Discussing some elements of energy balance and water balance and sustainable crop production

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The concept of ‘sustainablility’

The Bruntland Commision did define ‘sustainable development’ as development that meets the needs of the present without compromising the ability of future generations to meet their own needs.’

Sustainability relates to the continuity of economic, social, institutional and environmental aspects of human society; as well as the non-human environment.

The concept of ‘sustainablility’

The biological world including man is considered and interpreted as basically a relational system.

Man and the societies of man are elements of this system. ’Sustainability’ means the continuity of the social institutions and the next generations.

All the important relations of man has to be maintained in order to achieve sustainable development.

The concept of ‘sustainabiity’

’Sustainability ’ means that man achieves order in his relations. Then he must understand his relations.

Also man as an individual or as a leader of an institution or as a member of an institution actually must have care for the important relations when acting.

It is probably not possible to navigate the institutions and the environment towards some defined ideal end state. But it is probably possible act with care in our relations.

The biological world considered as a relational system

The biological world may be partly described in a database. One possibility is using a relational database. A human being then may be described as an object , an (n-tuple) containing relations to other parts of the biological world, including social constructions.

So the point is to understand and bring order and maintain in this relational system.

'Sustainability' then, once more , may be interpreted as the possibility to maintain some social constructions involving generations following each other.

Example of classification of reality in a relational database

In relational databases and in object-oriented numerical models of natural phenomena, the phenomena are classified, and the instances of the classes and the sub-classes are called objects.

Examples:

Man, parents, children, grand parents, farms, plants, crops, fields of cereals, leaves, apples, houses, trains, horses, precipitation, storms etc.

The “object” in a relational database system

The object of a class, is an instance/element of this class.

An object is defined as a relation or a subset of actual n-tuples.

An n-tuple is an ordered list of n objects.

An object in an n-tuple may appear at more than one place.

Developing social constructions

One must develop social constructions making it possible to take care of the important relations and making it possible for other groups (including other species) to care for their most important relations.

Later an example of a traditional Nordic farm will be discussed.

Agronomy of agricultural fields

Processes like plowing, sowing, 'harving',fertilization, weed management, management of pests and diseases, irrigation involves energy. Also water management are involved in some of the processes mentioned

Usually decision making connected to these processes are connected to economical concepts like money, because of the relational context of the crop production

When discussing sustainability parameters connected to water and energy transfer may be relevant

The agronomy of agricultural fields may partly described by the use of energy parameters

The energy balance and the water balance

It is possible to connect parameters called energy (the unit is Joule) or effect (unit is Joule per second) to many different processes, and energy is considered conserved. Therefore it is possible to describe the processes by using quantitative entities.

The water balance is connected to the energy balance

In processes containing different physical phases of water energy parameters may be attached to describe the processes. But usually also the mass of water is attached to the processes, and in the time scale and the spatial scale considered the mass of water is conserved.

The energy balance and the water balance of a cropped field

•The energy balance of a cropped field may be described by using the well known energy balance equation

$$R_n = H + \lambda E + S + D + J + \mu A$$

• The water balance of a cropped field is connected to the energy balance, and the most difficult element is the evaporation (Penman-Monteith):

$$\lambda E = [\Delta (R_n - S) + \rho C_p (e_w (T(z)) - e(z)) / r_a] / [\Delta + \gamma (1 + r_c / r_a)]$$

Irrigation of a potato field in Southern Norway

In Norway fields of potatoes and field grown vegetables are irrigated, and irrigation of potatoes is used as an example below. A traveller speed boom is used, having a discharge of 25-35 m^3/ hour at 3.0-4.5 bars pressure. The equipment is connected to a hydrant, and the water pressure is the source of distributing the water by the speed boom.

Growing season for potatoes and potential evaporation from the field is considered

May 17 to September 15,

week 21,22, 23,24, 25,26, 27, 28, 29,30, 31, 32, 33, 34,35,36, 37.

16 weeks

330 mm liquid water evaporated through potential evaporation

Water being added by irrigation : 100mm

Requirement of irrigation for each hectare

100mm means 10 x 1000 m^2 x 0.1 m= 1000 m^3

1000 tons of water or 1000 000 kg water

Requirement of energy to get this water lifted to 40 m above the field (to achieve a pressure of 4 bars)

gravitation of the earth g = 10 ms^{-2}

10^6 x g x 40 = 4 x10^6 Joule

or 4x10^2 Mjoule

Output of energy connected to the harvested crop

40 tons of potatoes

3.2 MJ pr. kg

3.2x 4 x 10^4 MJoule

9.6 x10^5 MJoule

Energy connected to each ton of crop

3.2 10^3 MJoule pr. ton

Rough estimate of energy connected to transport by small truck (15 tons capacity and a short hours drive))

Energy connected to each ton of crop

$3.2\ 10^3$ MJoule pr. ton

Energy content in irrigating 1 ton of crop

10 MJoule pr, ton

The energy content of 1l of diesel fuel is about

38.5 MJ

1 liter diesel fuel is considered used for transporting one ton of potatoes during a short hour in this example

Irrigation of cabbage in Southern Norway

In Norway field grown vegetables are irrigated, and irrigation of a field of cabbage is used as another example. The discharges takes place at 10-13 bars of pressure. The source of water for irrigation is a near by river, and the water is lifted about 2m and by electricity or diesel compressors the pressure of the water then is increased to about 10 bars, and discharged into the speed booms.

Water being added by irrigation : 100mm

Requirement of irrigation for each hectare

100mm means 10 x 1000 m^2 x 0.1 m= 1000 m^3

1000 tons of water or 1000 000 kg water

Requirement of energy to get this water lifted to 100 m above the field (to achieve a pressure of 10 bars)

gravitation of the earth g = 10 ms^{-2}

10^6 x g x 100 = 10^9 Joule

or 10^3 MJoule

Output of energy connected to the harvested crop

50 tons of cabbage

1 MJ pr. kg

50 x 10^3 MJoule pr. hectar

Energy connected to each ton of crop

10^3 MJoule pr. ton

Rough estimate of energy connected to tranport by small truck (15 tons capacity)

Energy connected to each ton of crop

10^3 MJoule pr. ton

Energy content in irrigating 1 ton of cabbage crop

10 Mjoule pr. ton

The energy content of 1 l of diesel fuel is about 38.5 MJ

1 liter diesel fuel is considered used for transporting one ton of cabbage, a short hour in this example.

Production and maintenance of machinery

Usually in agronomy energy consuming machinery is used, and the production and maintenance of this machinery consumes energy and also water is used in the processes.

The fertilization connected to crop production

•The fertilization of fields and orchards connercted to crop production also demands energy input

• In order to produce mineral fertilizers energy is involved

• Also the transport and distribution of the fertilizers demands energy

Transport, distribution and consumption connected to crop production

Transport is connected to bringing fertilizers, herbicides and pesticides to the farms

Transport is connected to distribution of the harvested products to the storage systems, to the industry and to the consumers

Transport demands great amounts of energy, usually gasoline and oil, but sometimes also electricity produced in some manner

The treatment of waste

Crop production, industrial use of crops as well as consumption of the crops give us waste

In the treatment of waste in several cases also energy is used, and water is used also

Recycling of minerals to make the demands of mineral fertilizers less important?

The minerals of the crops and the waste of the crop production do not disappear to a great degree(some minerals are released into the atmoshere as gases, and some minerals are transported into the fresh water systems and end into the ocean)

Is it possible to think of recycling of the minerals of the waste products of the production and consumption of crops?

Are the weather and climate in fact directly and indirectly influenced by the way industrialized crop production is organized?

In the global change scenarios, the output of green house gases is an important concern

Is this increasing output of green house gases depending of the industrialized way crop production and consumption of crop proucts is organizes, by using so much fossile fuel in the system of production, transport, distribution and treatment of waste?

Positive feed back mechanisms connected to the water cycle of the atmosphere?

Global change scenarios indicate that more energy is stored in the atmspheric envelope of air than before. The water cycle of the atmospheric system is very importantan

Two main positive feed back mechanisms are connected to the atmosheric system. One positive feed back system is connected to albedo. When the ice cover of the planet grows, the albedo wil ncrease, and the ice cover will grow even more.

Another positie feed back mechanism is connected to the temperature of the atmoshere and the ocen. Water vapour is one of the main green house gases. When the atmoshere gets warmer, more water vapour is contained in the atmoshere, and the outcome is a warmer atmosphere.

What are the sustainability for crop production in the climate system of the earth?

What are the sustainability for the crop production systems in the changing climate of the earth, containing more hot spells, more storms with strong winds and violent precipitation,as tropical cyclones, extratropical cyclones and storms of smaller extension?

We should look at the sustainable elements on the different levels of social organization, connected to crop production.

Sustainability and the content of social constructions?

Sustainability means maintaining certain important relations, connected to the next generations, to the environment and the other species, and to the generations before us.

It is possible to quantify many elements of relational systems by using n-tuples and relational databases.

We are building social constructions, and our living is limited and protected by the social constructions we belong to.

In order for social constructions to be sustainable, they must have a degree of autonomy, not always depending on other social systems.

Sustainability on different levels of social organization

Below I will look very generally at different levels of social organization:

The farm

The village and the muncipality of the farm

The society outside the closest community

The county level -the state and the national level

The global level

Is it possible to say something general about sustainability connected to the different levels containing meaning?

Looking into social constructions

Let us consider some elements of existing and possible social constructions to find possibilities to care for the important relations of man.

A social construction usually contans ownwrship and responsibility.

The society as a whole must support and protect social constructions that are sustainable

The farm and the family

As an examle i will use the old Nordic instutution of a free or alloidal farm:

The farm should be large enough to give sustainable livelyhood for the farmer and his family.

The farm should pass undivided from one generation to the next generation.

The owner (usually the oldest son of the former owner) and his family should live in the farm houses. The owner usually did participate in the work on the farm himself.

Families owning their farms usually took the responsibility for maintainig the farm, the fields, the cattle, the farm houses, the forest and the nature of the forest in such condition that the next generations could stay on the farm and make their living from the production of the farm

The local region of a farm with crop production

I look very generally at the closest community of a farm, the muncipality, the village or town nearby, the neighbouring farm land and the environment.

The muncipalty is responsible for some infrastructure (roads, fresh water supply, waste water treatment and treatment of waste water, managing waste etc.) , schools for the children, health care and social care, support of culture, local planning etc.

The local region usually contains local craftsmen, local industry and local stores. Sometimes the region also have some industry exporting industrial products from the region.

Sustainable management of a local region?

I am not able to say anything specifically about sustanability in a local context, a muncipality.

In order for the muncipality to be sustainable it must be able to protect and develop the sustainable social constructions in the regon. This is only possible I think if some people in charge take the responsibility and care for these constructions. Then they must have achieved insight and understanding of what is going on, as well as the ability to acting accordingly.

The level of a state or a nation

This level contains some sort of governement and institutions dealing with legislation, and many institutions being the outcome of the legislation.

On the stately level the present situation is governed and planning for the future is made.

There are stately institutions connected to: Economy and private enterprises, infrastructure, military activities, education abd research, protection of the borders, commercial and industrial activitiers, energy, agriculture and fisheries, care of health, cultural activites (organizes religion, art, sport), protection and management of environment and natural resources, foreign affairs, weaher and climate etc.

Sustainable solutions can only be made when people in charge have responsibility and care.

The global level

The global level contains souvereign states having military power and economical power and quarelling about natural resources and each of them protecting their own culture.

There are global problems connected to global change, environmental problems and also ptoblems of resources and political problems connected to global change.

Global issues are dealt with through cooperation on the stately level, and several international treatises are signed.

Solutions can only be made when people in charge have responsibility and care for the whole system.

Photograph: Bernhard Muehr
www.wolkenatlas.de, institute for Meteorology and Climate Research, University of Karlsruhe, Germany