Robust, Complex, Resilient and Efficient Food Systems for the 21st Century

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A Tale of Two Futures……

We live in the best of times….we live in the worst of times.

As humans we have the possibility of a great future – but we have a very very very big problem to overcome –

Global overheating leading to extreme CLIMATE CHANGE

Relatives and absolutes

One can improve the efficiency of use of fossil fuels and produce more efficiently but this does not mean that GHG emissions are reduced

Why?

Emissions are a combination of production and consumption

More from less and enough from less

Improving efficiency gives you more from less but still increases emissions

Improving efficiency and limiting consumption gives you enough from less and limits emissions

What does a food and economic system looks like for ‘enough from less’?

Four hypotheses

'When the facts change – I change my mind. What do you do?'
JM Keynes

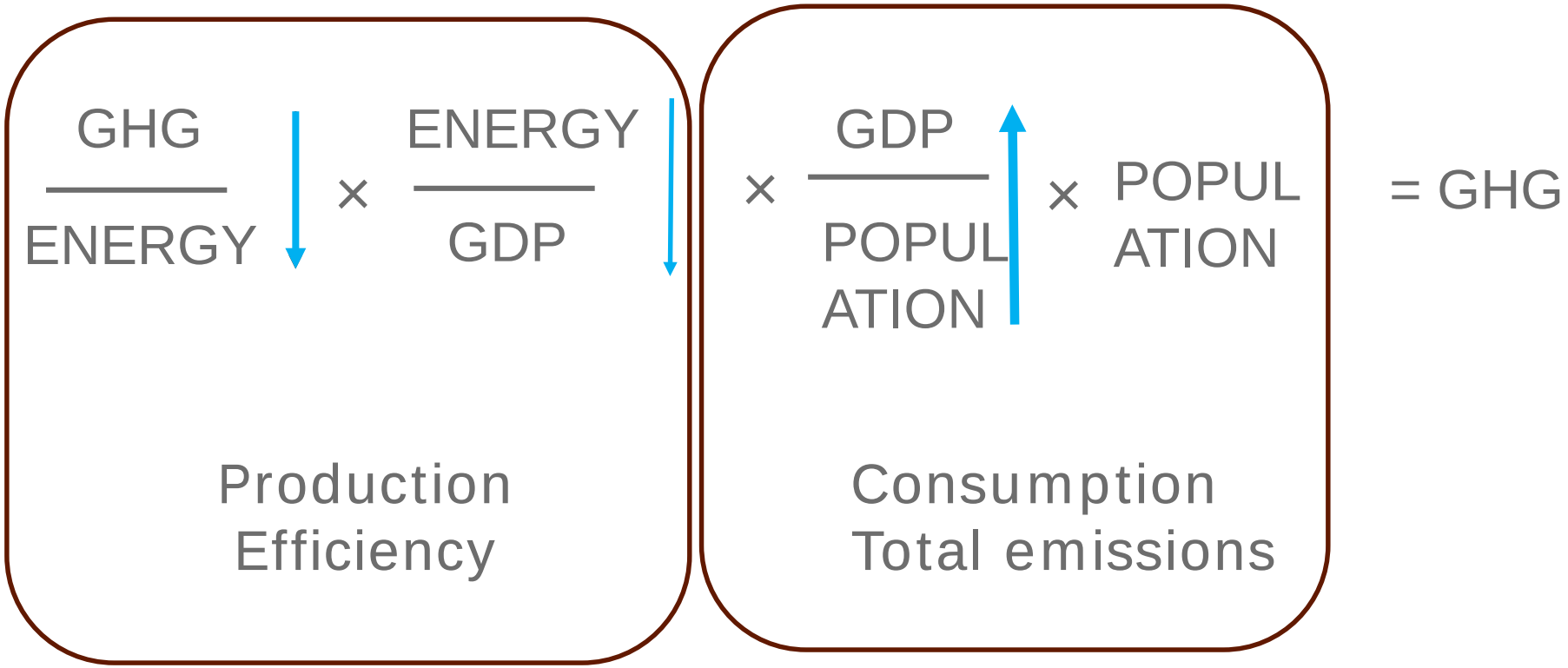
More from less does not lead to increased robustness: system redundancy is a good thing

Increased complexity can and cannot lead to increased robustness and resilience

Decreased robustness leads to decreased efficiency

Increased robustness leads to increased efficiency and resilience

Relative and Total GHG emissions



JRP's Simple Agricultural GHG Equation (KPI)

$$\frac{\text{YIELD}}{\text{AREA}} \times \frac{\text{ENERGY}}{\text{YIELD}} \times \frac{\text{GHG}}{\text{ENERGY}} \times \text{AREA} = \text{GHG}$$

Production Technology Fuels

Porter 2009

The KPI

Yield (productivity)

Carbon intensity of the energy

Energy use efficiency

Land-use change

$$GHG_{crop} \equiv \left(\frac{GHG_{LUC}}{E_{out}} + \frac{GHG_{soil}}{E_{out}} + \left(\frac{GHG_{energy}}{E_{in}} \times \frac{E_{in}}{E_{out}} \right) \right) \times \frac{E_{out}}{DM_{out}} \times \frac{DM_{out}}{Area} \times Area$$

Total emissions

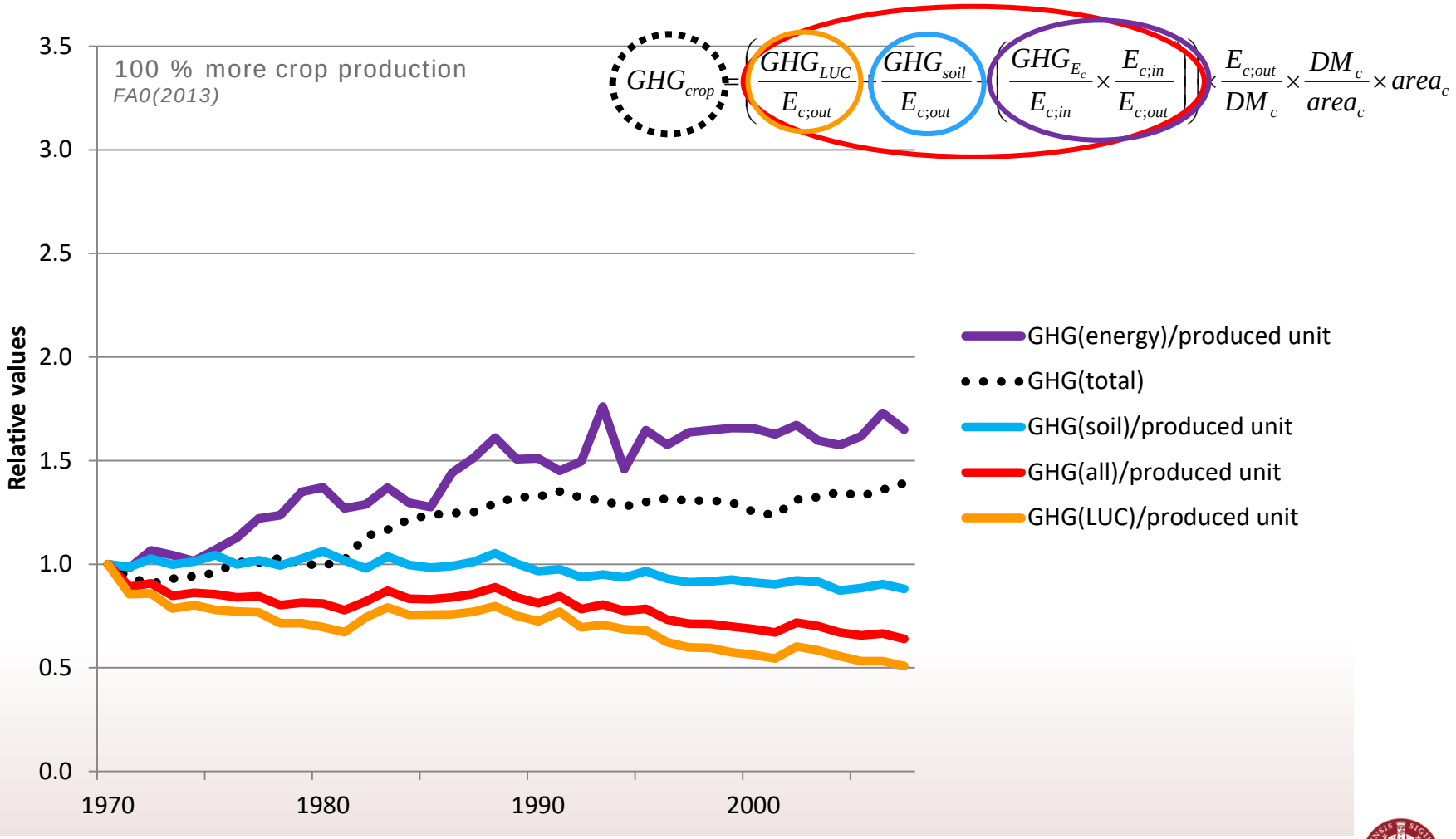
Emissions from soils

Cultivated area

Deconstruction
Management ‘handles’

Bennetzen *et al*. 2016

Emissions per produced crop



Bennetzen *et al*. 2016

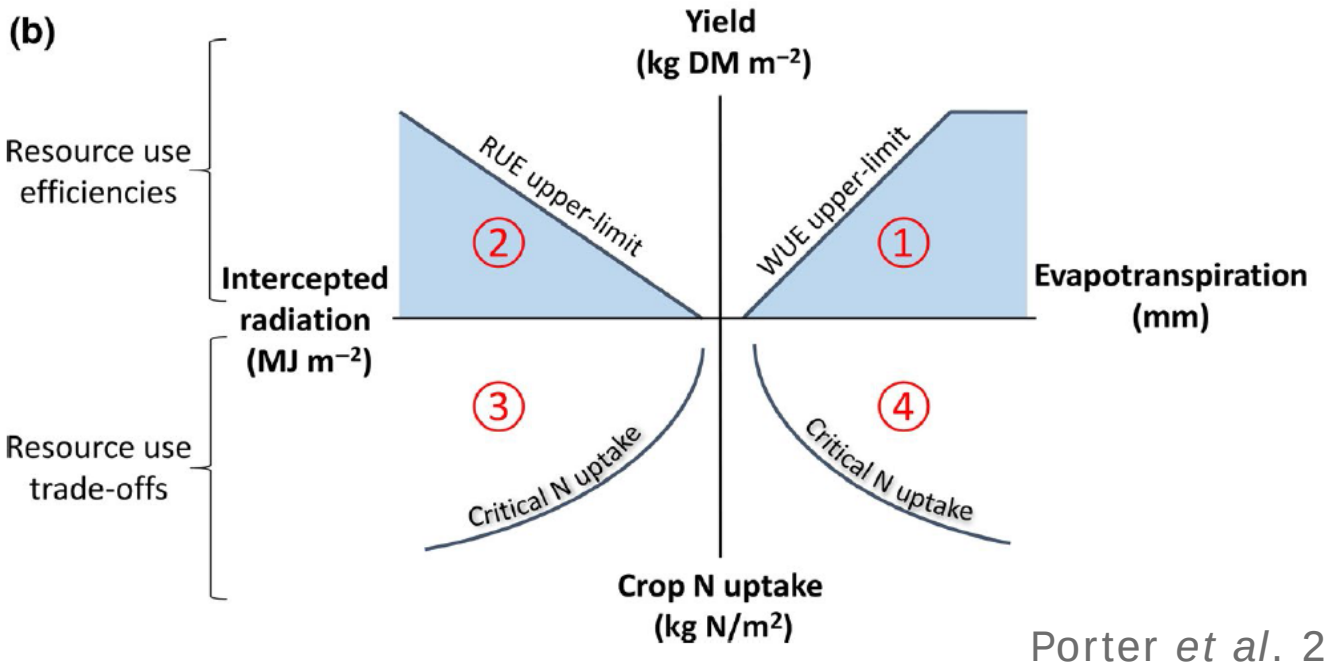
Resource Use Efficiencies Interact

(a)

$$\frac{\text{Yield}}{\text{Evapotranspiration}} \equiv \frac{\text{Yield}}{\text{Intercepted radiation}} \times \frac{\text{Intercepted radiation}}{\text{N uptake}} \times \frac{\text{N uptake}}{\text{Transpiration}}$$

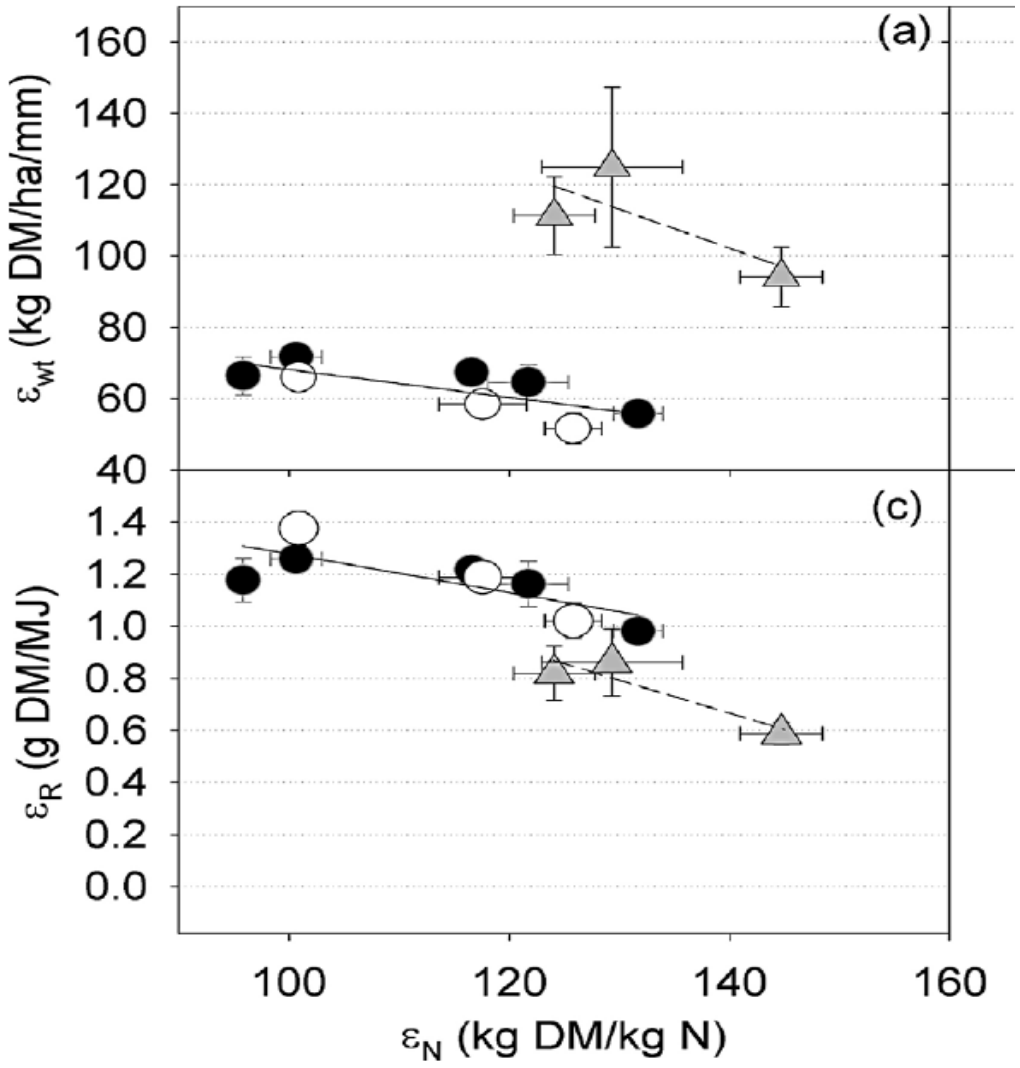
①	②	③	④
Water use efficiency (WUE)	Radiation use efficiency (RUE)	Radiation– N utilization trade-off	Nitrogen – water Utilization trade-off

(b)



Porter *et al*. 2019

Resource use efficiencies interact – Lincoln NZ



Teixiera *et al*. 2019

Connecting wealth, health, consumption and GHG emissions

Kaya identity
(Raupach & Field, 2004)

$$GHG_{kaya} = \frac{GHG}{energy} \times \frac{energy}{GDP} \times \frac{GDP}{capita} \times population$$

KPI
(Bennetzen et al, 2012)

$$GHG_{KPI} = \frac{GHG}{energy} \times \frac{energy}{drymatter} \times \frac{drymatter}{area} \times area$$

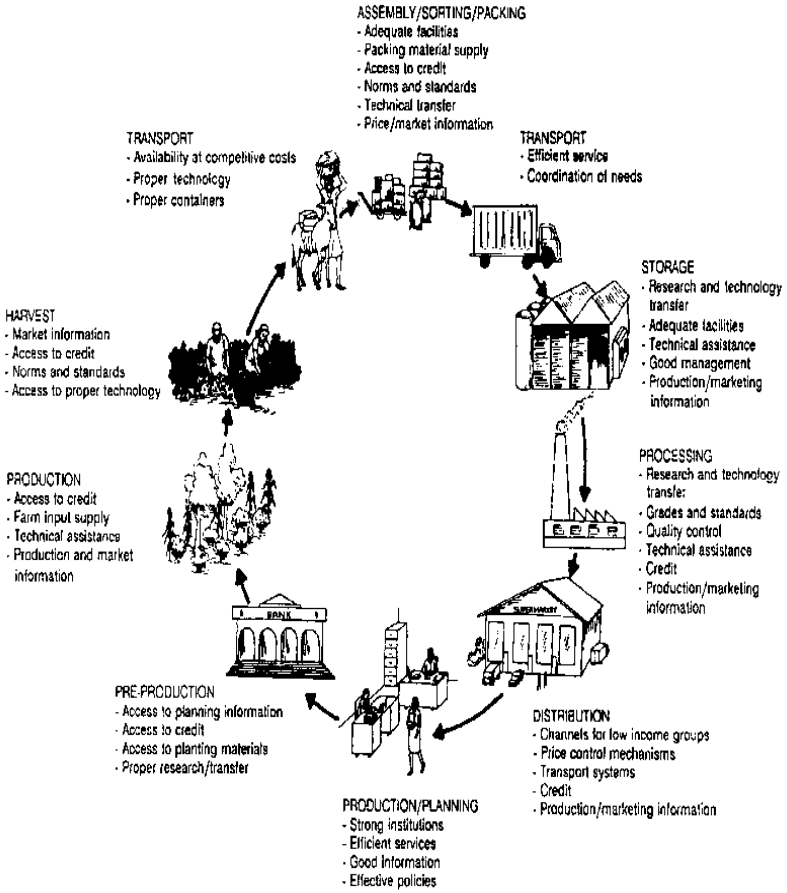
Diet demand

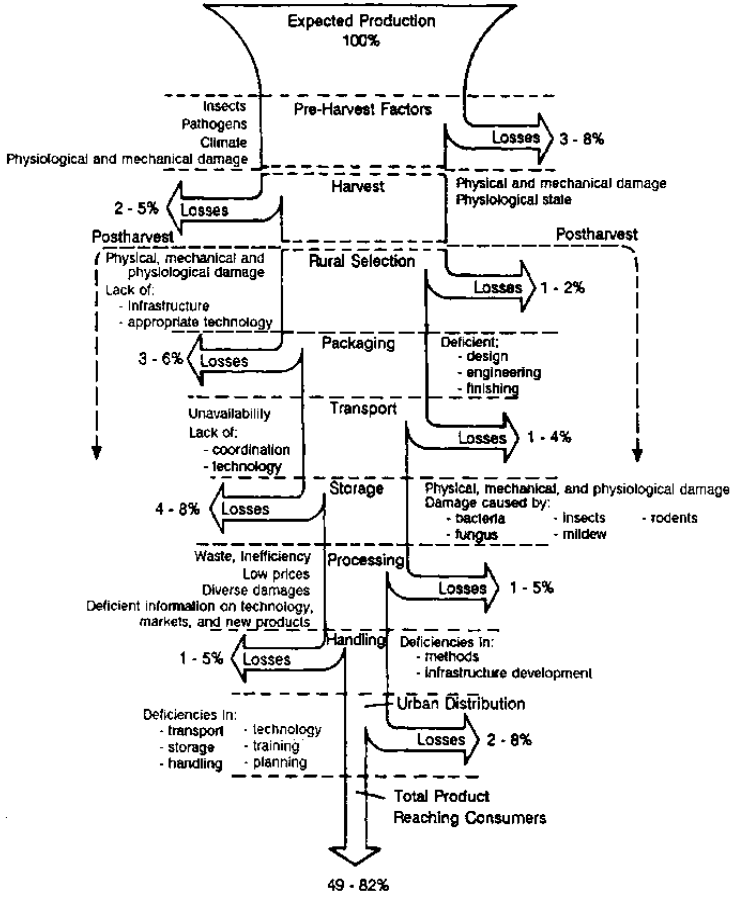
$$Demand = \frac{animalprot.}{totalprot.} \times \frac{totalprot.}{calorie} \times \frac{calorie}{capita} \times population$$

Diet supply

$$GHG = \frac{GHG_{bio}}{energy_{bio}} \times \frac{energy_{bio}}{animalpop.} \times animalpop.$$

Linear and circular





Circular Food Systems

1. Plant biomass is the basic building block of food and should be used by humans first;
2. Avoid food and resource losses and waste;
3. By-products from food production, processing and consumption should be recycled back into the food system;
4. Use animals for what they are good at.

Van Ittersum et al 2019

Four hypotheses

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Increased robustness leads to increased efficiency and resilience

Enough from Less

The Economist – ‘Capitalism must up its game; orthodox market economics has been useless in the current virus pandemic’

Have I got enough? How can I use less?

A robust, flexible, resilient and efficient food system and society needs insurance and assurance

How comfortable do we actually feel at present?

Thank you.