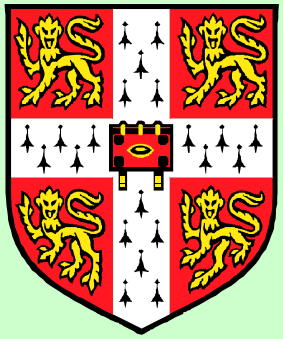
Assessing food sustainability



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What are the major problems in the world today?

For the world in general (and hence for humans)

Selfish, unplanned human use of world resources and harms to animals and plants.

Actions that cause climate change.

For humans

Anti-microbial resistance (AMR). Tuberculosis is again a major disease; it causes 1.6 million human deaths per year.

New diseases, some caused by careless human exploitation of other animal species. (Petrovan et al 2021)

(Secondary issues are terrorism, hunger, corruption.)

There is only **One Biology.**

Almost all human biological processes occur in other species, thus laboratory use.

A big attitude change is needed.

Who are 'we'?

Humans are animals.

'We' are not just humans, the term 'we' should encompass all sentient animals.

Sustainability

A key question about any production system is whether it is sustainable?

A system or procedure is sustainable if it is acceptable now and if its expected future effects are acceptable, in particular in relation to resource availability, consequences of functioning and morality of action.

We should consider what might be acceptable to other species.

The public has more information now and increasingly demands sustainability.

QUALITY of food and other products: now includes ethics of production method.

CHANGE FROM A PUSH ECONOMY TO A PULL ECONOMY

40-50 years ago, people in richer countries stopped buying some products on moral grounds, e.g. carpets and clothes made by child labour.

20 years ago, the public wanted agriculture products but farmers determined how they were produced.
Then Fair Trade and Welfare-Friendly products were demanded.

Consumers now exert control over more aspects of the production system.

What makes a production system unsustainable and results in product quality being judged as poor?

Adverse effects on human welfare, including (i) human health

Poor welfare of animals used for food production or otherwise affected

Unacceptable genetic modification

Harmful environmental effects - climate change and biodiversity reduction

Inefficient usage of world food resources

Human welfare (ii) not "Fair trade" – producers in poor countries do not receive a fair reward

Human welfare (iii) not preserving rural communities

How important are these? How do we put them all together?

How do we measure each component of sustainability?
A scoring system based on scientific and other quantitative evidence is needed.

Adverse effects on human welfare, including (i) human health

However, the main impact comes from people not buying the product and this will be measured by producers.

Example:
Saturated fats led some to avoid animal products.

Measures.
Direct methods: score mortality rate, morbidity rate, improved welfare if product used/consumed.

Public opinion surveys provide information about acceptability of health impacts.

How do we measure each aspect of sustainability?

Welfare of animals used for food production or otherwise affected

For the public, welfare of animals is the most important part of sustainability. Welfare: assessed using a wide range of scientific measures, varies from good to poor.

We now have much scientific evidence about the welfare of animals kept for food. There is less evidence about the welfare of animals affected by plant production.

Unacceptable genetic modification

Many people will not buy products associated in any way with GM (GM includes gene-editing).

Antipathy to genetically modifying or cloning: more if it is animals that are changed than if plants are changed.

For any GM product, different laws are needed because the rate of change can be much faster or fundamentally different from conventional breeding.

Measurements: (a) actual effects of GM,
(b) measurements of public acceptance.

How do we measure each aspect of sustainability?

Inefficient usage of world food resources is likely to become much more important as a factor affecting plant and animal production.

Agricultural products How can we reduce food waste?
Pass on edible food to other people. Feed food waste to pigs etc. (after treatment).

Animals that eat leaves and other food that humans cannot eat, such as ruminants and herbivorous fish, will become more important than animals that are carnivores or that eat grain.

Eat the wheat, maize, soya etc. that is produced rather than feeding it to pigs or poultry.
Do not feed it to ruminants as they can eat food that we cannot eat.
Dairy cows should not be fed grain. Negative energy balance if more than 30%.
Ruminants are an important source of human food for the future

Measure land area required, amount of water required per unit of product.

How do we measure each aspect of sustainability?

Harmful environmental effects

- climate change measure greenhouse gas production
- biodiversity reduction, indices of biodiversity
- water pollution, measures of pollutants and consequences

Agricultural products

For food and system comparison, we need figures for externalities per unit of food production.

Palm oil

Soya

Methods for producing sugar, maize, wheat, rice.

Crop burning in Asia gives off 379 m. tonnes CO_2 p.a. (34% of all from burning solids in Asia).

Animal production: plant production.

Some consumers are avoiding animal products in order to reduce climate change.

Cell-cultured meat likely to be widely produced, if shown to be sustainable.

How do we measure each aspect of sustainability?

6. Human welfare (ii) not "Fair trade" – producers in poor countries do not receive a fair reward

Agricultural products

Main measure is what consumers buy.

7. Human welfare (iii) not preserving rural communities

Agricultural products

Measure using public opinion questionnaires.

Measure human population movement.

Systems for the future? What is the future for agriculture in the world?

Consumers in more and more countries have concerns about biodiversity and animal welfare. Biodiversity decline is very rapid on farmed areas. Do we care?

Should **conservation** be just tiny islands of natural vegetation in a relatively barren world of agriculture (land-sparing)?

Plant production from a mixture of herbs shrubs and trees is much greater than than from a single level pasture system.

Use nitrogen-fixing shrubs such as *Leucaena* in semi-intensive silvopastoral systems.

. Greater biodiversity
. Less pollution run-off because of water-holding properties of soil
. Less methane production per kg of meat
. Better carbon sequestration
. Less disease, better welfare

How to compare? Objective method using all components of sustainability needed.
Comparisons using money, carbon usage or energy use do not work for all.

Beef production systems.
(systems considered)

EXAMPLE
(Broom 2021)

Extensive pasture, degraded

Extensive pasture, not degraded

Fertilised irrigated pasture, plus concentrates

Fertilised irrigated pasture, no concentrates

Fertilised irrigated pasture, then feedlot

Extensive pasture, then feedlot

Fertilised irrigated pasture, then indoor housing

Extensive pasture, then indoor housing

Indoor rearing, then indoor housing

Semi-intensive silvopastoral

Sustainability components

In scoring each of these, the whole system was considered, e.g. all food production, fertilizer usage etc.

Quantitative scientific evidence and evidence from well-conducted surveys of public opinion were used.

Overall negative effects were considered in these calculations

Sustainability components considered in this study of beef production systems:
Scored 0 to -5. Z noted if some consumers avoid completely

Human welfare: health

Welfare of cattle

Efficiency of use of world resources: land usage

Efficiency of use of world resources: land area per kg meat

Efficiency of use of world resources: amount of water per kg meat

Greenhouse gas production per unit of product

Extent of water pollution and nitrogen/phosphorus cycle disruption

Biodiversity decline

Reduction in carbon sequestration

Genetic modification, fair trade, rural community harms (all 0 for this comparison)

Beef production system	Sustainability component Land area to produce 1kg. beef
Extensive pasture, degraded	-5, Z
Extensive pasture, not degraded	-3
Fertilised irrigated pasture, plus concentrates	-3
Fertilised irrigated pasture, no concentrates	-2
Fertilised irrigated pasture, then feedlot	-2
Extensive pasture, then feedlot	-4
Fertilised irrigated pasture, then indoor housing	-2
Extensive pasture, then indoor housing	-4
Indoor rearing, then indoor housing	-3
Semi-intensive silvopastoral	-1

Beef production system	Sustainability component Cattle welfare
Extensive pasture, degraded	-3
Extensive pasture, not degraded	0
Fertilised irrigated pasture, plus concentrates	0
Fertilised irrigated pasture, no concentrates	0
Fertilised irrigated pasture, then feedlot	-2, Z
Extensive pasture, then feedlot	-2, Z
Fertilised irrigated pasture, then indoor housing	-3, Z
Extensive pasture, then indoor housing	-3, Z
Indoor rearing, then indoor housing	-4, Z
Semi-intensive silvopastoral	0

Beef production system	Sustainability component Greenhouse gas production
Extensive pasture, degraded	-5, Z
Extensive pasture, not degraded	-3
Fertilised irrigated pasture, plus concentrates	-2
Fertilised irrigated pasture, no concentrates	-2
Fertilised irrigated pasture, then feedlot	-1
Extensive pasture, then feedlot	-2
Fertilised irrigated pasture, then indoor housing	-1
Extensive pasture, then indoor housing	-3
Indoor rearing, then indoor housing	-1
Semi-intensive silvopastoral	-1

Beef production system	Sustainability component total of all components
Extensive pasture, degraded	-26, ZZ
Extensive pasture, not degraded	-12
Fertilised irrigated pasture, plus concentrates	-23
Fertilised irrigated pasture, no concentrates	-16
Fertilised irrigated pasture, then feedlot	-25, Z
Extensive pasture, then feedlot	-25, Z
Fertilised irrigated pasture, then indoor housing	-26, Z
Extensive pasture, then indoor housing	-26, ZZ
Indoor rearing, then indoor housing	-29, Z
Semi-intensive silvopastoral	-5

Conclusions

1. Sustainability is a wide-ranging concept with many components.

2. In order to evaluate sustainability, this simple scoring system takes into account all relevant components.

3. Scores are allocated using the available scientific literature concerning each component, also a category for factors unacceptable to some consumers.

4. Beef production systems: wide range, best much better than worst.

5. Least sustainable beef production systems: extensive grazing that causes land degradation and the use of feedlots or indoor housing with grain feeding.

6. Most sustainable: semi-intensive silvopastoral systems .
Well-managed pasture-fed beef from land where crop production is uneconomic is also sustainable.

5. The scoring system and results could be of value for policy makers, researchers, producers, organisations aiming to improve sustainability, and the general public.

References.

Balmford, A., Amano, T., Bartlett, H., Chadwick, D., Collins, A., Edwards, D., Field, R., Garnsworthy, P., Green, R., Smith, P., Waters, H., Broom, D.M., Chará, J., Finch, T., Garnett, E., Gathorne-Hardy, A., Hernandez-Medrano, J, Herrero, M., Hua, F., Latawiec, A., Misselbrook, T., Phalan, B., Simmons, B., Takahashi, T., Vause, J., zu Ermgassen, E. and Eisner, R. 2018. The environmental costs and benefits of high-yield farming. *Nature Sustainability,* 1, 477- 485. doi 10.1038/s41893-018-0138-5

Broom, D.M., Galindo, F.A. and Murgueitio, E. 2013. Sustainable, efficient livestock production with high biodiversity and good welfare for animals. *Proceedings of the Royal Society B. 280, 20132025.*

Broom, D.M. 2019. Land and water usage in beef production systems. *Animals*, 9, 286. doi:10.3390/ani9060286

Broom, D.M. 2021. A method for assessing sustainability, with beef production as an example. *Biological Reviews*, doi: 10.1111/brv.12726

Herrero, M. et al 2010. Smart investments in sustainable food production: revisiting mixed crop-livestock systems. *Science* 327, 822–825.

Murgueitio, E., Cuartas, C. A. and Naranjo, J. F. 2008. *Ganadería del Futuro*. Fundación CIPAV, Cali.

Petrovan, S.O., Aldridge, D.C., Bartlett, H., Bladon, A.J., Booth, H., Broad, S., Broom, D.M., Burgess, N., Cleaveland, S., Cunningham, A.A., Ferri, M., Hinsley, A., Hua, F., Hughes, A.C., Jones, K., Kelly, M., Mayes, G., Radakovic, M., Ugwu, C.A., Uddin, N., Verissimo, D., Walzer, C., White, T.B., Wood, J. and Sutherland, W.J. 2021. Post COVID-19: a solution scan of options for preventing future zoonotic epidemics. *Biological Reviews*, doi: 10.17605/OSF.IO/5JX3G