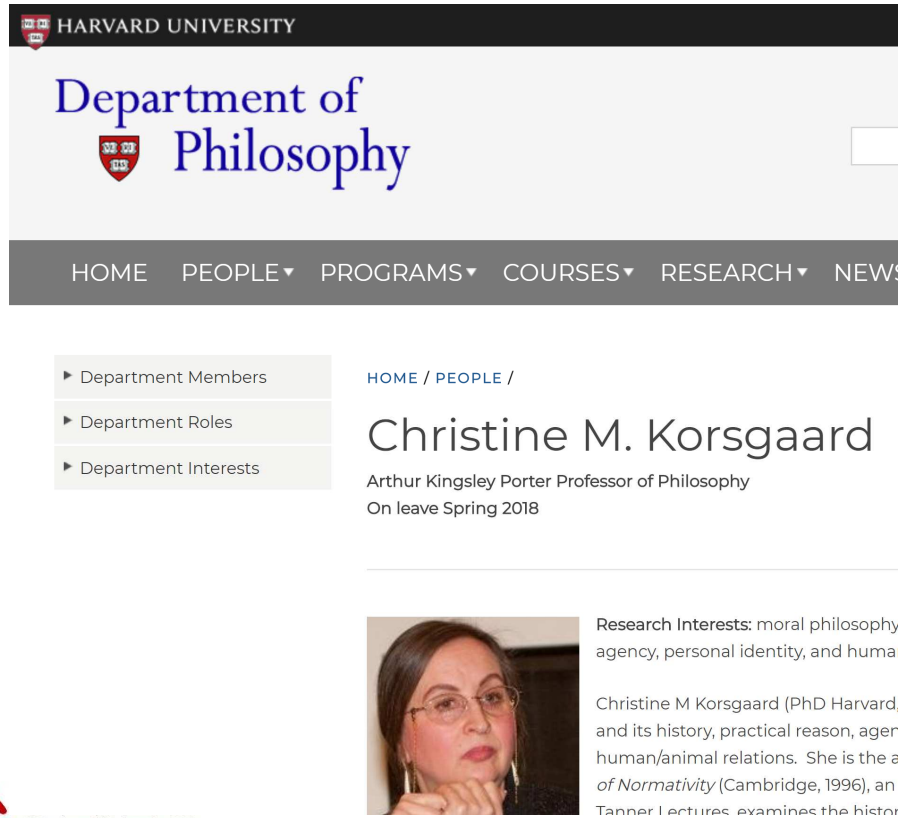
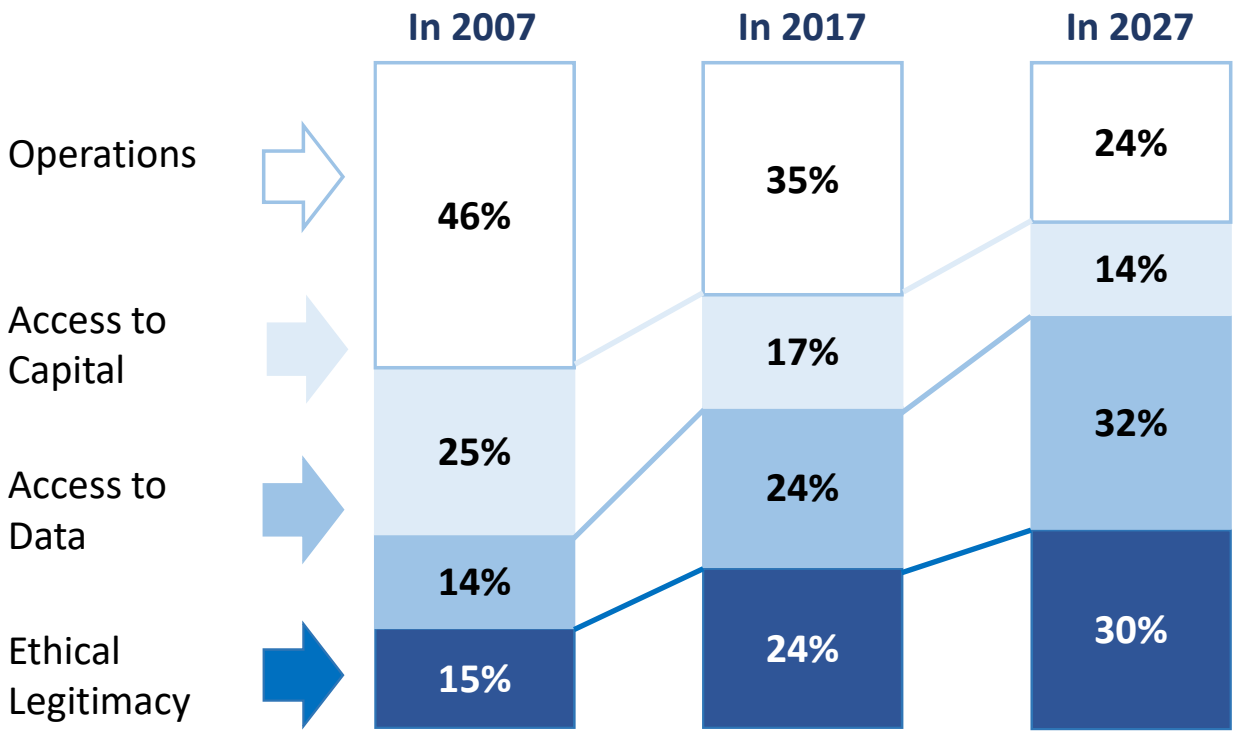
Ethical Norms 3/3:
Christine M. Korsgaard of Harvard University:



"Deaths and perhaps pains of some kinds of creatures should matter less to us than the deaths or pains of some others. Such deaths and pains should matter less, because — and only because — they matter less to the creatures themselves, not because the creatures matter less"

Q: What Will Be the Key Value Drivers? Answered by Top Decision Makers Food & Ag



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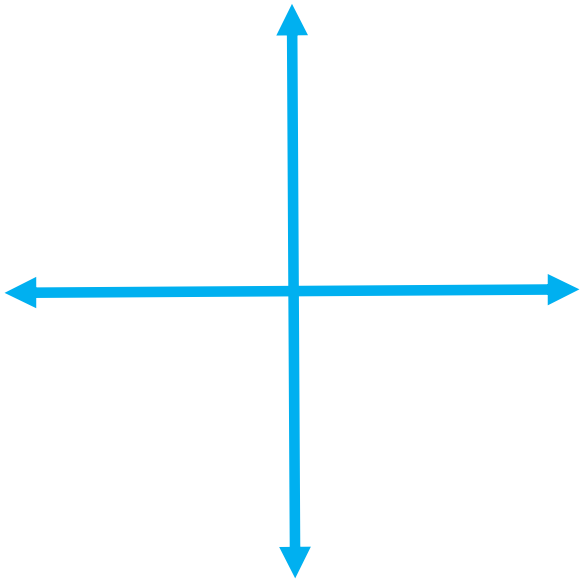
Source: Survey among top decision makers in the food and agribusiness industries, June 2017

Rates of Innovation (X) and Land Utilization (Y) Create Four Global Food Scenarios for 2050

INcrease
Global Ag Land by 10%*

Innovation
Proceeds at
Current Pace



Innovation
Speed
Doubles

DEcrease
Global Ag Land by 10%

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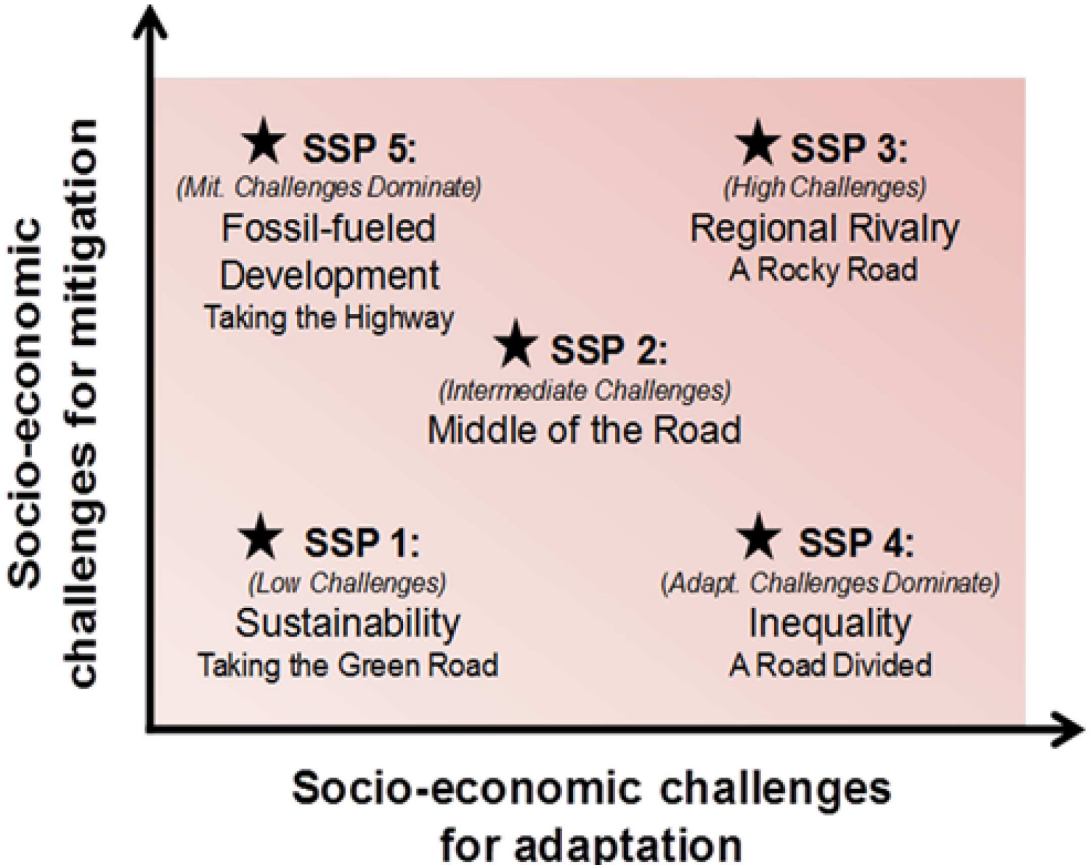
Source: Ederer et al, CEIBS / Wageningen University and Research

In the Standard Scenarios of the IPCC, there is no option of innovating ourselves towards sustainability (shared socioeconomic pathways))



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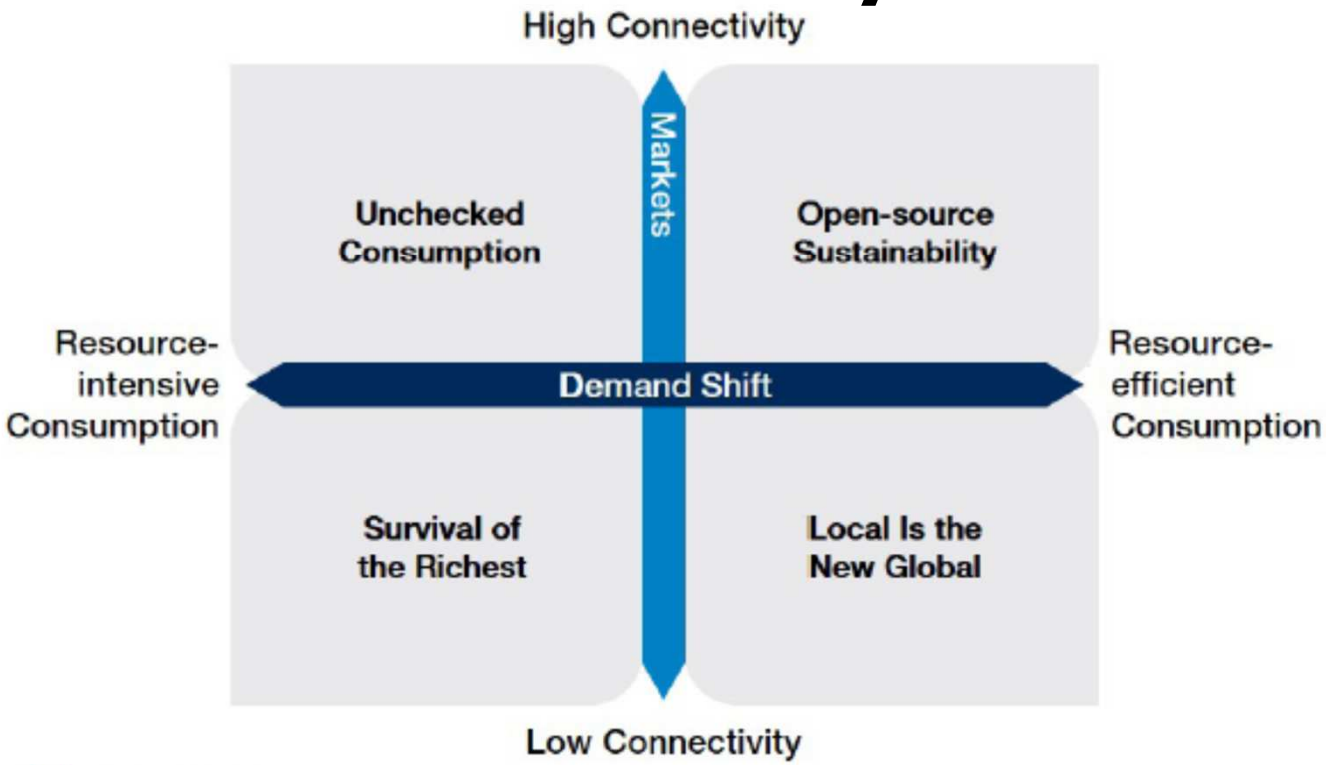
The World Economic Forum does not consider innovation and technology to be a critical uncertainty



Predictable Forces of Change: In tackling the focal question, a scenarios analysis first identifies trends whose future impacts are relatively certain. These include predictable developments such as demographic trends – for example, global population growth from now through 2030 can be taken as a given. For this analysis for instance, experts advised that climate change is a given – that global average temperatures will increase, bringing increased volatility and associated impacts on food systems. We incorporate that and other assumptions, such as the development of new technologies, into all future scenarios.

Critical Uncertainties: A scenarios analysis is built around the forces of change that will most profoundly and unpredictably impact the focal question. For this report, these include topics ranging from disruptive technologies to migration. After compiling a long list, experts chose the following two most critical uncertainties as the focus for this analysis:

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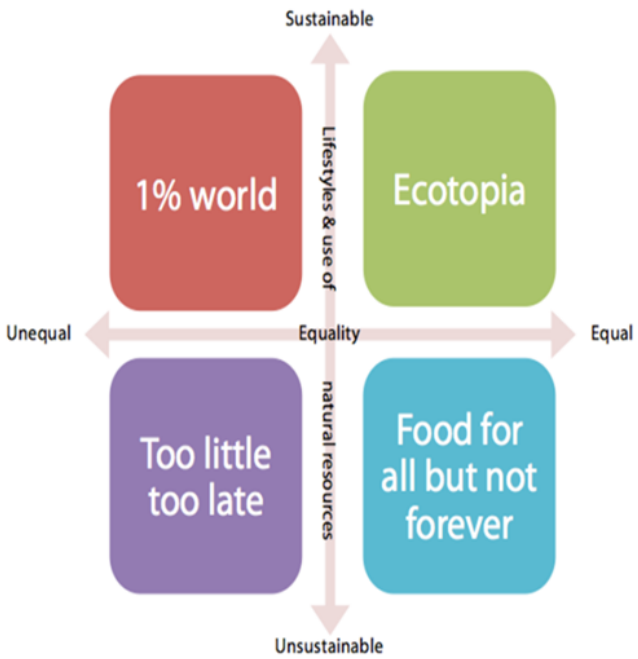
Foodsecure – EU research project (18 universities and more associated 2012-2017)



One percent world (ONEPW)

Investment in technology in hands of happy few, acting in the interest of the community.

Ecotopia (ECO)

Lower but more inclusive growth. Reduced consumer aspirations of elite consumers, behaviour change.

Food for all but not forever (FFANF)

A kickback from unsustainable use of resources leading to environmental breakdown and high costs of inaction.

Too little too late (TLTL)

Stagnation, fragmentation, environmental crisis, continuation of rising inequalities and lack of innovation

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Dr Michiel van Dijk (of Wageningen Univ.):

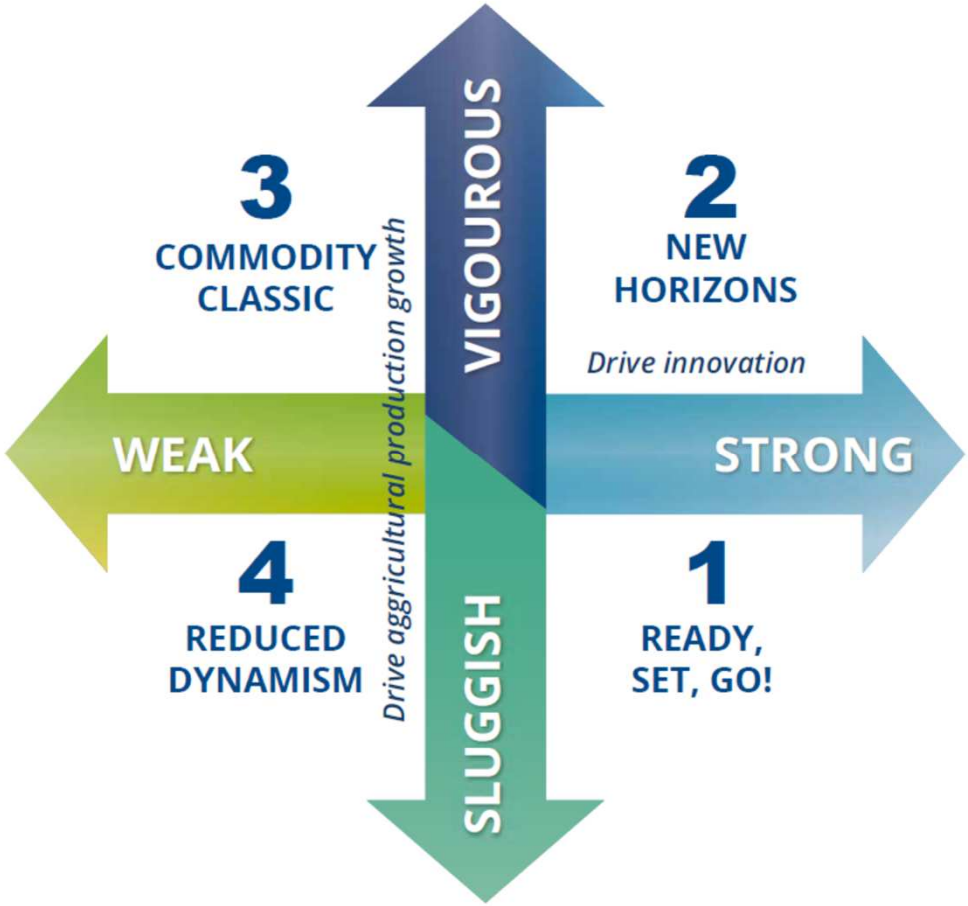
Table 3: Key drivers assumptions (global level) by scenario

Scenario exercise	Scenario	Population in 2050 (billion)	GDP growth (% per annum)	Cereal productivity (% per annum)	Crop area increase (% per annum)
SRES	A1F2	8.7	3.6	[1]	-
	A2	11.3	2.3	[1]	-
	B1	8.7	3.1	[1]	-
	B1	9.3	2.8	[1]	-
MA	Global orchestration	8.1	-	1.0	0.01
	Techno garden	8.8	-	~0.9	0.11
	Adapting mosaic	9.5	-	~0.6	0.23
	Order from strength	9.6	-	0.5	0.34
CAWMA	Pessimistic rainfed	8.9	2.2	1.4/0.7 (rainfed/irrigated)	0.14/0 (rainfed/irrigated)
	Optimistic rainfed	8.9	2.2	0.4/0.6 (rainfed/irrigated)	1.06/0 (rainfed/irrigated)
	Expanding irrigated areas	8.9	2.2	0.4/0.7 (rainfed/irrigated)	0.56/0.66 (rainfed/irrigated)
	Improving irrigation performance	8.9	2.2	0.4/1.5 (rainfed/irrigated)	0.66/0.18 (rainfed/irrigated)
	Trade	8.9	2.2	1.2/1.7 (rainfed/irrigated)	0.44/0 (rainfed/irrigated)
	Optimistic	-	2.2	1.1/1.1 (rainfed/irrigated)	0.32/0.78 (rainfed/irrigated)
IAASTD	Reference scenario	8.2	3.1	1.02	0.18/0.06 (rainfed/irrigated)
	High AKST	-	3.1	1.43	-
	High AKST High	-	3.3	1.63	0.15/0.08 (rainfed/irrigated)
	Low AKST	-	2.9	0.61	-
	Low AKST Low	-	2.9	0.41	0.21/0.05 (rainfed/irrigated)
WAT 2050	Baseline	9.2	3.1*	0.7/0.6 (rainfed/irrigated)	0.2
Agrimonde	Agrimonde GO	8.8	-	0.87	0.41
	Agrimonde 1	8.8	-	0.14-0.98	0.78
IMPACT 2050	Pessimistic	10.4	0.9	[3]	-
	Baseline	9.1	2.5	[3]	-
	Optimistic	7.9	3.2	[3]	-
GEO 5	Conventional worlds	-	-	-	0.23
	Sustainable worlds	-	-	-	-0.05

Note: All figures are transformed to annual growth rates or 2050 levels to make outcomes comparable across studies; [1] See Parry et al. (2004) for yield change maps; [2] From Alexandratos (2006); [3] For CSIRO A1B climate change scenario. See Nelson et al. (2010) for other climate change scenarios.

Source : Parry et al. (2004); Carpenter et al. (2005); de Fraiture et al. (2007); McIntyre et al. (2009); Bruno and Paillard (2009); Nelson et al. (2010); Reilly and Willenbockel (2010) Alexandratos (2011) and UNEP (2012).

The strategic scenarios of the International Fertilizer Organization (unpublished)



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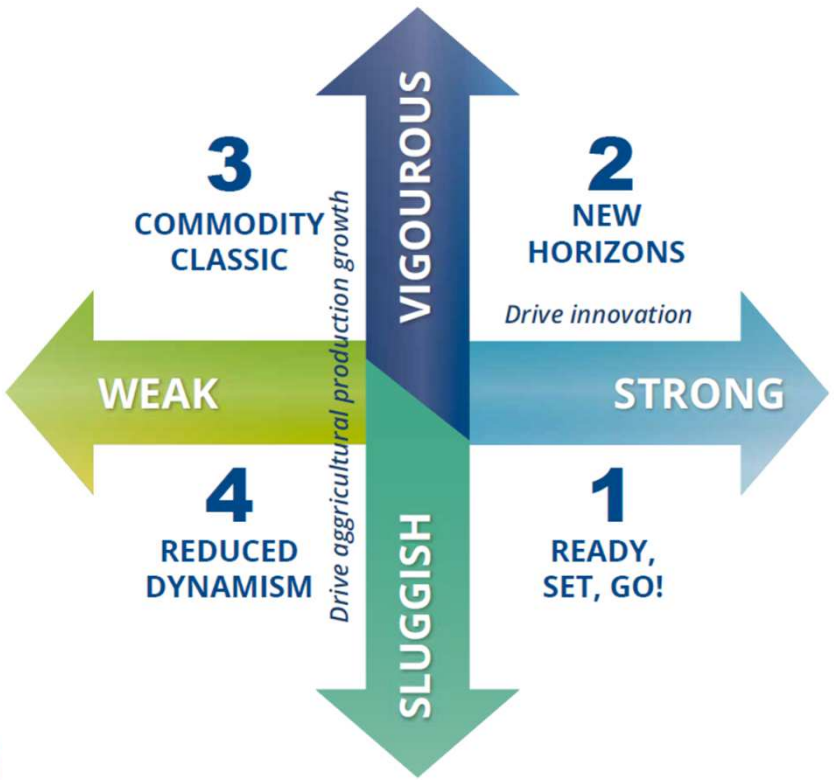
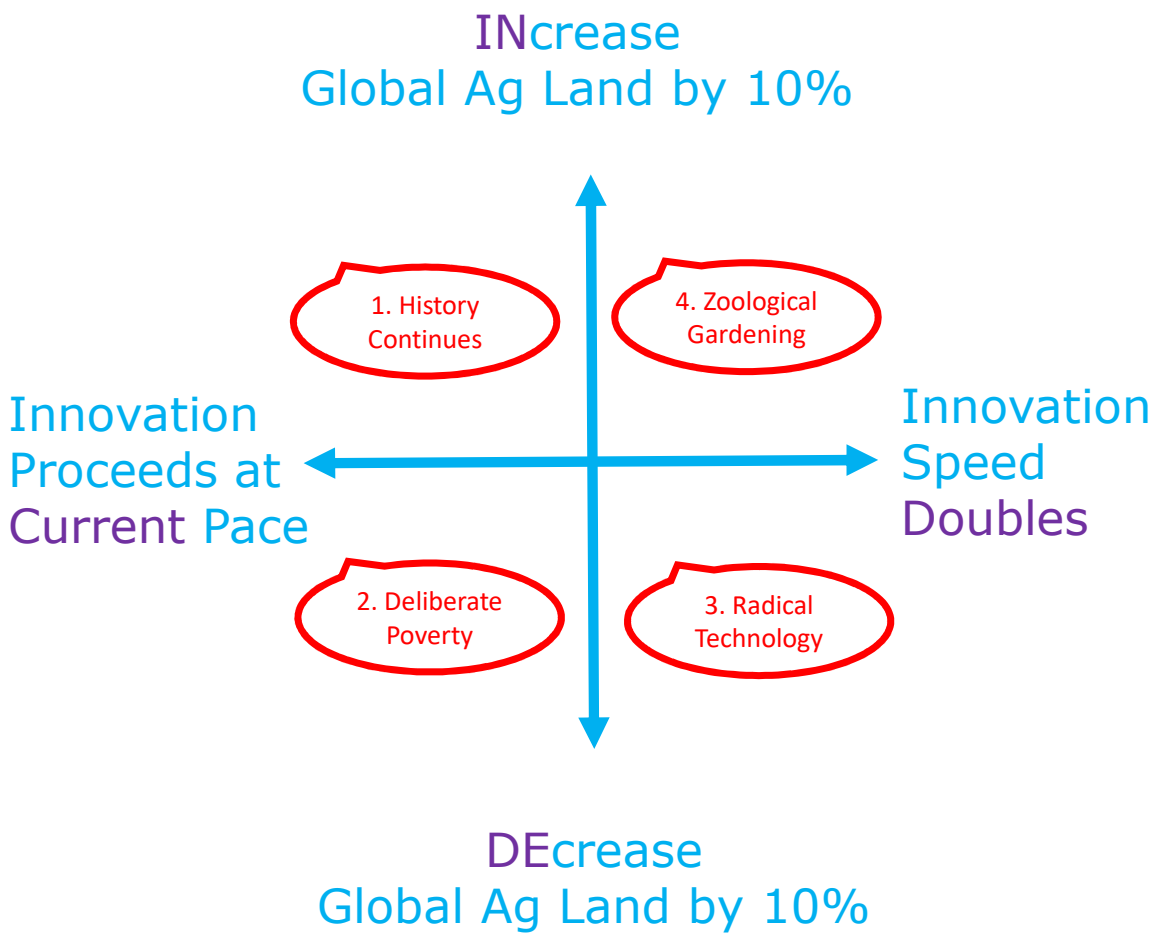
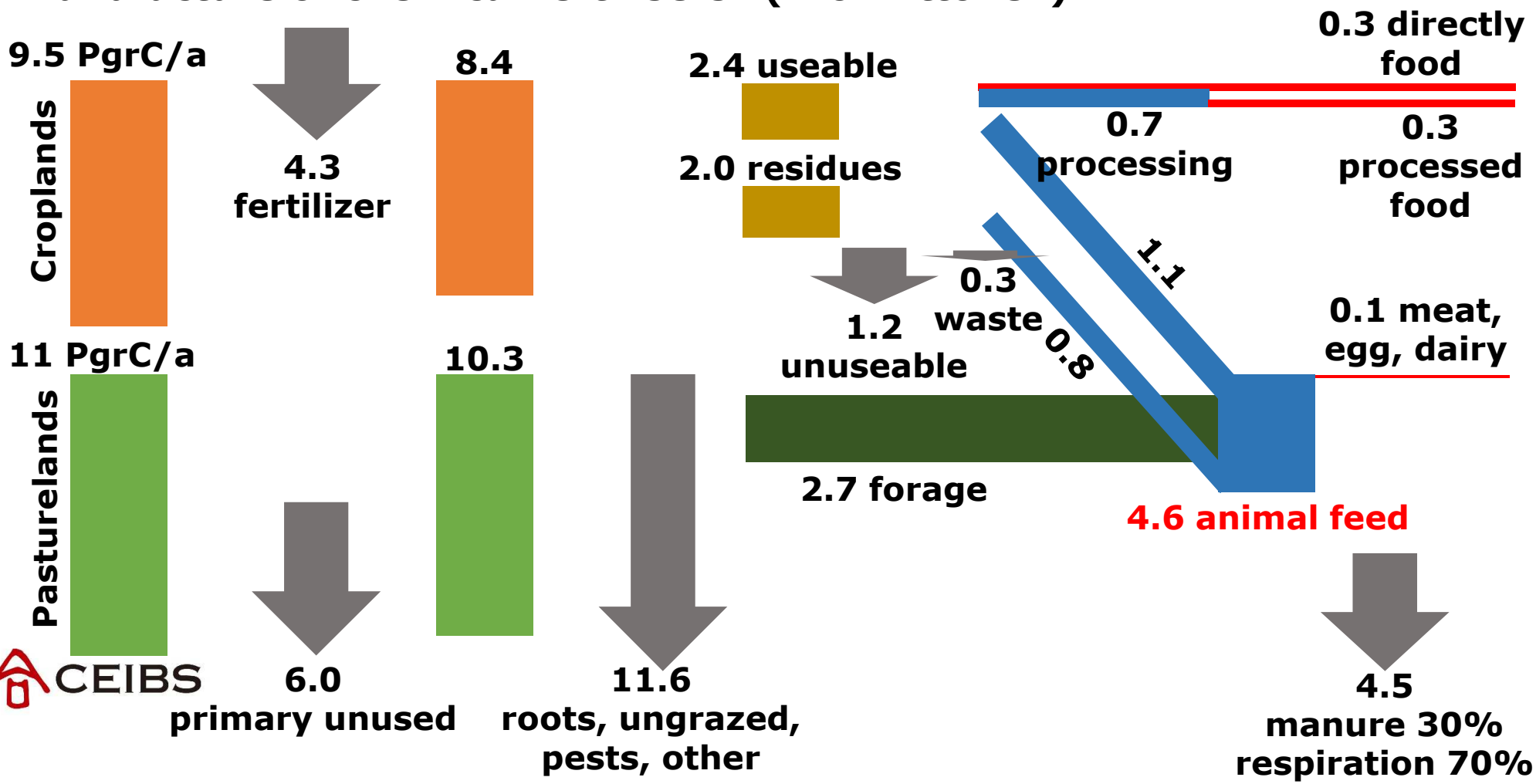
...similarities are not coincidental...





"Of the total energy contained in one grain of maize produced in high input agriculture about 70% comes from fossil fuels. More than 30% of this energy is used in the manufacture of chemical fertilisers" (Prof Tittonell)



Source: Bajželj et al, Univ. of Cambridge 2014 own modelling analysis

Thank you.

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